SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
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SURFACE VEHICLE STANDARD

SAE J88

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Submitted for recognition as an American National Standard

(R) SOUND MEASUREMENT—OFF-ROAD WORK MACHINES—EXTERIOR

Foreword—This Document has also changed to comply with the new SAE Technical Standards Board format.

1. Scope—This SAE Standard sets forth the instrumentation and procedure to be used in measuring the exterior sound levels for self-propelled sweepers as defined in SAE J2130 and self-propelled off-road work machines in categories 1, 2, 4, and 5 of SAE J1116.

This document does not address the operation of safety devices such as backup alarms, horns, or accessories. The sound levels obtained by using the test procedures set forth in this document are repeatable and are representative of the higher range of sound levels generated by machines under actual field operating conditions. Due to variability of field operating conditions, this data is not intended to be used for construction site boundary noise evaluations.

2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J184 AUG87—Qualifying a Sound Data Acquisition System
SAE J732—Specification Definitions—Front End Loader
SAE J1116 JUN86—Categories of Off-Road Self-Propelled Work Machines
SAE J1382 AUG85—Classification, Nomenclature, and Specification Definitions for Trenching Machines
SAE J2130—Identification of Self-Propelled Sweepers

2.1.2 ANSI PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI S1.4-1983—Specification for Sound Level Meters

2.1.3 IEC PUBLICATION—Available from International Electrotechnical Commission, 3, rue de Verambe, P.O. Box 131, 1211 Geneva 20, Switzerland.

IEC 804-1985—Integrating Sound Level Meters

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2.2 Related Publications—The following publications are provided for information purposes only and are not a required part of this document.

2.2.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1262—Sound Measurement—Trenching Machines

2.2.2 ANSI PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI S1.40-1984—Specification for Acoustical Calibrators

3. Instrumentation

3.1 A sound level meter which meets the Type 1 requirements of ANSI S1.4-1983 shall be used. Alternatively an integrating sound level meter may be used if it meets IEC 804-1985 requirements. If an integrating sound level meter is used for dynamic measurements, it must have a slow dynamic characteristic, and max hold.

3.2 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 for SAE J184 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).

3.3 An acoustical calibrator (accuracy within ±0.5 dB(A)—see 5.2.4) shall be used to ensure correct calibration of the sound level meter(s).

3.4 The use of a windscreen may be required under some test conditions. Refer to 4.1.3, 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 5.2.2.)

3.5 An anemometer or other device for measurement of ambient wind speed and direction shall be used. The accuracy is ±10% at the highest recommended wind speed. (See 5.2.2.)

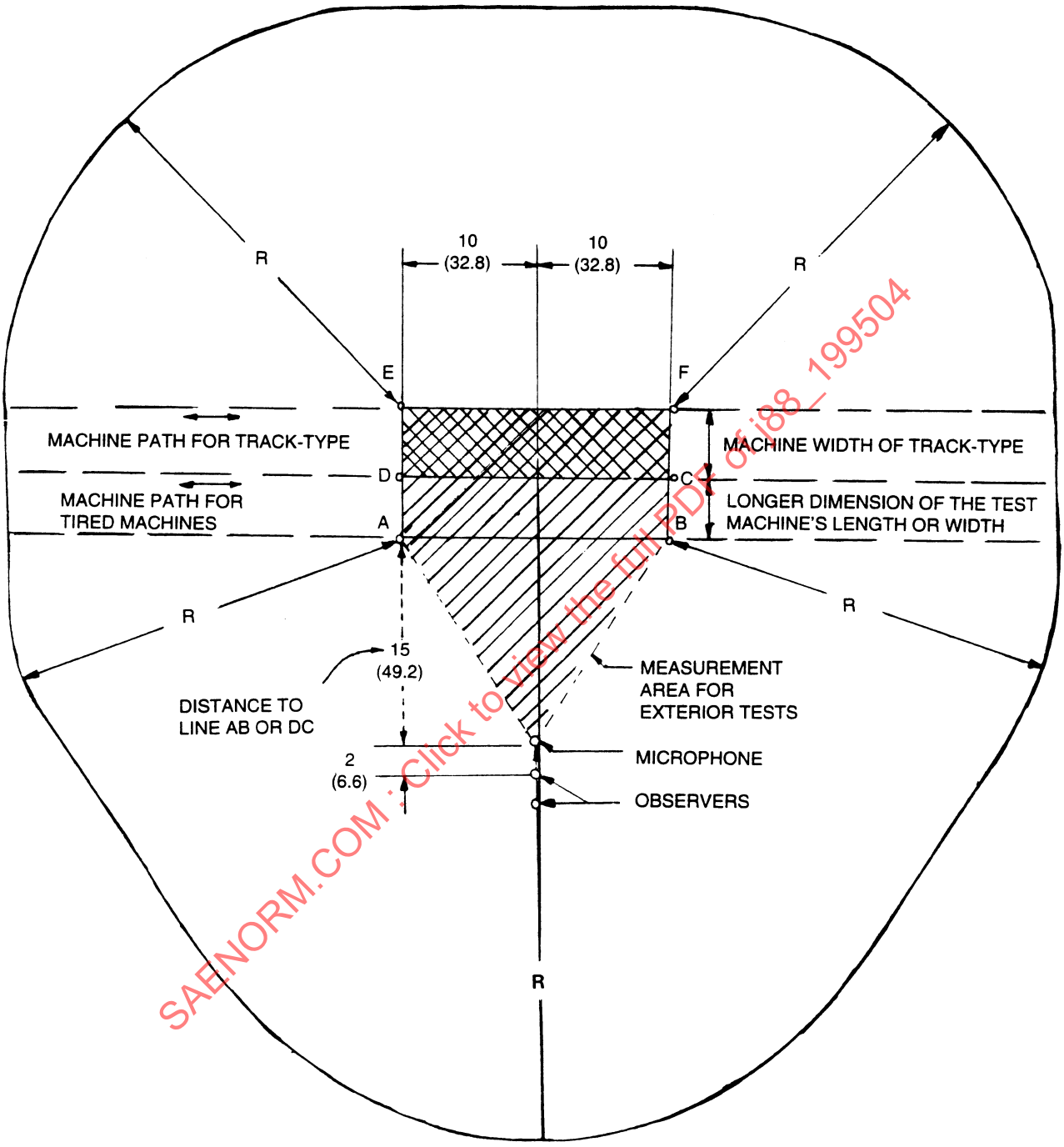
3.6 A speed indicator shall be used for determination of machine power source(s) rpm (accuracy within ±2% of the indicated reading).

3.7 A thermometer for measurement of ambient temperature (accuracy within ±1 ×C) shall be used.

3.8 A barometer shall be used to measure atmospheric pressure (accuracy within ±1 kPa of the indicated reading).

4. Procedure

4.1 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 of either the microphone or the machinery being measured (see Figure 1).



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

DIMENSIONS ARE IN m (ft)

FIGURE 1—TEST SITE CONFIGURATION

4.1.1 The minimum measurement area (see Figure 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 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.

4.1.2 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 of the earthmoving machinery and 2 m 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 Figure 1).

4.1.3 The ambient sound level due to sources other than the machinery being measured (including wind effects) shall be at least 10 dB(A) lower than the sound level of the machinery being measured. (See 4.3.3.)

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

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

4.1.6 Moving Tests

4.1.6.1 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 Figure 1.

4.1.6.2 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 Figure 1.

4.2 Tests Required—Machines that are used primarily in a mobile mode shall be tested per 4.2.1.1, 4.2.1.2, 4.2.1.3, 4.2.1.4, and 4.2.2.

Combined machines (such as loaders with a backhoe) shall be tested per 4.2.1.1, 4.2.1.2, 4.2.1.3, 4.2.1.4, and 4.2.2.

Rubber-tired and tracked excavators shall be tested in a stationary test mode only per 4.2.1.1, 4.2.1.2, 4.2.1.3, and 4.2.1.4.

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

4.2.1.1 Operate mobile machine power source(s) at no-load with all component drive systems in neutral position and maximum governed speed (high idle at no load) at a stabilized condition.

4.2.1.2 Operate machine power source(s) at no-load and at manufacturer's specified rated speed with all component drive systems in neutral position.

4.2.1.3 Operate mobile machine power source(s) 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 allow 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. It is recommended that care be taken to ensure stabilized combustion chamber surface temperatures prior to this test sequence. For some types of engines, such as engines with precombustion chambers, repeatability of sound levels may be affected. Between cycles, a cool-down period of 5 min is recommended.

4.2.1.4 With the power source(s) at the maximum governed speed (high idle) or manufacturer's recommended 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 extended and/or maximum height position, and then back to original position. The component cycled must have controls at the operator's station. This cycling should be done as fast as practical, taking into consideration all the pertinent safety factors, and be accomplished without exceeding relief valve settings. For short cycle hydraulic operation, the system may be feathered.

For safety reasons and undesirability of change of location of major noise source(s) 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.

For units such as nonriding trenching machines without power steering or hydraulic controls, this section shall be omitted. In no case shall the digging chain (wheel) or vibratory plow drives be engaged for this test or other tests in this document. For self-propelled street sweepers, the brooms may be lowered and raised for this portion of the test.

4.2.2 CONSTANT SPEED MOVING TEST—Machines shall be operated in a forward intermediate gear ratio at no-load at a location as specified in 4.1.6.1 or 4.1.6.2. The power source(s) 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 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 power source(s) and drive controls, then the ground speed may be increased or decreased so as to still permit the power source(s) governor control(s) to be set in the maximum (high idle) position. Machines that have major noise-generating components which are normally in use at this ground speed, shall have these major components in operation during this test. For self-propelled street sweepers, these components include water systems, brooms, and blower or conveying systems.

4.2.3 Machines that have 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, brooms on sweepers, dozers on either wheel or track-type tractors, and backfill blades, digging booms (wheel), direct burial plows, or backhoes on trenchers. For all tests, except component cycling, these attachments shall be in a minimum transport position of 160 to 320 mm for dozers, scrapers, etc. For loaders and trenchers with loaders, use carry position as specified by SAE J732. 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. For trenching machines and self-propelled sweepers these attachments shall be in their normal transport position, for example, backfill blade or brooms fully raised; plow, boom, or wheel fully raised and restrained (if appropriate).

4.3 Measurements

4.3.1 The microphone shall be located at a height of 1.2 m above the ground plane.

4.3.2 All sound level measurements shall be taken using the A-weighting network. For dynamic power source(s) cycling, component cycling, and constant speed moving test conditions, the sound level meter shall be set for slow dynamic characteristic (see 3.1). For the stabilized test condition of maximum governed speed (high idle) or rated engine speed, the time weighted average sound level (Leq) may be used in place of the slow dynamic characteristic.

4.3.3 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 and within at least 3 m of one specified location of the microphone as shown in Figure 1.

4.3.4 The stabilized maximum governed power source(s) speed shall be measured and recorded.

4.3.5 The power source(s) speed(s) shall be monitored during the rated speed test per 4.2.1.2.

4.3.6 The gear ratio and approximate ground speed during the moving test shall be recorded.

4.3.7 The sound level meter needle movement, digital readout, or graphic level recorder trace shall be observed during each test sequence. 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 noise such as bucket rap against stops) shall be recorded for each test sequence. For a digital-type readout, the meter must be frequently reset so the out-of-character sound levels for the test sequence are not included if the maximum hold mode is being used.

4.3.8 For the stabilized test condition, of maximum governed speed (high idle) or rated speed, a single reading shall be recorded at each measuring point.

4.3.9 For power source(s) cycling, component cycling, and the constant speed moving test conditions 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.

4.3.10 NUMBER OF SIMULATED WORK CYCLES—Three simulated work cycles shall be carried out resulting in three measurements to be taken at each microphone position.

It is necessary to have two of the readings at the microphone within a 2 dB range of each other. If these results are not obtained, additional simulated work cycles shall be taken to meet this requirement. Operational procedures may require correction to achieve this.

4.3.11 DETERMINATION OF MEASUREMENT RESULT—Report, as the value of the continuous A-weighted sound pressure level, the arithmetic mean of the highest values that are within a 2 dB range of each other for each microphone position.

4.3.12 For stationary tests, record the sound level obtained at a distance of 15 m from each major surface, 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, backfill blades, backhoes, rippers, and booms (see Figure 2). These attachments should not be removed for the tests, but are not considered in defining major surfaces (see SAE J1382). 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 4.2.1.1, 4.2.1.2, 4.2.1.3, and 4.2.1.4.

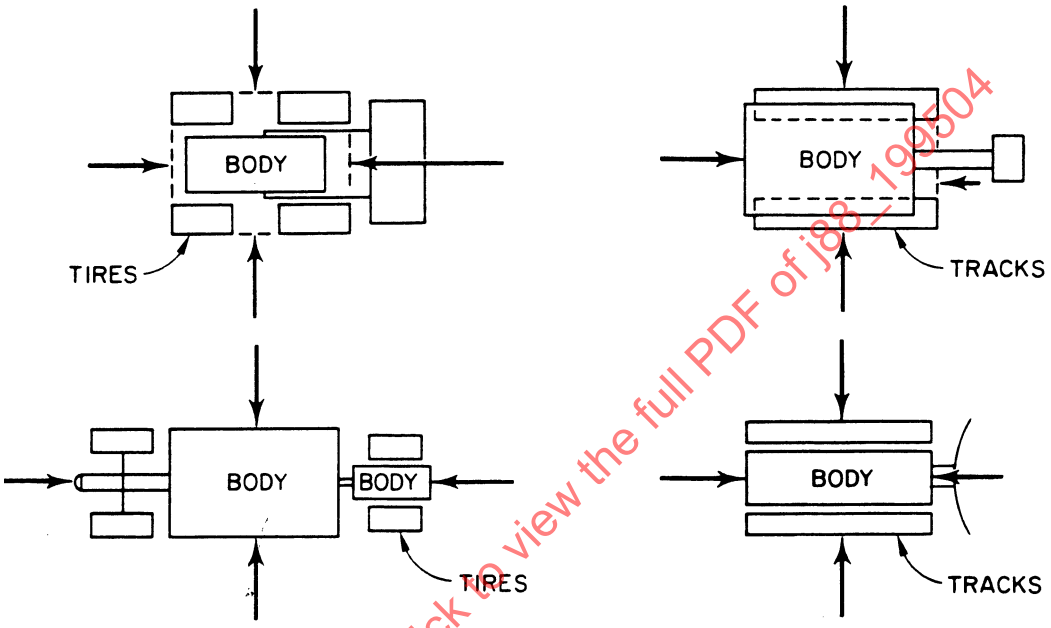


FIGURE 2—MAJOR SURFACE OUTLINES

4.3.13 For moving tests, take measurements at a distance of 15 m from each major surface, measured in a direction normal to both major side surfaces which are parallel to the machine path, as shown in Figure 1. Operate the machine in a manner specified in 4.2.2.

4.3.14 The reported sound level for each of the stationary test modes (per 4.2.1.1, 4.2.1.2, 4.2.1.3, and 4.2.1.4) 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 4.2.2) shall be the arithmetical average of the recorded sound levels at each of the two measuring points. The reported sound levels for a given machine shall be included in the report format as shown in Appendix A.

5. General Comments

5.1 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.

5.2 Safety and Operation—All relevant safety precautions and the manufacturer's operating instructions shall be followed during the test. Any signal devices, such as forward-warning horn or backup alarm, shall not be activated during the test.

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.

5.2.1 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.

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

A microphone windscreen shall not be used except when it is required to reduce wind induced noise that is within 15 dB(A) of the sound level of the source being measured. When a windscreen is used it shall not affect the sound level of the source being measured by more than ±0.5 dB(A) under zero wind speed conditions.

Note—In practice, windscreens are seldom required to reduce A-weighted wind induced noise, with the possible exception of microphone locations in the fan blast of the machine.

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

5.2.4 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 machine 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.

5.3 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.

6. Notes

6.1 Marginal Indicia—The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

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