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SURFACE VEHICLE STANDARD

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(R) SOUND MEASUREMENT—OFF-ROAD WORK MACHINES— OPERATOR—SINGULAR TYPE

Foreword—This Document has not changed other than to put it into the new SAE Technical Standards Board Format.

1. Scope—This SAE Standard describes the instrumentation and procedures to be used in measuring sound levels at the operator station 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 SAE document is applicable to machines that have operator stations where the operator can either stand or sit and will be either transported by, or walk with the machine during its operation. The sound levels obtained using this procedure are repeatable and 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 operator noise exposure evaluations. Measurement and calculation of the operator's sound exposure should follow SAE J1166.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise specified, the latest issue 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 JUN92—Specification Definitions—Loaders
SAE J833 MAY89—USA Human Physical Dimensions
SAE J1116 JUN86—Categories of Off-Road Self-Propelled Work Machines
SAE J1166 MAY90—Sound Measurement—Off-Road Self-Propelled Work Machines Operator-Work Cycle
SAE J2130—Identification of Self-Propelled Sweepers

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

ANSI S1.4-1983—Specifications for Sound Level Meters
IEC 804-1985—Integrating Sound Level Meter

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

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

SAE J1262—Sound Measurement—Trenching Machines

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

ISO 6394—Acoustics—Measurement of airborne noise emitted by earthmoving machinery—Operator's position—Stationary test condition

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 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 of 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—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 4.2), 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, if the machine to be tested has no operator enclosure or will be operated in the open configuration—doors and/or windows open during machine operation. The accuracy is ±10% at the highest wind speed. (See 5.2.2.)

3.6 A speed indicator for determination of machine power source(s) rpm shall be used (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 for measuring atmospheric pressure (accuracy within ±1 kPa of the indicated reading).

4. Procedure

4.1 Test Site

4.1.1 The test area shall consist of a smooth, uniform plane that has open space free of uncompacted snow, tall grass, and large reflecting surfaces such as a signboard, building, or vertical earth and rock embankment within 15 m of the machine being measured (see 5.2.5).

4.1.2 Steel wheel and crawler machines shall be tested with the machines on a level surface of compacted earth or gravel. The moisture content should be low enough to prevent the material from sticking to the wheels or tracks. Other types of machinery may be tested with the machinery on a level surface of either hardpacked earth, gravel, concrete, or asphalt. The level surface should not have over ±1% grade in the direction of travel.

4.2 Environmental, Operator, and Machine Guidelines

4.2.1 No person other than the operator shall be in the operator's station area of the machine.

4.2.2 The ambient sound level measured at the microphone location (including wind effects), due to sources other than machinery being measured, shall be at least 10 dB(A) lower than the level of the machine being tested.

4.2.3 An operator shall be selected whose physical dimensions are as close as possible to a 50th percentile person (Reference SAE J833):

a. Standing Height—With shoes 1715 mm (5th percentile—1550 mm and 95th percentile—1880 mm)
b. Sitting Height—880 mm (5th percentile—800 mm and 95th percentile—960 mm)
c. Head Width—145 to 165 mm (5th percentile—145 mm and 95th percentile—165 mm)

An operator with physical dimensions that fall outside the 5th percentile to the 95th percentile range should not be permitted to operate the machine during this sound evaluation test.

4.2.4 The microphone shall be located 200 mm ± 20 mm from the median plane of the head and in line with the eyes and to the side of the head where the equivalent continuous A-weighted sound pressure level is highest. The microphone should either point in the direction of the operator's vision (head mounted) or upward (shoulder mounted). It is envisioned that a head-mounted or shoulder-mounted microphone will be remote mounted via a cable. Microphones mounted on the machinery should point in the forward direction of travel. Care shall be taken to isolate the microphone from vibrations or movements which could affect the measurements.

If more than one operating position is located on the machine, sound levels at all positions will be measured and the highest value reported.

NOTE—A 13 mm nominal diameter microphone is recommended.

4.2.5 When the test machine has a fully enclosed operator's station, measurements are to be taken with windows, doors, and vents in a fully closed position and the appropriate climatizing accessories in operation. For air circulation fan(s) with two positions, the high speed shall be used. If more than two operating speeds are available, the air conditioning and/or pressurizing ventilating system(s) shall be operated at midrange speed. If the air conditioning and/or pressure ventilating system(s) has(have) a recirculation and outside air position, the control shall be set for outside air. The test machine shall also be tested under a fully open configuration—all doors, windows, and vents open if they are designed to be open during machine operation. Climatizing accessory fans shall be off for the fully open configuration.

4.2.6 The machine shall be at a stabilized operating temperature during the test and must be operated in a manner such that the break-in procedure specified by the manufacturer is not violated.

4.3 Tests Required—Machines that are used primarily in a mobile mode shall be tested per 4.3.1.1, 4.3.1.2, 4.3.1.3, 4.3.1.4, and 4.3.2. Combined machines (such as loaders with a backhoe), shall be tested per 4.3.1.1, 4.3.1.2, 4.3.1.3, 4.3.1.4, and 4.3.2 when in the loader mode and tested per 4.3.1.1, 4.3.1.2, 4.3.1.3, and 4.3.1.4 when in the backhoe mode.

Rubber-tired and tracked excavators shall be tested in a stationary test mode only per 4.3.1.1, 4.3.1.2, 4.3.1.3, and 4.3.1.4.

4.3.1 STATIONARY TESTS WITH GROUND PROPULSION TRANSMISSION SHIFT SELECTOR IN NEUTRAL POSITION

4.3.1.1 Operate mobile machine power source(s) at no load and at a stabilized maximum governed speed (high idle). All major component drive systems shall be in neutral position.

4.3.1.2 Operate all power sources at no load and rated speed with all major component drive systems in neutral position.

4.3.1.3 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 pre-combustion chambers, repeatability of sound levels may be affected. Between cycles, a cool down period of 5 min is recommended.

4.3.1.4 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 the 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.

4.3.2 CONSTANT SPEED MOVING TEST—Machines shall be operated in a forward intermediate gear ratio at no load. The power source(s) shall be operated at maximum governed speed (high idle). Intermediate is intended to mean second gear ratio for machines with three or four gear ratios, third gear ratio for machines with five or six gear ratios, fourth gear ratio for machines with seven or eight gear ratios, etc. (Gear ratio refers to overall gear reductions.) If there is a problem with a 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 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 to be set in 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.

4.3.3 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 crawler tractors, and back fill blades, digging booms (wheel), direct burial plows, and backhoes on trenching machines. 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 trenching machines and 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). Loaders and trenchers with loaders shall use carry position as specified by SAE J732.

4.4 Measurements

4.4.1 The microphone shall be located next to the operator's right or left ear as stated in 4.2.4 for all operating conditions.

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

4.4.3 The ambient temperature, atmospheric pressure, and A-weighted sound level shall be measured and recorded at the operator's station with the machine shut down. If the machine has a fully enclosed operator's station, these measurements shall be taken with the tested enclosure configuration. The ambient wind speed and direction shall be measured for all applicable tests.

4.4.4 The stabilized maximum governed power source(s) speed (high idle) at no load shall be measured and recorded.

4.4.5 The power source(s) speed shall be monitored during the rated speed test.

4.4.6 The gear ratio and approximate ground speed during the moving tests shall be recorded.

4.4.7 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 sound 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.

4.4.8 For the stabilized test condition of maximum governed speed (high idle) or rated speed, a single reading shall be recorded.

4.4.9 For power source(s) cycling, component cycling, and constant speed moving test conditions, a minimum of three valid readings shall be taken for each measuring point.

4.4.10 NUMBER OF SIMULATED WORK CYCLES—Three simulated work cycles shall be carried out resulting in three measurements to be taken at the 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.

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

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 the instrumentation and operational requirements shall be prerequisite of all personnel attached to the evaluation program.

5.2 Proper use of all test instrumentation is essential to obtain valid measurements. Operating manual 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 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 wind speeds.

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 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 tests to be valid.

5.2.5 The overall effect due to an alternate test environment on the sound level measurement shall not exceed ±1.0 dB(A) from the sound level measurement made at the test site described in 4.1.1.

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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