

Sound Power Determination – Earthmoving Machinery– Static Condition– SAE J1372 JUN83

SAE Recommended Practice
Last Revised June 1983

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**SOUND POWER DETERMINATION—
EARTHMOVING MACHINERY—
STATIC CONDITION—SAE J1372 JUN83**

SAE Recommended Practice

Report of the Construction, Agricultural, and Off-Road Machinery Sound Level Technical Committee, approved December 1981, last revised June 1983.
Rationale statement available.

1. Purpose and Scope

1.1 Purpose—This SAE Recommended Practice sets forth the procedures to be used in determining the exterior A-weighted equivalent continuous sound power level emitted by earthmoving machinery defined in ϕ SAE J1057 JUN81.

1.2 Scope—The requirements for setting up and operating the machinery, the microphone array and the size of the hemispherical measurement surface are given in this recommended practice. This recommended practice shall be used in conjunction with ISO 4872-1978, which gives the basic criteria for the acoustic environment, instrumentation, microphone positions, procedures for the measurement of the A-weighted sound pressure levels and the calculation of the A-weighted sound power levels.

2. Instrumentation

- ϕ **2.1** The sound level meter and/or appropriate components of the measuring instrumentation shall meet the Type 1 requirements of the ANSI S1.4-1982 or IEC 651-1979 specifications for sound level meters.
- ϕ **2.2** An acoustical calibrator for use in calibration prior to and after test sequence [accuracy within ± 0.5 dB(A)—see paragraph 4.2.3].
- ϕ **2.3** 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.

ϕ **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.

2.4 An anemometer or other device for use in measurement of ambient wind speed and direction [accuracy within $\pm 10\%$ at 20 km/h (12.4 mph)].

2.5 A power source (engine) speed indicator for ensuring that constant manufacturer's specified engine speed is maintained during the test sequence (accuracy within $\pm 2\%$ of the indicated reading).

2.6 A thermometer for use in measurement of ambient temperature ϕ [accuracy within $\pm 1^\circ\text{C}$ ($\pm 2^\circ\text{F}$)].

3. Procedure

3.1 Test Site—The test environment shall satisfy the criteria described in ISO 4872-1978, Section 4 and Annex A. Ideally, measurements should be made in a test environment that provides a free field over a reflecting plane. There shall be no sound reflecting obstacles within a distance from the source equal to three times the radius of the measurement hemisphere.

3.2 Hemisphere Size—The radius of the microphone array hemisphere shall be determined by the length of the basic machine structure. This is the length, denoted by L in Figs. 1-6, which encloses the main body of the machine and excludes major attachments such as dozer blades, buckets, and booms.

The radius of the measurement surface is obtained from Table 1 according to the basic length, L, of the machine.

3.3 Measurement Surface—The measurement surface given as alter-

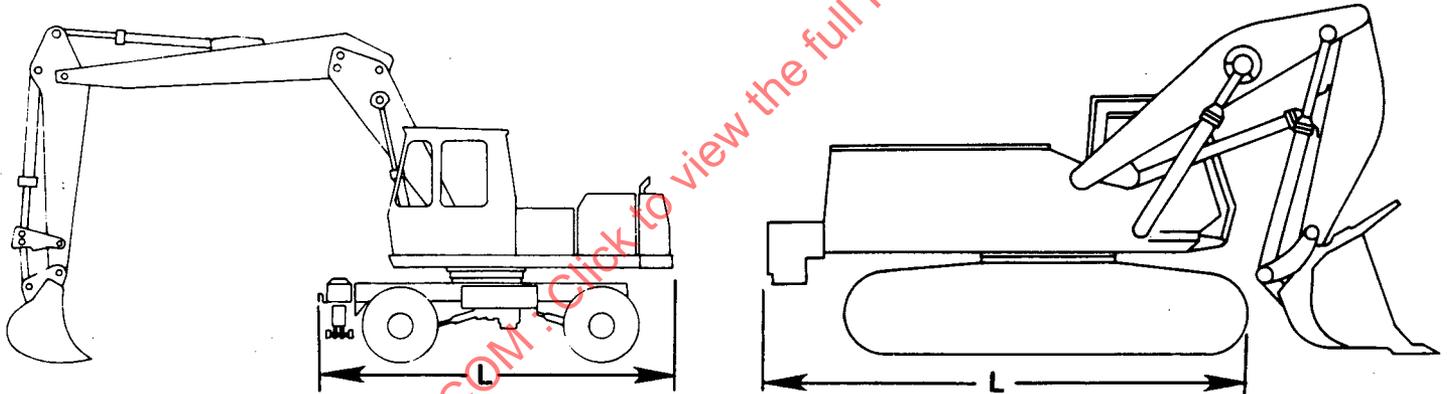


FIG. 1

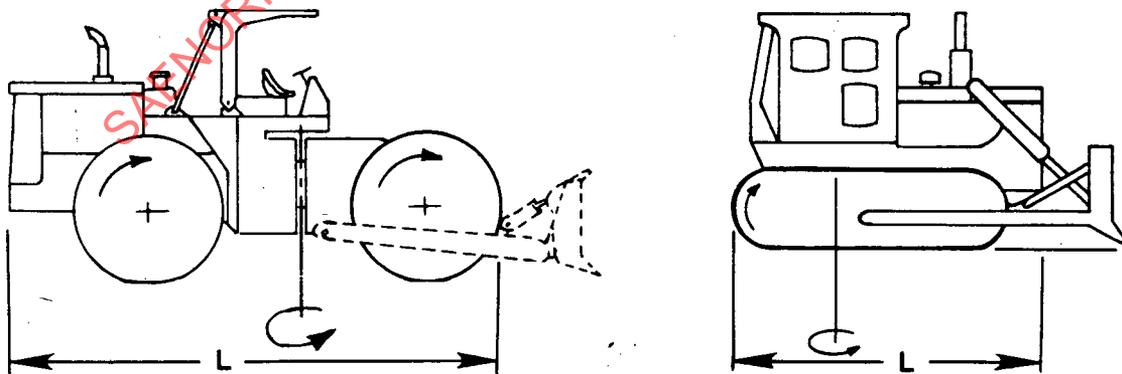


FIG. 2

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.

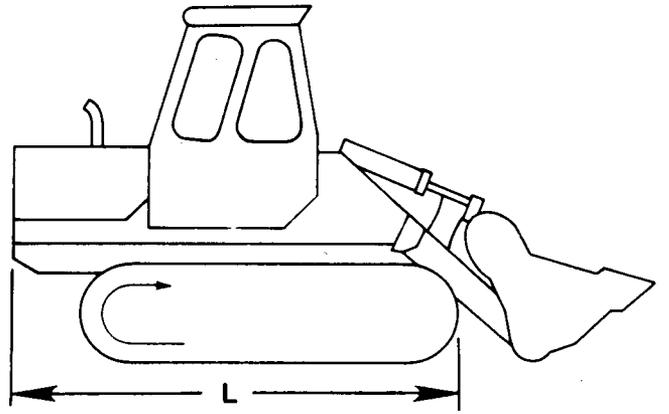
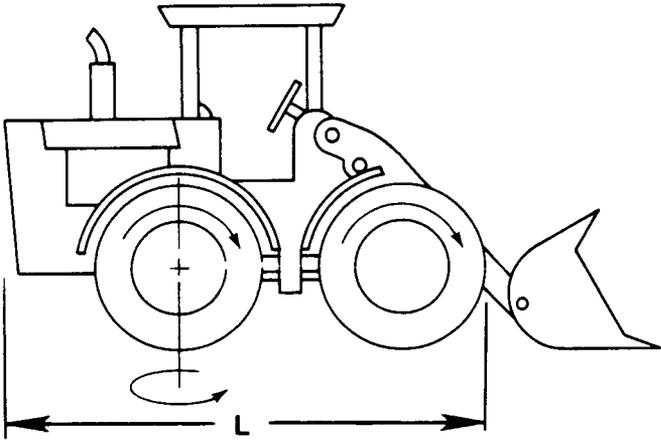


FIG. 3

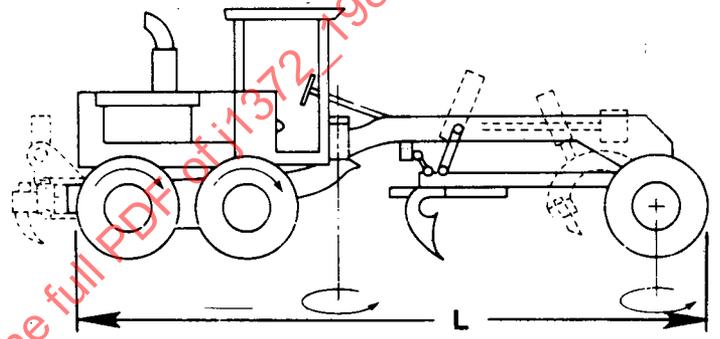
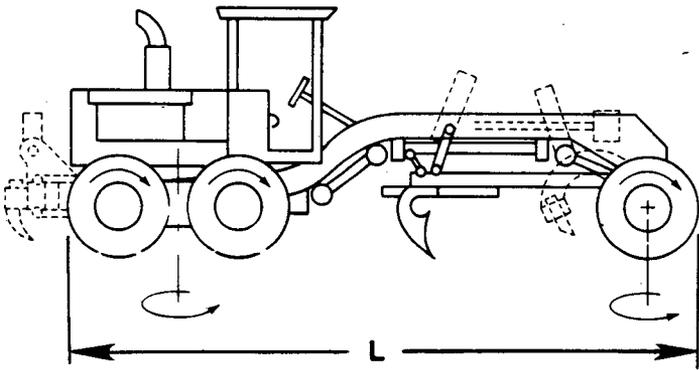


FIG. 4

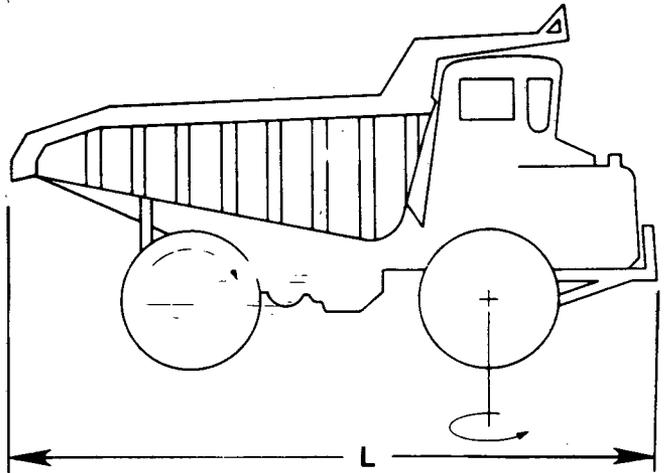
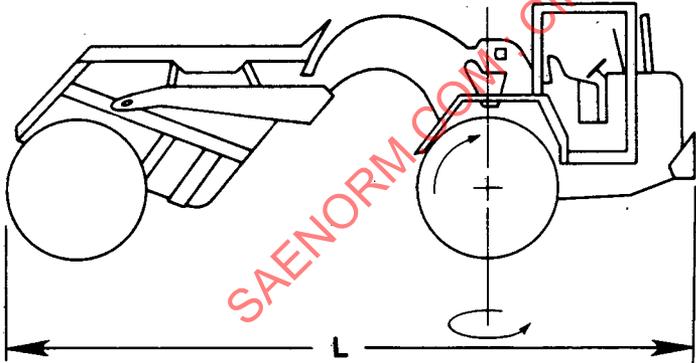


FIG. 5

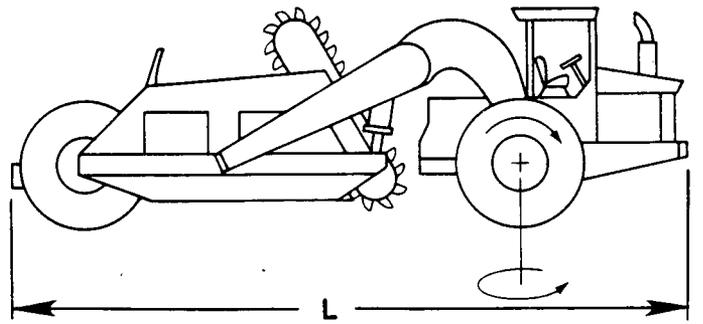
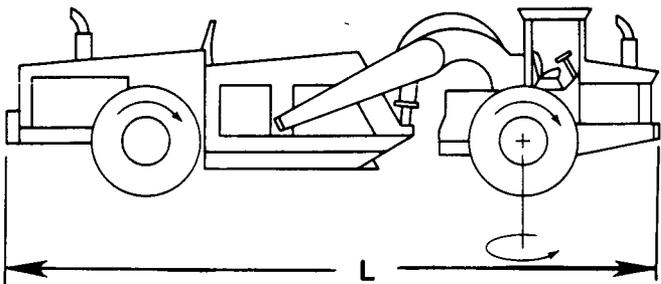


FIG. 6

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TABLE 1

Basic Length L of the Machine	Radius of Hemispherical Measurement Surface
$L \leq 1.5 \text{ m}$	4 m
$1.5 \text{ m} < L \leq 4 \text{ m}$	10 m
$L > 4 \text{ m}$	16 m

native B in paragraph 7.2.3 of ISO 4872-1978 shall be used. Only microphone locations 2, 4, 6, 8, 10, and 12 shall be used in this measurement procedure. The location and the coordinates of the microphone positions are given in Fig. 7 and Table 2 as shown:

$$\begin{aligned}x &= (x/r)r \\y &= (y/r)r \\z &= (z/r)r\end{aligned}$$

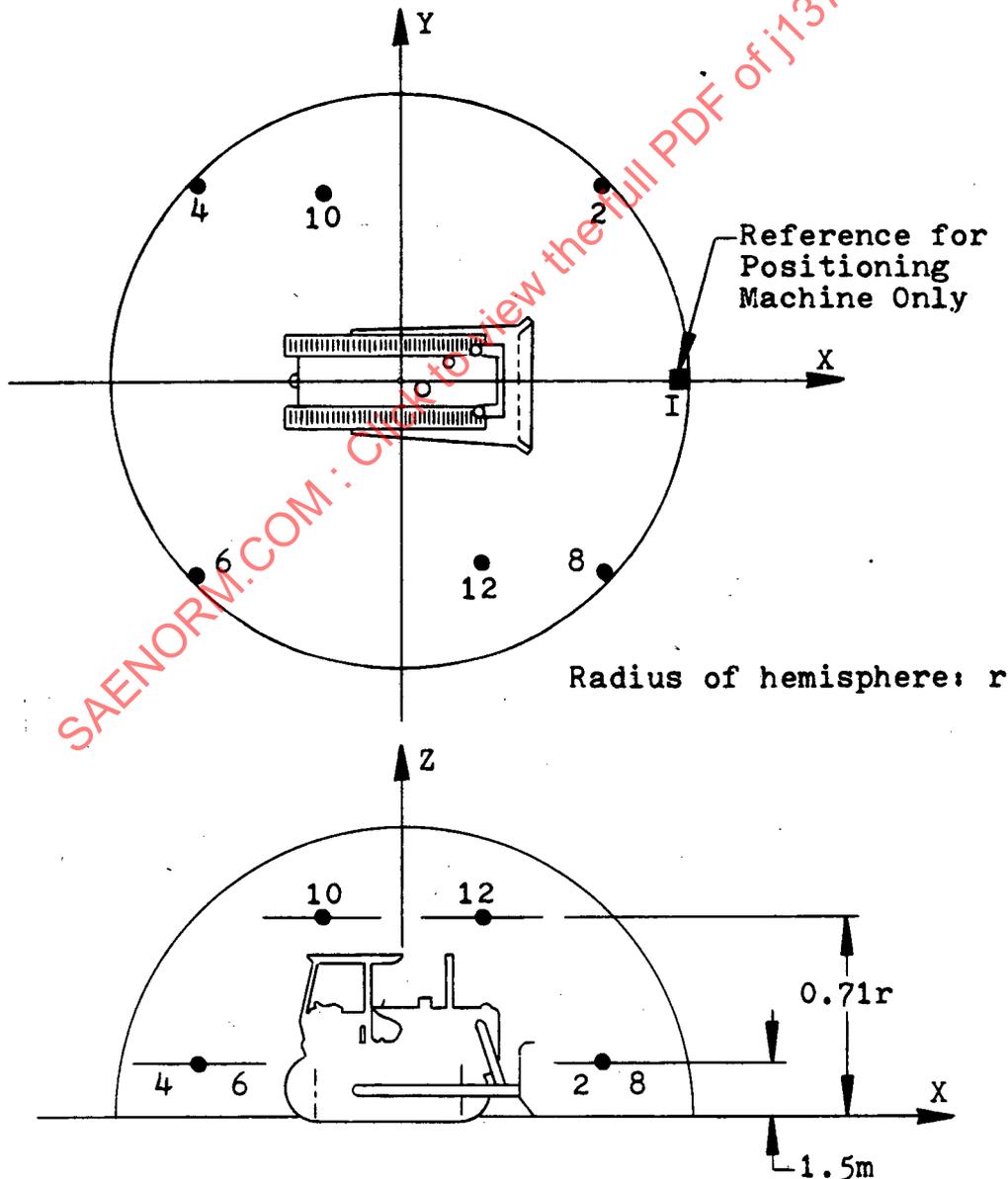
3.4 Machine Location—The machine excluding the attachments shall be positioned so that the front surface is directed towards position ϕ I of the hemisphere and the basic machine geometric center coincides with the intersection of the hemisphere centerlines. Attachments (or equipment) may be attached to the machine or remain loose (not secured), provided they are positioned in the appropriate location. The attachments shall be held approximately 0.3 m (1 ft) above the ground by the normal support system or may rest on wood or rubber blocks.

TABLE 2—COORDINATES OF THE MICROPHONE LOCATION POINTS

No.	$\frac{x}{r}$	$\frac{y}{r}$	$\frac{z}{r}$	z
2	0.7	0.7	—	1.5 m
4	-0.7	0.7	—	1.5 m
6	-0.7	-0.7	—	1.5 m
8	0.7	-0.7	—	1.5 m
10	-0.27	0.65	0.71	—
12	0.27	-0.65	0.71	—

3.5 Machine Operation—During the test sequence, the machine shall be in a stationary position with the engine operating at manufacturer's specified rated speed under no-load condition and with the transmission in neutral. On a machine which has multiple engines, all engines shall operate concurrently. No machine test data shall be taken until the machine has attained a stabilized operating temperature for the prevailing ambient conditions.

3.6 Criterion for Background Noise—At the test microphone positions, the A-weighted sound pressure level due to the background noise shall be at least 10 dB below the measured sound pressure level when the machine is under test. If this criterion is not met, then corrections for background noise must be made in accordance with the procedure outlined in ISO 4872-1978.



φ FIG. 7—MICROPHONE ARRAY ON THE HEMISPHERE

3.7 **Wind**—The wind speed at the test site shall be measured at a ϕ height of 2 m (6.6 ft) above the ground.

3.8 **Climatic Conditions**—Measurements shall not be conducted ϕ when precipitation is falling or when the test surface is covered with snow or temperature is below -10°C (14°F) or above $+50^{\circ}\text{C}$ (122°F) or if the wind velocity exceeds 8 m/s (17.9 mph).

3.9 Measurements

3.9.1 Ambient wind and temperature data shall be measured and recorded.

ϕ 3.9.2 The sound level meter or instrumentation shall be set to the A-weighting network. Slow response shall be used on non-integrating sound level meters or instrumentation. Orient the microphone according to the manufacturer's instructions for that specific microphone.

ϕ 3.9.3 Background A-weighted sound pressure levels at the test microphone locations shall be measured and recorded.

ϕ 3.9.4 For an integrating sound level meter(s), the integration period shall be 20–30 s. Readings should be measured and recorded simultaneously at all six microphone locations with the machine stationary and the engine operating at rated speed no-load. If simultaneous readings cannot be acquired, then a sequential procedure may be used that acquires one 20–30 s reading at each of the microphone locations 2, 4, 6, 8, 10, and 12. This data sequence shall be completed as rapidly as practical, but not exceeding 1 h.

ϕ 3.9.5 For a non-integrating sound level meter, paragraph 3.9.4 must be followed except that the single reading at each microphone location shall be calculated from a series of at least three independent readings taken in succession. Each reading shall be obtained by observing the meter readout for at least 10 s to determine the central tendency excluding any momentary high or low sound pressure levels. If the three readings at any microphone location are not within 2 dB(A) of each other, then additional readings shall be recorded until the last three readings are within 2 dB(A). This series shall be reduced to a single value for each microphone location by arithmetically averaging the last three readings. This data measuring sequence should be accomplished in a time period of less than 1 h.

ϕ NOTE: All intermediate results will be recorded or calculated to an accuracy of at least the nearest half a decibel.

3.10 Calculations

3.10.1 CALCULATION OF SURFACE ENERGY AVERAGE SOUND PRESSURE

The surface energy average sound pressure level \bar{L}_{pAeq} shall be calculated ϕ from the values of the energy average A-weighted equivalent continuous sound pressure level L_{pAeqi} by using the following equation:

$$\bar{L}_{pAeq} = 10 \log_{10} \frac{1}{N} \left[\sum_{i=1}^{i=N} 10^{0.1L_{pAeqi}} \right] \quad (1)$$

ϕ where \bar{L}_{pAeq} is the surface energy average sound pressure level in decibels.
 L_{pAeqi} is the A-weighted equivalent continuous sound pressure level resulting from the i^{th} measurement location corrected for background noise in decibels. Ref: $20\mu\text{Pa}$;

N is the total number of microphone positions, 6.

NOTE: If a non-integrating sound level meter is used, then in all equations and on the reported values, the references to energy average sound pressure level and subscript eq should be deleted.

3.10.2 **CALCULATION OF SOUND POWER LEVEL**—The A-weighted sound ϕ power level of the source, L_{WAeq} , in bels Ref: 1pW shall be calculated from the following equation:

$$\phi \quad L_{WAeq} = \left(\bar{L}_{pAeq} + 10 \log_{10} \frac{S}{S_0} - K \right) / 10 \quad (2)$$

where S is the area of the measurement surface in square meters.

ϕ Ref: $S_0 = 1 \text{ m}^2$. ($S = 2\pi r^2$ for a hemispherical measurement surface)

If the test site parameters described in paragraph 3.1 are met, then the environmental factor K is zero. If these parameters are not met, then Annex A of ISO 4872–1978 must be used to determine K.

Radius	$10 \log_{10} \frac{S}{S_0}$
4 m	20
10 m	28
16 m	32

ϕ 3.10.3 **COMMENT ON REPORTING IN BELS**—If the A-weighted sound ϕ power level of a machine is 112.3 dB, the sound power level according

to paragraphs 3.10 and 3.12.1 shall be reported as described by appropriate paragraphs of ANSI S1.23–1976:

$$\text{Equivalent A-Weighted Sound Power Level} = 11.2 \text{ bels} \\ \text{or } L_{WAeq} = 11.2 \text{ bels}$$

3.11 Information to be Recorded

3.11.1 **MACHINERY UNDER TEST**—The machine manufacturer, machine model number, serial number, machine arrangement including major attachments, and the engine speed at rated speed no-load condition shall be recorded.

3.11.2 ACOUSTIC ENVIRONMENT

3.11.2.1 Description of the test site including the type of surface and the value of K. ϕ

3.11.2.2 Air temperature and wind velocity at 2 m (6.6 ft) above test site.

3.11.3 INSTRUMENTATION

3.11.3.1 Instrumentation used for the measurements including name, type, serial number and manufacturer.

3.11.3.2 Method used to calibrate the instrumentation system.

3.11.3.3 The date and place of calibration of the acoustical calibrator.

3.11.4 ACOUSTICAL DATA

3.11.4.1 The location of the microphones.

3.11.4.2 The A-weighted equivalent continuous sound pressure level ϕ (\bar{L}_{pAeqi}) at each microphone position as defined in paragraph 3.9.4 or ϕ 3.9.5.

3.11.4.3 The background A-weighted sound pressure level at each microphone position.

3.11.4.4 The surface energy average sound pressure level (\bar{L}_{pAeq}).

3.11.4.5 The A-weighted sound power level (L_{WAeq}).

3.12 Information to be Reported

3.12.1 The calculated sound power level L_{WAeq} in bels from paragraph 3.10.2 shall be rounded off to the nearest 0.1 bel [$<0.05 = \text{lower number}$; $\geq 0.05 = \text{higher number}$ (see paragraph 3.10.3)]. ϕ

3.12.2 Machine manufacturer, model number, serial number, net power in kilowatts as defined in ISO 1585–1974, measured engine speed at rated no-load condition, machine arrangement including major attachments and description of test site surface.

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. Attention to detail and a thorough understanding of the machine and test instrumentation operational requirements shall be prerequisites 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) must be known. Instrumentation can be influenced by low or high temperature, and caution should be exercised.

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

4.2.3 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. The calibration before and after shall not vary by more than ± 0.5 dB for tests to be valid.

4.2.4 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 paragraph 3.1.

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. Reference Material

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

ANSI S1.2–1961 (R1971), Physical Measurement of Sound

ANSI S1.4–1982, Specifications for Sound Level Meters

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

ANSI S1.23–1976, Method for the Designation of Sound Power Emitted by Machinery and Equipment

SAE Standard J245, Engine Rating Code—Spark Ignition

SAE Standard J270, Engine Rating Code—Diesel

SAE Recommended Practice J184a, Qualifying a Sound Data Acquisition System