Sound Power Determination—Earthmoving Machinery—Static Condition—SAE J1372 DEC81

SAE Recommended Practice
Approved December 1981

THIS IS A PREPRINT WHICH IS SUBJECT TO REVISIONS AND CORRECTIONS. THE FINAL VERSION WILL APPEAR IN THE 1983 EDITION OF THE SAE HANDBOOK.

PREPRINT

SOUND POWER DETERMINATION—EARTHMOVING MACHINERY—STATIC CONDITION—SAE J1372 DEC81

SAE Recommended Practice

Report of the Construction, Agriculture, and Off-Road Machinery Sound Level Technical Committee, approved December 1981. Rationale statement included in appendix.

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 SAE J1057a.

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

2.1 The preferred measurement instrument is an integrating sound level meter having a digital readout and designed to permit the determination of the value of the A-weighted sound pressure level averaged over time on an energy basis.

2.2 An alternative measurement instrument is a non-integrating sound level meter.

2.3 Whatever the type of instrumentation used, appropriate components of the measuring instrumentation system shall meet the Type 1 requirements given in the relevant clauses of IEC Publication 651–1979 and ANSI S1.4–1971 (R1976).

2.4 An acoustical calibrator for use in calibration prior to and after test sequence [accuracy within ±0.5 dB(A)—see paragraph 4.2.3].

2.5 The use of a windscreen may be required under some test conditions (refer to paragraph 3.7). 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 3.8).

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

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

2.8 A thermometer for use in measurement of ambient temperature [accuracy within ±1°C (±2°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.

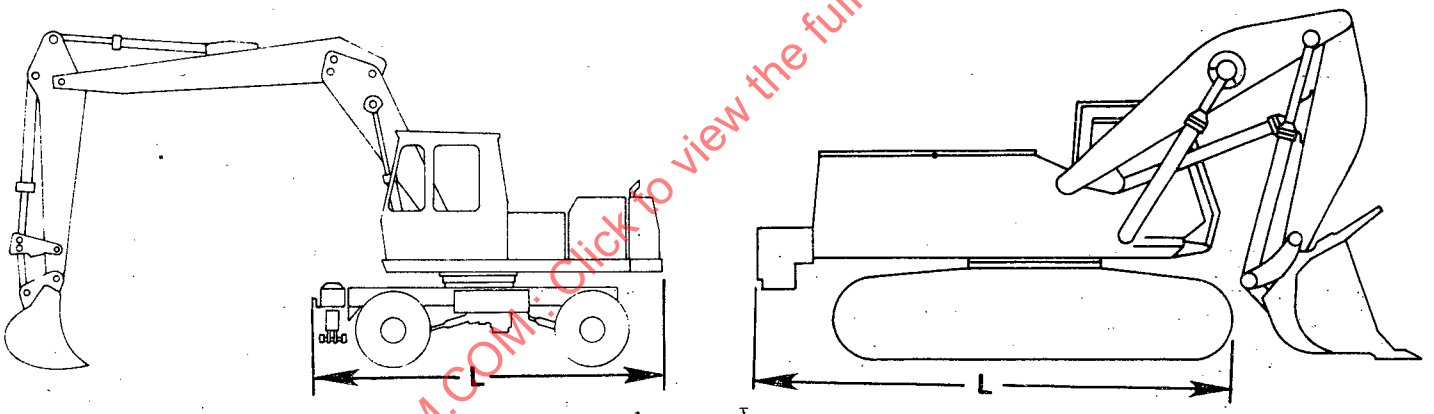

FIG. 1

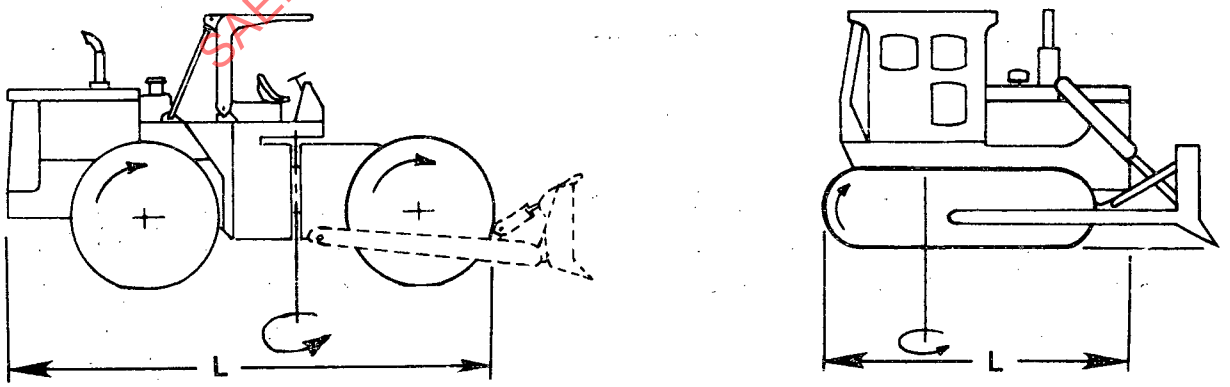

FIG. 2

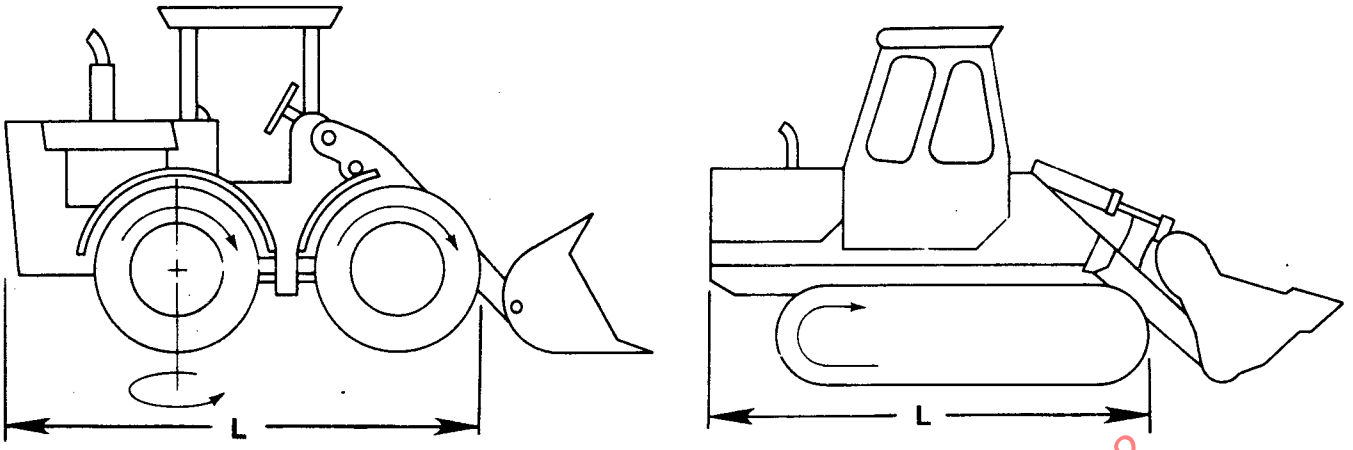

FIG. 3

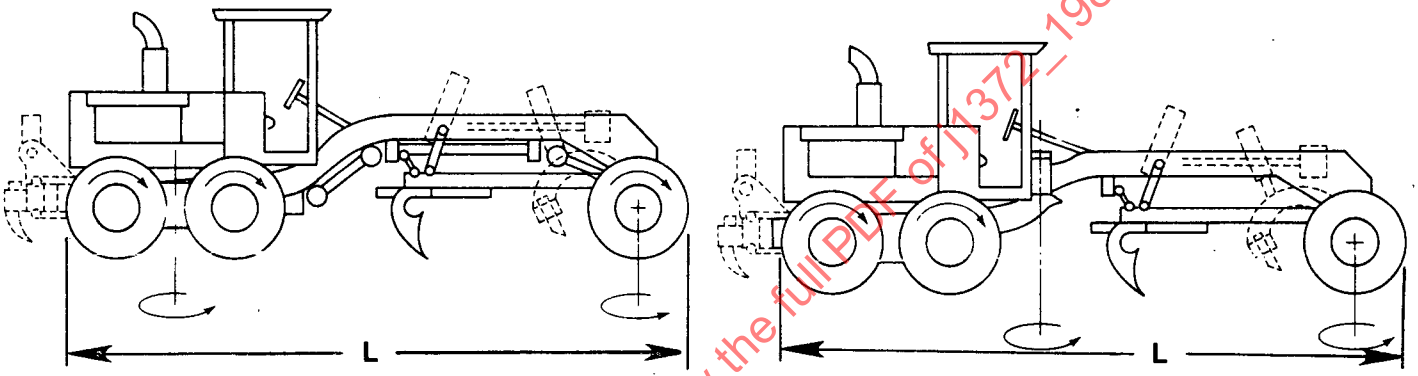

FIG. 4

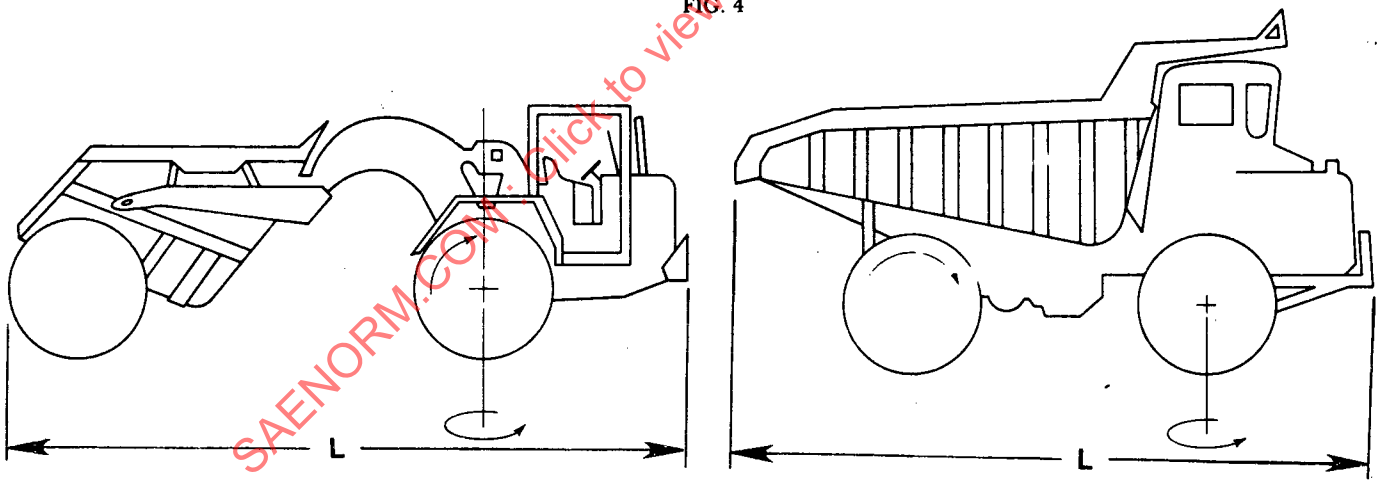

FIG. 5

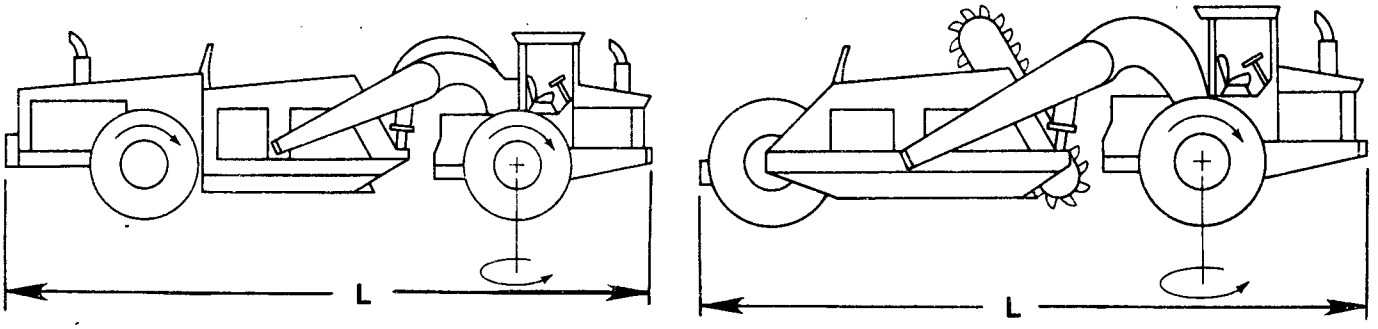

FIG. 6

TABLE 1

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

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 alternative 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:

$$x = (x/r)r$$
$$y = (y/r)r$$
$$z = (z/r)r$$

TABLE 2—COORDINATES OF THE MICROPHONE LOCATION POINTS

No.	x/r	y/r	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	—

3.4 Machine Location—The machine excluding the attachments shall be positioned so that the front surface is directed towards position 1 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.

3.5 Machine Operation—During the test sequence, the machine shall be in a stationary position with the engine operating at manufactur-

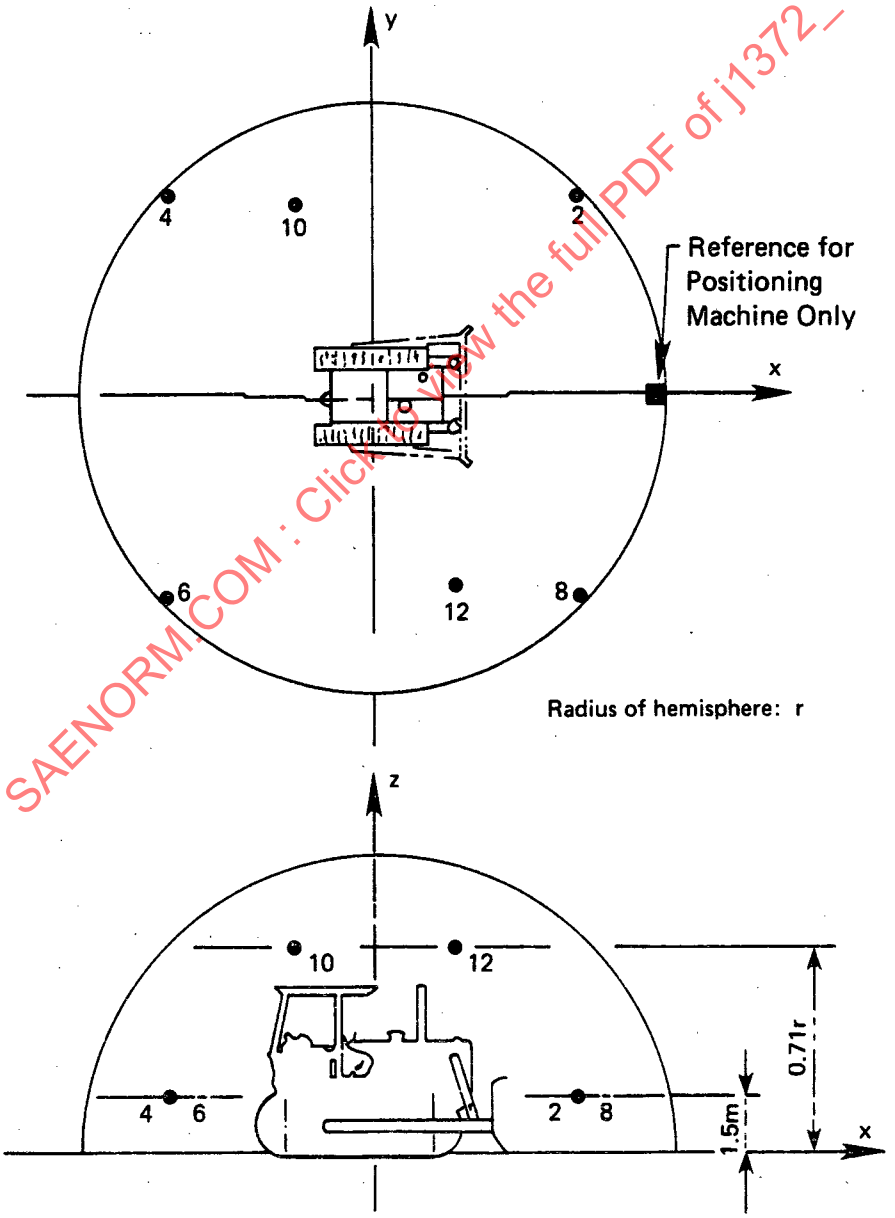

FIG. 7—MICROPHONE ARRAY ON THE HEMISPHERE

er'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.

3.7 Wind—The wind speed at the test site shall be measured at a height of 2 m (6.6 ft) above the ground. For wind speeds in excess of 1 m/s (2.2 mph), a microphone windscreen shall be used and appropriate compensation for the effect of its use shall be considered and included in the final reported data.

3.8 Climatic Conditions—Measurements shall not be conducted when precipitation, that is, rain or snow, is falling or when ground surface is covered with snow or temperature is below −10°C (14°F) or above +50°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.

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

3.9.3 Set the sound level meter to the A-weighting network and slow response if possible. Orient the microphone according to the manufacturer's instructions for that specific microphone.

3.9.4 For an integrating sound level meter(s) with a digital readout, A-weighted equivalent continuous sound pressure level readings for a period of 15–30 s each should be measured and recorded simultaneously at all six microphone locations with the machine stationary and the engine operating at rated speed no-load. These measurements shall be repeated three times in as short a time as practical but not exceeding 1 h. If simultaneous readings cannot be acquired, then a sequential procedure may be used that acquires a single reading at each of the microphone locations 2, 4, 6, 8, 10, and 12. This measurement sequence shall be repeated until three complete sets of data are acquired. This latter data sequence procedure must also be done in a time period of less than 1 h.

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 consist of a series of at least three readings taken as rapidly in succession as practical. This series shall be reduced to a single value for each microphone location by arithmetically averaging the three or more separate readings. If the three readings at any microphone location are not within 2 dB(A) of each other, then additional sets of three readings shall be recorded only at that location until three readings within a set are within 2 dB(A). If four sets of three readings each fail to provide a set of values which are within 2 dB(A), then all 12 values shall be averaged to provide a single value for that location. This data measuring sequence should be accomplished in a time period of less than 1 h.

NOTE: All intermediate results such as sound pressure and sound power levels will be recorded or calculated to the nearest tenth of 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 from each set of measured values of the energy average A-weighted equivalent continuous sound pressure level L_{pAeqi} by using the following equation:

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

where $\bar{L}_{pAeq}$ is the surface energy average sound pressure level in bels.

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: 20μPa;

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 power level of the source, L_{WAeq}, in bels shall be calculated from the following equation:

$$L_{WAeq} = \bar{L}_{pAeq} + \log_{10} \frac{S}{S_o} - K \quad (2)$$

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

Ref: $S_o = 1\ m^2$. ($S = 2\pi r^2$ for a hemispherical measurement surface) (3)

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	$\log_{10} \frac{S}{S_o}$
4 m	2.0
10 m	2.8
16 m	3.2

If there is no pair of calculated values within 1 dB of each other, then additional tests shall be completed until there is a pair of calculated values that are within 1 dB of each other. The reported value shall then be the highest L_{WAeq} of the highest pair.

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.

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 levels (L_{pAeqi}) at each microphone position (all three data sets) as defined in paragraph 3.9.4.

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 = lower number; ≥0.05 = higher number (see Section 5)].

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 (tem-