RATIONALE

The committee has agreed upon increasing tolerances on entry speed and full throttle position to reduce the amount of test runs needed to satisfy requirements. These increases in tolerance do not change the highest sound measured for the test.

FOREWORD

This SAE Recommended Practice is intended as a guide toward standard practice, but may be subject to frequent change to keep pace with experience and technical advances.

1. SCOPE

This SAE Recommended Practice establishes the instrumentation, test site, and test procedure for determining the maximum exterior sound level for snowmobiles.

Sound propagation is directly related to the ground cover and provides the largest variation to the measured result. A correction factor is introduced to improve year round test repeatability of the results on grass surfaces by correcting their spectrum to be similar to snow covered spectra.

Measured sound pressure levels are also highly dependent on the degree of track slip present when performing the vehicle acceleration. Operators should attempt to limit track slip as much as possible while maintaining the requirements described in 5.1.1.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1   SAE Publication

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J184   Qualifying a Sound Data Acquisition System

2.1.2   ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI S1.4   Specification for Sound Level Meters

ANSI S1.11   Specification for 1/3 Octave Bands

2.1.3   ISO Publication

Available from International Organization for Standardization (ISO), 1 rue de Varembe, Case Postale 56, CH-1211 Geneva 20, Switzerland, Tel: +41-22-749-01-11, www.iso.org.

ISO 3741   Acoustics—Determination of sound power levels and sound energy levels of noise sources using sound pressure—Precision methods for reverberation test rooms

2.1.4   JASA Publication

Available from The Journal of the Acoustical Society of America (JASA), American Institute of Physics, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502, Tel: 516-576-2360, http://asa.aip.org.

Cramer, O., 'The Variation of the Specific Heat Ratio and the Speed of Sound in Air with Temperature, Pressure, Humidity and CO_2 Concentration,' Journal of the Acoustical Society of America, 93 (5), 1993

2.1.5   Metrologia Publication

Available from The Institute of Physics (IOP), Institute of Physics Publishing, Dirac House, Temple Back, Bristol BS1 6BE, United Kingdom, Tel: +44-0-117-929-7481, http://publishing.iop.org.

Giacomo, P., 'Equation for the Determination of the Density of Moist Air,' Metrologia, Springer-Verlag, 1982

2.2   Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1   ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ANSI S1.1   Acoustical Terminology

ANSI S1.13   Methods of Measurements of Sound Pressure Levels

3. INSTRUMENTATION

The following instrumentation shall be used for the measurements required.

3.1   A sound level meter which meets the Type 1 requirements of ANSI S1.4.

3.1.1   As an alternative to making direct measurements using a sound level meter, a microphone or sound level meter may be used with an audio recorder and/or a graphic level recorder or other indicating instrument provided the system meets the requirements of SAE J184.

3.1.2   The microphone shall be used with an acceptable windscreen. To be acceptable, the screen must not affect the microphone response by more than ±1 dB for frequencies of 20 to 4000 Hz or ±1 1/2 dB for frequencies of 4000 to 10 000 Hz.

3.1.3   For summer testing, the sound level meter or audio recorder must be capable of calculating 1/3 octave bands from 20 to 10 000 Hz following the Type 1 requirements of ANSI S1.11.

3.2   A sound level calibrator with an accuracy of ±0.2 dB.

3.3   An engine speed sensor or other means of continuously recording engine speed during the event with a steady-state accuracy of ±3% at the prescribed test speed.

3.4   A sensor capable of recording when the full throttle position is achieved.

3.5   A sensor to indicate the vehicle position at the start, full throttle location, and end of the course.

3.6   A sensor to determine the vehicle velocity during the event.

3.7   Thermometer.

3.8   Barometer.

3.9   Sling psychrometer, or dew point apparatus.

3.10   Windvane.

3.11   Anemometer.

3.12   Grass Surface Testing Only

Sound pressure source capable of generating a minimum sound power level of 60 dBA or higher from 100 to 200 Hz and a minimum sound power level of 90 dBA or higher from 250 to 1000 Hz.

4. TEST SITE

4.1   A suitable test site shall be a level, open space free from the effects of large sound reflecting surfaces. Parked vehicles, signboards, or other obstacles must not be located within 30 m (100 ft) of either the vehicle path or the microphone. (See Figure 1.)
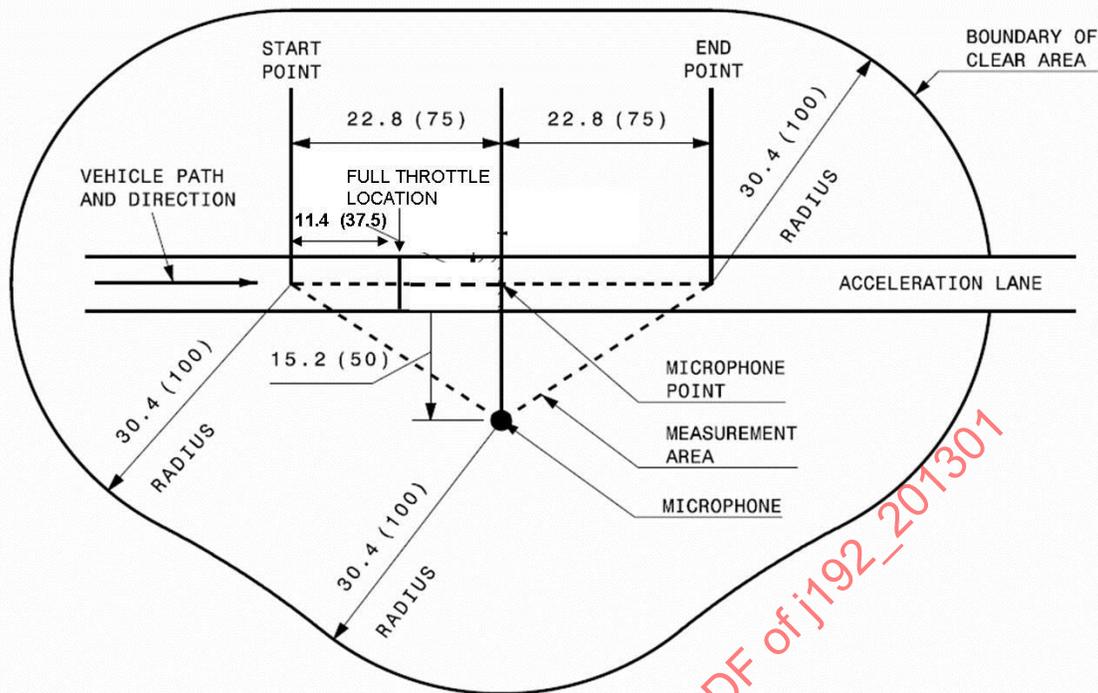
FIGURE 1 - UNIDIRECTIONAL TEST SITE LAYOUT

4.2   The microphone shall be located 15 m (50 ft) from the centerline of the snowmobile path and 1.2 m (4 ft) above the snow or turf. The normal to the vehicle path from the microphone shall establish the microphone point on the snowmobile path.

4.3   The measurement area shall be the triangular area formed by the start point, the end point, and the microphone location.

4.4   Test site validation must be accomplished before any snowmobile sound measurements can be performed.

4.4.1   Snow Covered Surface

The surface of the ground within the measurement area, including the snowmobile path, shall be covered with a maximum of 75 mm (3 in) of loose snow over a base consisting of at least 75 mm (3 in) of snow sufficiently compacted to support the snowmobile without significant penetration.

The hardness of the snow surface shall be verified prior to testing by traversing the snowmobile over the test lane at a steady speed as slow as clutch engagement will allow and verifying at least 25 mm of track lug penetration. A track with less than a 25 mm lug shall have full lug penetration. Lug height is to be determined by measuring from the track belt to the maximum lug height.

4.4.2   Grass Covered Surface

May be used provided that the surface of the ground within the measurement area, including the snowmobile path, shall be primarily covered with grass, up to a maximum of 75 mm (3 in) in height free of visible droplets of water. The grass covered surface must be evaluated for acoustic performance using the sound source procedure described in Section 6.

4.4.2.1   Unpacked snow layer is defined as any loose pack snow atop a packed base.

4.4.2.2   The packed surface should be as consistent as possible along the snowmobile path and the area between the acceleration path and the microphone.

4.4.2.3   The depth of packed snow shall be measured with a 1/4 in diameter solid cylindrical probe. The probe into the packed base layer must reach a minimum depth of 75 mm (3 in) with minimal force (<20 lb).

4.5   The reference point of the snowmobile, to indicate where the snowmobile is on the snowmobile path, shall be the front of the ski(s).

4.6   While making sound level measurements, not more than one person, other than the observer reading the meter, shall be within 15 m (50 ft) of the snowmobile or microphone, and that person shall be directly behind the observer reading the meter, on a line through the microphone and the observer.

4.7   The ambient A-weighted sound level (including wind effects), coming from sources other than the snowmobile being measured, shall be at least 10 dB lower than the level of the test snowmobile and the sound source.

5.   PROCEDURE

5.1   Snowmobile Operation

A full-throttle acceleration test as specified as follows, is the basis for establishing maximum noise capabilities of the snowmobile.

5.1.1   For the test, approach the starting point at a steady speed of 24 km/h ± 4 km/h (15 mph ± 2.5 mph). When the starting point is reached, smoothly open the throttle in a linear manner such that a full throttle condition is achieved within 11.4 m (37.4 ft) ± 2.5 m (8.2 ft) of the entry point of the test course. Maintain wide open throttle until the end point is reached. The centerline of the snowmobile must not deviate more than 1 m (3 ft) from either side of the centerline of the snowmobile path. Record the maximum engine speed reached.

5.1.2   On snow surfaces when multiple machines are to be tested, course maintenance or a different acceleration lane shall be used for each different snowmobile evaluation, in an attempt to limit track slip.

5.1.3   On snow surfaces, the compacted snow base shall allow no more than 150 mm (6 in) of track penetration measured at the 11.4 m position from the start of the course during the acceleration test.

5.1.4   If the snowmobile is unable to attain a speed of 24 km/h (15 mph) on approach to the start point, pass the start point at wide open throttle, and maintain wide open throttle until the end point is passed.

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

5.2.1   The applicable reading shall be the highest sound level indicated for the run, between the start point and the end point, ignoring unrelated peaks due to extraneous noises or surface irregularities. Measurement runs can be repeated to eliminate irregularity effects.

5.2.2   Test runs shall be repeated until three readings within a 2 dB range per snowmobile side have been obtained. The sound level for each side of the snowmobile shall be the average of all three readings, rounded to the nearest integer. The sound level reported shall be that for the side of the snowmobile with the highest readings after environmental corrections have been applied as described in Section 6.

5.3   During the test period, the atmospheric temperature, barometric pressure, humidity, wind speed, and wind direction shall be recorded at intervals not exceeding 1 h.

6.   ENVIRONMENTAL CORRECTION

6.1   Snow Surface

The preferred test surface of snow requires no correction process.

6.2   Grass Surface

An omnidirectional sound source with known acoustic properties should be used to measure the sound propagation properties of the environment. The sound source should be evaluated to obtain a known sound power level for each 1/3 octave band from 100 to 1000 Hz following ISO 3741. The field measurement of the sound source's sound pressure level should be performed regularly throughout the testing session as changes in air temperature distribution from the ground upwards, wind, and humidity as well as snowmobile traffic will change these measurements. The source should produce broadband noise in the frequency range from 100 to 1000 Hz and is to be placed in the center of the snowmobile path with its center 500 mm (20 in) above the surface and a 1/3 octave sound spectrum measured. The 1/3 octave measurement for the speaker should be a linear average across a 10 second time window.

Assuming an ideal sound propagation with a monopole source located on the ground surface, the sound pressure at the measurement point can be calculated from the known sound power of the acoustic source at each 1/3 octave frequency using Equation 1. The speed of sound and air density calculations are functions of air temperature, barometric pressure and relative humidity. The speed of sound calculation is presented in Equation 2 from the reference of Section 2.1.4. The air density calculations are presented in Equation 3 from the reference of Section 2.1.4 respectively.

$$p^2_{ideal(rms)}(f) = \frac{W(f) \cdot \rho c}{2\pi \cdot r^2}$$

$where:$

$p^2_{ideal(rms)}(f) = $ RMS Sound Pressure as a function of frequency

$f = $ Frequency   (Eq. 1)

$W(f) = $ Sound Power as a function of frequency

$\rho = $ Air Density

$c = $ Speed of Sound

$r = $ Distance from Source to Receiver in meters

$$c = A_0 + A_1 T + A_2 T^2 + \left(A_3 + A_4 T + A_5 T^2 \right) X_w +$$
$$\left(A_6 + A_7 T + A_8 T^2 \right) P + \left(A_9 + A_{10} T + A_{11} T^2 \right) X_c +$$
$$A_{12} X_w^2 + A_{13} P^2 + A_{14} X_c^2 + A_{15} X_w P X_c$$

where :

$T = $ Temperature $\left({}^{\circ}C \right)$

$P = $ Barometric Pressure $\left(Pa \right)$

$X_c = 0.000314 = $ Mole Fraction of CO_2 in Air

$X_w = \dfrac{rh \cdot E_f \cdot psv}{P} = $ Mole Fraction of Water Vapor in Air

$rh = $ Relative Humidity $\left(\%/100 \right)$

$E_f = 1.00062 + 3.14e - 8 \cdot P + 5.6e - 7 \cdot \left(T + 273.15 \right)^2$

    Enhancement Factor

$$psv = \exp \left(\begin{array}{l} 1.2811805e - 5 \cdot \left(T + 273.15 \right)^2 - \\ 1.9509874e - 2 \cdot \left(T + 273.15 \right) + \\ 34.04926034 - 6.3536311e3 / \left(T + 273.15 \right) \end{array} \right)$$ (Eq. 2)

    Saturation Vapor Pressure of Water in Air