SAE INTERNATIONAL

SURFACE VEHICLE STANDARD	J192™	MAR2021
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Maximum Exterior Sound Level for Snowmobiles

RATIONALE

To allow more flexibility, the use of weather station data has been added in 5.3.

1. SCOPE

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

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 Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J184 Qualifying a Sound Data Acquisition System

2.1.2 ANSI Accredited Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ANSI/ASA S1.4-2014/Part 1/IEC 61672-1:2013 Electroacoustics - Sound Level Meters - Part 1: Specifications

ANSI/ASA S1.11-2014/Part 1/IEC 61260-1:2014 Electroacoustics - Octave-Band And Fractional-Octave-Band Filters - Part 1: Specifications

2.1.3 ISO Publications

Available from International Organization for Standardization, ISO Central Secretariat,1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, Tel: +41-22-749-01-11, www.iso.org.

ISO 3741:2010 Acoustics - Determination of Sound Power Levels and Sound Energy Levels of Noise Sources Using Sound Pressure - Precision Methods for Reverberation Test Rooms

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 Accredited Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ANSI/ASA S1.1 Acoustical Terminology

ANSI/ASA S1.13 Measurements of Sound Pressure Levels in Air

2.2.2 JASA Publications

Available from The Journal of the Acoustical Society of America (JASA), American Institute of Physics, Suite 1 NO1, 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.

2.2.3 Metrologia Publications

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.

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/ASA 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 10000 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 10000 Hz following the Type 1 requirements of ANSI/ASA S1.11/Part 1/IEC 61260-1.

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

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 30.4 m of either the vehicle path or the microphone (see Figure 1).

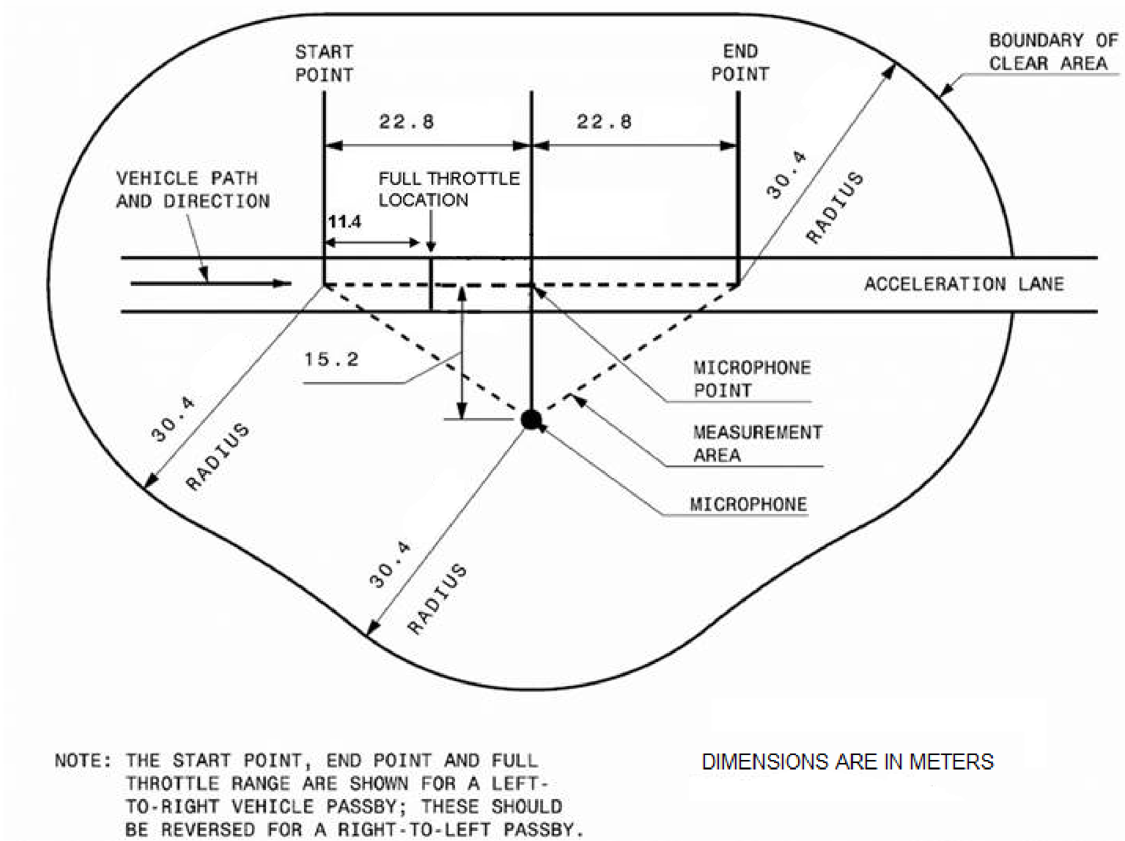

Figure 1 - Unidirectional test site layout

4.1 The microphone shall be located 15.2 m from the centerline of the snowmobile path and 1.2 m above the snow or turf. The normal to the vehicle path from the microphone shall establish the microphone point on the snowmobile path.

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

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

4.3.1 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 of loose snow over a base consisting of at least 75 mm 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.

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

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

4.3.1.2 The depth of packed snow shall be measured with a 6 mm diameter solid cylindrical probe. The probe into the packed base layer must reach a minimum depth of 75 mm with minimal force (<90 N).

4.3.2 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 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 7.

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

4.5 While making sound level measurements, not more than one person, other than the observer reading the meter, shall be within 15.2 m 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.

4.6 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. 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 ± 2.5 m 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 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 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 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.

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 hour. Also record test surface conditions.

5.3.1 As a substitute to direct test site measurement of atmospheric temperature, barometric pressure, humidity, wind speed, and wind direction, appropriate weather station data may be recorded under these conditions:

a. The weather station geographic location is no more than 56.4 km from the test site.

b. The weather station elevation is within 152.4 m of the test site.

6. DATA PROCESSING AND REPORTING

6.1 Environmental correction, as described in Section 7, shall be applied to each measurement run. For each side of the snowmobile, the three corrected readings shall be averaged then rounded to the nearest integer and subtracted by 2 dB(A) to account for measurement uncertainty, as explained in 8.6. The reported sound level shall be that for the side of the snowmobile with the highest value.

7. ENVIRONMENTAL CORRECTION

7.1 Snow Surface

The preferred test surface of snow requires no correction process.

7.2 Grass Surface

If required, the correction process described in this section shall be used.

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 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 2.1.4. The air density calculations are presented in Equation 3 from the reference of 2.1.4, respectively.

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

where:

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

$f=$ Frequency (Eq. 1)

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

$\rho=$ Air Density

$c=$ Speed of Sound

$r=$ Distance from Source to Receiver in meters

$$c=A_0+A_1T+A_2T^2+\left(A_3+A_4T+A_5T^2\right)X_w+\left(A_6+A_7T+A_8T^2\right)P+\left(A_9+A_{10}T+A_{11}T^2\right)X_c+A_{12}X_w^2+A_{13}P^2+A_{14}X_c^2+A_{15}X_wPX_c$$

where:

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

$P=$ Barometric Pressure $\left(\mathrm{Pa}\right)$

$X_c=0.000314=$ 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

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

Saturation Vapor Pressure of Water in Air

Table 1 - Values for speed of sound calculation constants

A_0	A_1	A_2	A_3
331.5024	0.603055	-0.000528	51.471935
A_4	A_5	A_6	A_7
0.1495874	-0.000782	-1.82e-7	3.73e-8
A_8	A_9	A_{10}	A_{11}
-2.93e-10	-85.20931	-0.228525	5.91e-5
A_{12}	A_{13}	A_{14}	A_{15}
-2.835149	-2.15e-13	29.179762	0.000486

$$Z = 1 - \left(\frac{P}{T+273.15}\right)\left(a_0 + a_1 T + a_2 T^2 + \left(b_0 + b_1 T\right)X_w + \left(c_0 + c_1 T\right)X_w^2\right) + \left(\frac{P^2}{T+273.15}\right)\left(d + gX_w^2\right) \quad \text{(Eq. 3)}$$

Table 2 - Values for air density calculation constants

a0	***a1***	***a2***
1.62419e-6	-2.8969e-8	1.0880e-10
b0	***b1***	***c0***
5.575e-6	-2.589e-8	1.9297e-4
c1	***d***	***g***
-2.285e-6	1.73e-11	-1.034e-8

Once the ideal sound pressure level has been determined for each 1/3 octave band from 100 to 1000 Hz, a set of corrections must be added to the ideal levels to obtain a reference response curve representative of the average sound propagation of snow covered ground in the winter. The correction factors to apply to obtain the reference curve are defined in Table 3.

Table 3 - Factors to define reference response curve

100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1000 Hz
0 dB	0 dB	-3.5 dB	-5 dB	-6.5 dB	-7 dB	-7 dB	-10 dB	-7.5 dB	-5 dB	-3 dB

The difference between the measured sound source level and the calculated reference level defines the correction factor to apply to the snowmobile pass-by data following Equation 4. Correction factors are applied to the 1/3 octave spectra from 100 to 1000 Hz where the maximum level was obtained during the pass-by event. The 1/3 octave spectrum and the maximum level are determined using an A-weighted exponential average with a 1 second time constant. After the correction factors have been applied to the snowmobile spectra, the overall level must be calculated by summing the 1/3 octave bands up to 10000 Hz. The calculated overall level with the correction factors applied is the value to be reported during grass surface testing following Equation 5.

$$\begin{aligned}
&\text{If: } SPL_{measured}(f) > SPL_{reference}(f) \\
&\text{Then: } SPL_{correction}(f) = SPL_{measured}(f) - SPL_{reference}(f) \\
&\text{If: } SPL_{measured}(f) < SPL_{reference}(f) \\
&\text{Then: } SPL_{correction}(f) = 0
\end{aligned} \quad \text{(Eq. 4)}$$

$$\begin{aligned}
&SPL_{corrected}(f) = SPL_{MaxLevel}(f) - SPL_{correction}(f) \\
&p_{Overall}^2 = p_{ref}^2 \sum 10^{\left(\frac{SPL_{corrected}(f)}{10}\right)} \\
&SPL_{Overall} = 10\log_{10}\left(\frac{p_{Overall}^2}{p_{ref}^2}\right) \\
&where: p_{ref} = 20e-6Pa
\end{aligned} \quad \text{(Eq. 5)}$$

8. GENERAL COMMENTS

8.1 It is recommended that persons technically trained and experienced in the current techniques of sound measurements select the equipment and conduct the tests.

8.2 The operation of recording and measuring equipment is likely to be affected by temperature near or below 0 °C; hence, special precautions must be taken to ensure the reliability of sound level meter readings and/or recordings.

8.3 Proper acoustical calibration procedure shall account for the influence of extension cables, etc. Field calibration shall be made immediately before and after each test sequence. Internal calibration means are acceptable for field use, provided that external calibration is accomplished immediately before and after field use.

8.4 Instrument manufacturer's specifications for the proper use of the test equipment shall be adhered to.

8.5 Measurements shall be made only when the wind speed is below 19 km/h and the absolute barometric pressure is between 93 kPa and 103 kPa (27.5 in Hg and 30.5 in Hg).

8.6 The method has been found to have a measurement uncertainty of ±2 dBA for well-maintained snow surfaces and ±2 dBA for grass surfaces with the inclusion of the correction factor. This uncertainty is from variations in test sites, temperature gradients, wind velocity gradients, test equipment, and inherent differences in nominally identical vehicles. This explains the 2 dB(A) subtraction that is integrated into the reported sound level of Section 6.

8.7 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.

8.8 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.

9. NOTES

9.1 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE SAE SNOWMOBILE TECHNICAL COMMITTEE
OF THE SAE SPECIALIZED VEHICLE AND EQUIPMENT COUNCIL