SAE International

SURFACE VEHICLE STANDARD

SAE J2889-1 SEP2011

Issued 2011-09

Measurement of Minimum Noise Emitted by Road Vehicles

RATIONALE

This Surface Vehicle Standard provides a method to measure the minimum noise emission of road vehicles and external sound generation systems intended for the purpose to provide acoustic information to pedestrians. This standard provides a performance-based and technology neutral test procedure. This standard reflects the development of engine and propulsion technologies which have noise emission characteristics that cannot be correctly tested under existing SAE Standards.

FOREWORD

This SAE Standard is derived from SAE J2805. This SAE Standard retains relevant descriptions and requirements for measurement facilities, equipment, ambient conditions and other factors from SAE J2805 .

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/J2889/1_201109

TABLE OF CONTENTS

1. SCOPE

This SAE Standard is derived from SAE J2805 and specifies an engineering method for measuring the minimum noise emitted by road vehicles. The specifications reproduce the level of noise which is generated by the principal vehicle noise sources consistent with minimal noise emission in urban traffic. The method is designed to meet the requirements of simplicity as far as they are consistent with reproducibility of results under the operating conditions of the vehicle.

The test method requires an acoustical environment which is only obtained in an extensive open space. Such conditions usually exist during:

- Measurements of vehicles for regulatory certification
- Measurements at the manufacturing stage
- Measurements at official testing stations

The results obtained by this method give an objective measure of the noise emitted under the specified conditions of test. It is necessary to consider the fact that the subjective appraisal of the annoyance, perceptibility, and/or detectability of different motor vehicles or classes of motor vehicles due to their noise emission are not simply related to the indications of a sound measurement system. As annoyance, perceptibility, and/or detectability are strongly related to personal human perception, physiological human condition, culture, and environmental conditions, there are large variations and therefore these terms are not useful as parameters to describe a specific vehicle condition.

Spot checks of vehicles chosen at random rarely occur in an ideal acoustical environment. If measurements are carried out on the road in an acoustical environment which does not fulfill the requirements stated in this SAE Standard, the results obtained may deviate appreciably from the results obtained using the specified conditions.

In addition, this standard provides an engineering method to assess the performance of external sound generation systems intended for the purpose of providing acoustic information to pedestrians on a vehicle's operating condition. This information is reported as objective criteria related to the external sound generation system's sound pressure level, frequency content, and changes in sound pressure level and frequency content as a function of vehicle speed. As such, these measures can provide pedestrians with information on the location, speed, acceleration, and deceleration behavior of a vehicle.

2. REFERENCES

2.1 SAE Publications

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 J366 Exterior Sound Level for Heavy Trucks and Buses

SAE J986 Sound Level for Passenger Cars and Light Trucks

SAE J1349 Engine Power Test Code – Spark Ignition and Compression Ignition – Net Power Rating

SAE J1470 Measurement of Noise Emitted by Accelerating Highway Vehicles

SAE J1715 Hybrid Electric Vehicle (HEV) & Electric Vehicle (EV) Terminology

SAE J2805 Measurement of Noise Emitted by Accelerating Road Vehicles

2.2 ISO Publications

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

ISO 362-1:2007 Measurement of noise emitted by accelerating road vehicles - Engineering method - Part1: M and N Categories

ISO 10844:2011 Acoustics - Test surface for road vehicle noise measurements

ISO 3745:2003 Acoustics - Determination of sound power levels of noise sources using sound pressure - Precision methods for anechoic and hemi-anechoic rooms.: Annex A

ISO 26101 Acoustics – Test methods for qualification of free-field environments

2.3 IEC Publications

Available from International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, CH-1211 Genvea 20, Switzerland, Tel: +41-22-919-02-11, www.iec.ch.

IEC 60942:2003 Electroacoustics - Sound calibrators

IEC 61672-1:2002 Electroacoustics - Sound level meters - Part 1: Specifications

2.4 ANSI/ASA Publications

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

ANSI/ASA S 1.11-2004 (R2009) American National Standard Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters

3. DEFINITIONS

3.1 VEHICLE CATEGORIES

3.1.1 Category M

Power driven vehicles having at least four wheels and used for the carriage of passengers

3.1.1.1 Category M1

Vehicles used for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat.

3.1.1.2 Category M2

Vehicles used for the carriage of passengers and comprising more than eight seats in addition to the driver's seat and having a maximum mass not exceeding 5000 kg.

NOTE: In this definition, "maximum mass" is equivalent to "maximum authorized mass" used elsewhere in this Standard.

3.1.1.3 Category M3

Vehicles used for the carriage of passengers and comprising more than eight seats in addition to the driver's seat and having a maximum mass exceeding 5000 kg.

NOTE: In this definition, "maximum mass" is equivalent to "maximum authorized mass" used elsewhere in this International Standard.

3.1.2 Category N

Power driven vehicles having at least four wheels and used for the carriage of goods.

3.1.2.1 Category N1

Vehicles used for the carriage of goods and having a maximum authorized mass not exceeding 3500 kg.

3.1.2.2 Category N2

Vehicles used for the carriage of goods and having a maximum authorized mass exceeding 3500 kg but not exceeding 12000 kg.

3.1.2.3 Category N3

Vehicles used for the carriage of goods and having a maximum authorized mass exceeding 12000 kg.

3.2 Reference Point

Point depending on the design and category of the vehicle.

3.2.1 Reference Point for Category M1 and N1 vehicles

- For front engine vehicles, it is the front end of the vehicle
- For mid engine vehicles, it is the center of the vehicle
- For rear engine vehicles, it is the rear end of the vehicle

3.2.2 Reference Point for Category M2, M3, N2 and N3 Vehicles

- For front engine vehicles, it is the front end of the vehicle
- For all other vehicles, it is the border of the engine closest to the front of the vehicle

3.3 Engine

Internal Combustion power source without detachable accessories

3.4 External Sound Generation System

Audio system which provides an additional audio signal to the external environment of the vehicle.

4. SYMBOLS AND ABBREVIATED TERMS

TABLE 1 - LISTS SYMBOLS AND THE PARAGRAPH THEY ARE FIRST USED.

Symbol	Unit	Clause	Explanation
AA'	-	7.3.1	Line perpendicular to vehicle travel which indicates beginning of zone to record sound pressure level during test
BB'	-	7.3.1	Line perpendicular to vehicle travel which indicates end of zone to record sound pressure level during test
CC'	-	7.1	Centerline of vehicle travel
j	-	7.4.1	Index for single test run within stopped or slow speed cruise test conditions
L_{stop}	dBA	7.4.3	Stopped vehicle A-weighted sound pressure level
L_{crs}	dBA	7.4.4	Cruise vehicle A-weighted sound pressure level
L_{corr}	dB	6.5	Background noise correction
$L_{test,j}$	dBA	6.5	A-weighted sound pressure level result of jth test run
$L_{testcorr,j}$	dBA	6.5	A-weighted sound pressure level result of jth test run corrected for background noise
L_{bgn}	dBA	6.3	Background A-weighted sound pressure level.
$L_{bgn,p-p}$	dBA	6.3	Peak-to-peak value of the representative background noise A-weighted sound pressure level
ΔL	dB	6.3	A-weighted sound pressure level of jth test result minus the A-weighted background noise level ($\Delta L = L_{test,j} - L_{bgn}$)
PP'	-	7.1	Line perpendicular to vehicle travel which indicates location of microphones
$v_{AA'}$	km/h	5.2	Vehicle velocity when reference point passes line AA'. See clause 3.2 for definition of reference point.
$v_{BB'}$	km/h	5.2	Vehicle velocity when reference point or rear of vehicle passes line BB' . See clause 3.2 for definition of reference point.
$v_{PP'}$	km/h	5.2	Vehicle velocity when reference point passes line PP'. See clause 3.2 for definition of reference point.
v_{test}	km/h	7.3.2	Target vehicle test velocity

5. INSTRUMENTATION

5.1 Instruments for Acoustical Measurement

5.1.1 General

The apparatus used for measuring the sound pressure level shall be a sound level meter or equivalent measurement system meeting the requirements of Class 1 instruments (inclusive of the recommended windscreen, if used). These requirements are described in IEC 61672-1.

The entire measurement system shall be checked by means of a sound calibrator that fulfils the requirements of Class 1 sound calibrators according to IEC 60942.

Measurements shall be carried out using the time weighting "F" of the acoustic measurement instrument and the "A" frequency weighting curve also described in IEC 61672-1. When using a system that includes a periodic monitoring of the A-weighted sound pressure level, a reading should be made at a time interval not greater than 30 ms.

The instruments shall be maintained and calibrated in accordance to the instructions of the instrument manufacturer.

5.1.2 Calibration

At the beginning and at the end of every measurement session, the entire acoustic measurement system shall be checked by means of a sound calibrator as described in 5.1.1. Without any further adjustment, the difference between the readings shall be less than or equal to 0.5 dB. If this value is exceeded, the results of the measurements obtained after the previous satisfactory check shall be discarded.

5.1.3 Compliance with Requirements

Compliance of the sound calibrator with the requirements of IEC 60942 shall be verified once a year. Compliance of the instrumentation system with the requirements of IEC 61672-1 shall be verified at least every 2 years. All compliance testing shall be conducted by a laboratory which is authorized to perform calibrations traceable to the appropriate standards.

5.2 Instrumentation for Speed Measurements

The rotational speed of the engine shall be measured with an instrument meeting specification limits of at least ± 2% or better at the engine speeds required for the measurements being performed.

The road speed of the vehicle shall be measured with instruments meeting specification limits of at least ± 1.0 km/h when using continuous measuring devices.

If testing uses independent measurements of speed, this instrumentation shall meet specification limits of at least ± 0.2 km/h.

NOTE: Independent measurements of speed are when two or more separate devices will determine the $v_{AA'}$ $v_{BB'}$ and $v_{PP'}$ values. A continuous measuring device will determine all required speed information with one device

5.3 Meteorological Instrumentation

The meteorological instrumentation used to monitor the environmental conditions during the test shall meet the specifications of:

+/-1 °C or less for a temperature measuring device;

+/-1.0 m/s for a wind speed-measuring device;

± 5 hPa for a barometric pressure measuring device;

± 5 % for a relative humidity measuring device.

6. ACOUSTICAL ENVIRONMENT, METEOROLOGICAL CONDITIONS, AND BACKGROUND NOISE

6.1 Test Site

6.1.1 Outdoor Testing

The test site shall be substantially level. The test track construction and surface shall meet the requirements of ISO 10844.

Within a radius of 50 m around the center of the track, the space shall be free of large reflecting objects such as fences, rocks, bridges or buildings. The test track and the surface of the site shall be dry and free from absorbing materials such as powdery snow, or loose debris.

In the vicinity of the microphone, there shall be no obstacle that could influence the acoustical field and no person shall remain between the microphone and the noise source. The meter observer shall be positioned so as not to influence the meter reading.

NOTE: Buildings outside the 50 m radius might have significant influence if their reflection focuses on the test track.

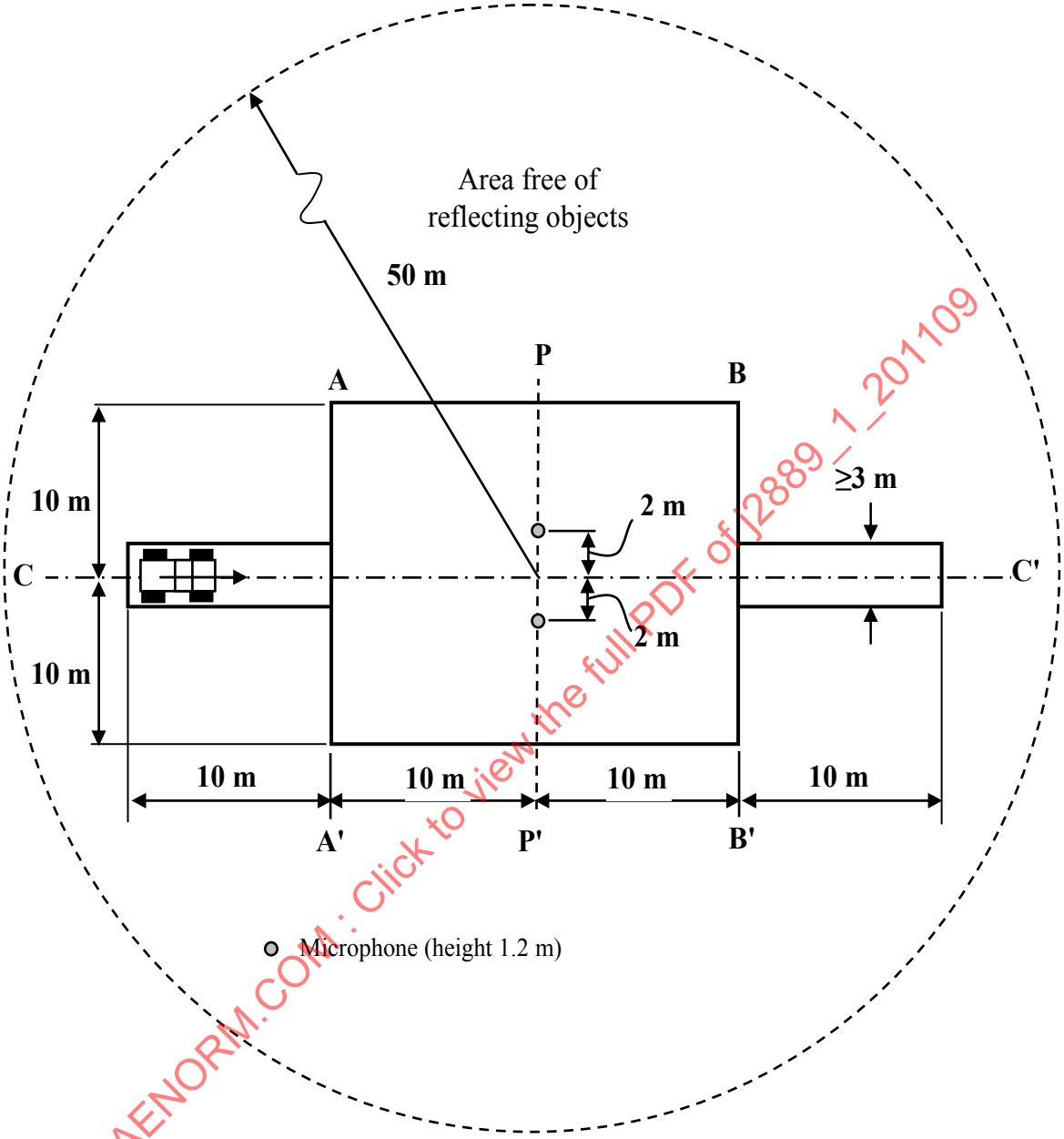

FIGURE 1 – TEST SITE DIMENSIONS – SHADED AREA IS THE MINIMUM AREA TO BE COVERED WITH A SURFACE COMPLYING WITH ISO 10844

6.1.2 Indoor Hemi-Anechoic Testing

The test facility shall have a cutoff frequency of 100 Hz or lower.

The test facility shall meet requirements of ISO 3745, Annex A, or ISO 26101, when published.

6.2 Meteorological Conditions

The meteorological instrumentation shall deliver data representative for the test site and shall be positioned adjacent to the test area at a height representative of the height of the measuring microphone.

The measurements shall be made when the ambient air temperature is within the range from 5 °C to 40 °C.

The ambient temperature may of necessity be restricted to a narrower temperature range such that all key vehicle functionalities that can reduce vehicle noise emissions (e.g. start/stop, hybrid propulsion, battery propulsion, fuel-cell stack operation) are enabled per manufacturer's specifications.

The tests shall not be carried out if the wind speed, including gusts, at microphone height exceeds 5 m/s, during the sound measurement interval.

A value representative of temperature, wind speed and direction, relative humidity, and barometric pressure shall be recorded during the sound measurement interval.

6.3 Background Noise

6.4 Measurement Criteria

The background, or ambient noise, shall be measured for duration of at least 10 seconds before and after a series of vehicle tests. A 10 second sample taken from this measurement shall be used to calculate the reported background noise, taking account to insure the 10 second sample selected is representative of the background noise in absence of any transient disturbance. The measurements shall be made with the same microphones and microphone locations used during the test.

The minimum A-weighted sound pressure level in the selected 10 second sample shall be reported as the background noise, L_{bgn} and the 1/3 octave frequency per ANSI S1.11, at this level of background noise, shall be reported.

NOTE: Standard sound level meters typically have peak hold functions designed to provide maximum sound pressure levels over a time period. Care should be taken to insure that the data measurement and analysis system is capable of reporting of minimum sound pressure level over a time period.

6.5 Vehicle Measurement Correction Criteria

Depending on the level and peak to peak fluctuation of the background noise, the measured *j*th test result within a test condition, $L_{test,j}$, shall be corrected according to the table below to obtain the noise-corrected level $L_{testcorr,j}$. Except where noted, $L_{testcorr,j} = L_{test,j} - L_{corr}$.

Correction for Background Noise			
Background Noise Level L_{bgn}	Peak-to-Peak Background Noise Level $L_{bgn, p-p}$	Sound Pressure Level of *j*th test result minus Background Noise Level $\Delta L = L_{test,j} - L_{bgn}$	Correction L_{corr}
> 25 dBA	See Note 1 below	> 10 dB	0 dB
	< 2 dB	8-10 dB	0.5 dB
		6-8 dB	1.0 dB
		4.5-6 dB	1.5 dB
		3-4.5 dB	2.5 dB
		< 3 dB	Do not correct, report out: $L_{testcorr, j} \leq L_{bgn}$
< 25 dBA	See Note 1 below	< 10 dB	Do not correct, report out: $L_{testcorr, j} < L_{test,j}$
		> 10 dB	0 dB

NOTE 1: The trained technician should ensure that there is not excessive fluctuation in noise level that could potentially result in an inappropriate noise correction.

NOTE 2: These criteria are established to insure accurate vehicle measurements while recognizing the practical issue that A-weighted sound pressure levels lower than 25 dB are not necessary to measure accurately for the purposes of this standard. The use of indoor test facilities may be necessary to achieve the specifications in this standard.

7. TEST PROCEDURES

7.1 Microphone Positions

The distance from the microphone positions on the microphone line PP' to the perpendicular reference line CC' (see ISO 10844) on the test track shall be 2.0 m ± 0.05 m.

The microphone shall be located 1.2 m ± 0.02 m above the ground level. The reference direction for free field conditions (see IEC 61672-1) shall be horizontal and directed perpendicularly towards the path of the vehicle line CC'.

7.2 Conditions of the Vehicle

7.2.1 General Conditions

The vehicle shall be supplied as specified by the vehicle manufacturer.

Before the measurements are started, the vehicle shall be brought to its normal operating conditions.

Any sound peak which appears to be unrelated to the characteristics of the general sound level of the vehicle shall be ignored in taking the readings. The selected sound sample shall be representative of the vehicle minimum noise emission in the condition of test in absence of any transient disturbance.

7.2.1.1 Battery State of Charge

If so equipped, propulsion batteries shall have a state-of-charge sufficiently high to enable all key functionalities per the manufacturer's specifications. Propulsion batteries shall be within their component-temperature window to enable all key functionalities that could reduce vehicle noise emissions. Any other type of rechargeable energy storage system shall be ready to operate during the test.

7.2.1.2 Accessory Loads

If the vehicle is equipped with an internal combustion engine and a second source of propulsive power, all vehicle loads that would or could automatically force an engine re-start or prevent engine shut down shall be switched off.

All audio, entertainment, communication, and navigation systems shall be switched off.

NOTE: Example loads could include air conditioning, defroster operation, window de-icing, seat heaters or coolers, etc.

7.2.1.3 Multi-Mode Operation

If the vehicle is equipped with multiple driver selectable operating modes, the mode which provides the lowest noise emission during the proscribed test conditions of 7.3 shall be selected.

When the vehicle provides multiple operating modes that are automatically selected by the vehicle, it is the responsibility of the manufacturer to determine the correct manner of testing to achieve the minimum noise emission.

In cases where it is not possible to determine the vehicle operating mode providing the lowest noise emission, all modes shall be tested and the lowest mode shall be used to report the vehicle noise emission per this SAE standard.

NOTE: Modes include, but are not limited to: Engine operation state, driver selectable operating modes, vehicle selectable operating modes, and transmission selection mode.

7.2.1.4 Warning Signals

If a vehicle is being tested to assess the sound emission performance of an external sound generation system, this system shall be noted in the report.

No audio warning signals of any kind internal to the vehicle shall operate during the tests.

7.2.2 Test Mass of the Vehicle

Measurements shall be made on vehicles at curb mass as defined by the manufacturer.

7.2.3 Tire Selection and Condition

The tires shall be appropriate for the vehicle and inflated to the pressure recommended by the tire manufacturer for the test mass of the vehicle.

The tires for test are selected by the vehicle manufacturer, and shall correspond to one of the tire sizes and types designated for the vehicle by the vehicle manufacturer. The minimum tread depth shall be at least 80% of the full tread depth.

NOTE: The tread depth can have an influence on the test result.

7.3 Operating Conditions

7.3.1 General Conditions

The path of the centerline of the vehicle shall follow line CC' as closely as possible throughout the entire test, from the approach to line AA' until the rear of the vehicle passes line BB' . Any trailer, which is not readily separable from the towing vehicle, shall be ignored when considering the crossing of the line BB'.

7.3.2 Test Speeds

The vehicle shall reach the test speed, v_{test} , when the reference point according to 3.2 is at line PP'. During the constant speed test the acceleration control unit shall be positioned to maintain a constant speed between AA' and BB'. The vehicle shall be operated as defined by the manufacturer for normal operation.

NOTE: Normal operation may include shutoff of one or more propulsion sources.

7.3.2.1 Stopped Condition

The test speed v_{test} shall be 0 km/h with the reference point on the PP' line.

The vehicle sound pressure level shall be measured for duration of 10 seconds.

If the vehicle is equipped with an internal combustion engine and a second source of propulsive power, the stopped condition test measurement shall be made after a time delay from the vehicle stopped condition to allow engine shutdown, and before vehicle loads can force an engine re-start.

7.3.2.1.1 Manual Transmission Vehicle

The vehicle shall be tested in the appropriate stopped mode as defined in 7.2.1.3

7.3.2.1.2 Automatic Transmission Vehicle

The vehicle shall be tested in the appropriate stopped mode as defined in 7.2.1.3

7.3.2.2 Slow Speed Cruise

The test speed v_{test} shall be 10 km/h ±1km/h between AA' and PP'. In the case of front engine vehicles, the test speed v_{test} may be 10 km/h ±1 km/h between AA' and BB'.

NOTE: For the purpose of assessing the performance of an external sound generation system, the sound pressure level of the vehicle may be measured with the vehicle at 0 km/hr and the engine rotational speed and external sound generation system controlled as to simulate operation at 10 km/hr. Engine may be switched off or with its rotational speed controlled as to simulate operation at 10 km/h. In both cases, the true test level at 10 km/hr will be equal or higher to the simulated test level.