	SURFACE VEHICLE STANDARD	SAE	J2805 OCT2008
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Measurement of Noise Emitted by Accelerating Road Vehicles

RATIONALE

This Surface Vehicle Standard was developed to provide a method to measure the noise emission of road vehicles consistent with actual in-use urban vehicle noise emission. This document was further developed to provide a performance based and technology neutral test standard to reflect the development of engine and propulsion technologies that cannot be correctly tested under existing SAE Standards.

FOREWORD

This SAE Standard is based on ISO 362-1:2007 with additional clarifications based on review of ISO 362-1:2007 by the SAE Light Vehicle Exterior Noise Committee and editorial changes to bring the document into alignment with SAE editorial standards. Evaluation of ISO 362-1:2007 was conducted by the SAE Light Vehicle Exterior Noise Committee through a SAE Cooperative Research Project in 2004. The results of this project were considered prior to the preparation of this document.

TABLE OF CONTENTS

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1.   SCOPE

This SAE Standard is equivalent to ISO 362-1:2007 and specifies an engineering method for measuring the noise emitted by road vehicles under typical urban traffic conditions. The specifications are intended to reproduce the level of noise which is generated by the principal noise sources during normal driving 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 are usually provided for 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 noise annoyance of different classes of motor vehicles is not simply related to the indications of a sound measurement system. As annoyance is strongly related to personal human perception, physiological human condition, culture, environmental condition there is a large variation and therefore not useful as a parameter to describe a specific vehicle condition.

Spot checks of vehicles chosen at random are rarely made 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 document, the results obtained may deviate appreciably from the results obtained using the specified conditions.

2. REFERENCES

2.1   Applicable Publications

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version 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 J1349   Engine Power Test Code—Spark Ignition and Compression Ignition—Net Power Rating

2.1.2   ISO Publications

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

ISO 362-1:2007   Measurement of noise emitted by accelerating road vehicles—Engineering method—Part 1: M and N categories

ISO 10844:1994   Acoustics—Test surface for road vehicle noise measurements

2.1.3   IEC Publications

Available from International Electrotechnical Commission, 3, rue de Verambe, P.O. Box 131, 1211 Geneva 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

2.2   Related Publications

The following publications are provided for information purposes and are not a required part of this document.

2.2.1   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 J1470   Measurement of Noise Emitted by Accelerating Highway Vehicles

3. DEFINITIONS

3.1   Vehicle Mass Definitions

Mass definitions in this document refer to ISO 1176 and ISO 2416.

3.1.1   Curb Mass

Complete shipping mass of a vehicle fitted with all equipment necessary for normal operation plus the mass of the following elements for M1, N1, and M2 having a maximum authorized mass not exceeding 3500 kg:

- lubricants, coolant (if needed), washer fluid,

- fuel (tank filled to at least 90% of the capacity specified by the manufacturer),

- other equipment if included as basic parts for the vehicle such as: Spare wheel(s), wheel chocks, fire extinguisher(s), spare parts, and tool kit.

3.1.2   Maximum Authorized Mass

Curb mass plus the maximum authorized payload.

3.1.3   Target Mass

Mass for N2 and N3 vehicles as defined by Table 3.

3.1.4   Test Mass

Actual mass of N2 and N3 vehicles used during test as defined by Table 3. Test mass may be lower than target mass due to axle loading limitations.

3.1.5   Unladen Vehicle Mass

Mass without payload of a complete N2, N3, M2 having a maximum authorized mass greater than 3500 kg, or M3 vehicle as determined by the following conditions:

a.   mass of the vehicle with bodywork and all factory fitted equipment, electrical and auxiliary equipment for normal operation of vehicle, including liquids, tools, fire extinguisher, standard spare parts, chocks and spare wheel, if fitted

b.   the fuel tank is filled to at least 90 percent of rated capacity and the other liquid containing systems (except those for used water) are filled to 100 percent of the capacity specified by the manufacturer

3.1.6   Driver Mass

Nominal mass of driver as defined in ISO 2416.

3.1.7   Mass in Running Order

Unladen vehicle mass plus driver mass. In the case of M2 and M3 vehicles which include seating positions for additional crewmembers, an additional driver mass is added for each crew seating position.

3.1.8   Maximum Axle (group of axles) Capacity

Permissible mass corresponding to the maximum mass to be carried by the axle (group of axles) as defined by the vehicle manufacturer, not exceeding the axle manufacturer's specifications.

3.1.9   Unladen Axle (group of axles) Load

Actual mass carried by the axle (group of axles) in unladen condition.

NOTE: The unladen vehicle mass is equal to the sum of the unladen axles (group of axles) load.

3.1.10   Extra Loading

Mass which is to be added to the unladen vehicle mass.

3.1.11   Laden Axle (group of axles) Load

Actual mass carried by the axle (group of axles) in laden condition.

3.2   Power to Mass Ratio Index, PMR

Dimensionless quantity used for the calculation of acceleration according to the equation:

$$PMR = \frac{P_n}{m_t} \times 1000$$ (Eq. 1)

where

  PMR is a dimensionless quantity
  P_n is the numerical value of engine power expressed in kilowatts
  m_t is the numerical value of the test mass expressed in kilograms

3.3   Rated Engine Speed, *S*

Engine speed at which an internal combustion engine develops its rated maximum net power as stated by the manufacturer.

NOTE: SAE J1349 provides a test method to establish rated engine speed.

3.4   Vehicle Categories

3.4.1   Category M

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

3.4.1.1   Category M1

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

3.4.1.2   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 document.

3.4.1.3   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 document.

3.4.2   Category N

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

3.4.2.1   Category N1

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

3.4.2.2   Category N2

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

3.4.2.3   Category N3

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

3.5   Reference Point

Point depending on the design and category of the vehicle.

3.5.1   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 centre of the vehicle

- for rear engine vehicles, it is the rear end of the vehicle

3.5.2   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

3.6   Target Acceleration

Acceleration at a partial throttle condition in urban traffic and is derived from statistical investigations.

3.7   Reference Acceleration

Required acceleration during the acceleration test on the test track.

3.8   Gear Ratio Weighting Factor, k

Dimensionless quantity used to combine the test results of two gear ratios for the acceleration test and the constant speed test.

3.9   Partial Power Factor, k_p

Dimensionless quantity used for the weighted combination of the test results of the acceleration test and the constant speed test for vehicles of category M1, N1 and M2 having a maximum authorized mass not exceeding 3500 kg.

3.10 Pre-Acceleration

Application of acceleration control device prior to AA' for the purpose of achieving stable acceleration between AA' and BB'.

3.11 Locked Gear Ratios

Control of transmission such that the transmission gear cannot change during a test.

3.12 Engine

Power source without detachable accessories.

3.13 Test Track Length, l_{10}

Length of test track used in calculation of acceleration from points PP' to BB'.

3.14 Test Track Length, l_{20}

Length of test track used in calculation of acceleration from points AA' to BB'.

4.   SYMBOLS AND ABBREVIATED TERMS

Table 1 lists symbols and the paragraph they are first used.

TABLE 1 - SYMBOLS AND ABBREVIATIONS

Symbol	Unit	Clause	Explanation
AA'	-	3.10	Line perpendicular to vehicle travel which indicates beginning of zone to record sound pressure level during test
$a_{wot\,i}$	m/s²	5.1	Acceleration at wide open throttle in gear i
$a_{wot\,i+1}$	m/s²	5.1	Acceleration at wide open throttle in gear $i+1$
$a_{wot\,test}$	m/s²	5.1	Acceleration at wide open throttle in single gear test cases
$a_{wot\,ref}$	m/s²	5.4	Reference acceleration for the wide open throttle test
a_{urban}	m/s²	5.3	Target acceleration respective urban traffic acceleration
BB'	-	3.10	Line perpendicular to vehicle travel which indicates end of zone to record sound pressure level during test
CC'	-	8.1	Line of vehicle travel through test surface defined in ISO 10844
gear i	-	8.3.1.3.2	The first of two gear ratio for use in the vehicle test
gear $i+1$	-	8.3.1.3.2	The second of two gear ratio with an engine speed lower than gear ratio i
j	-		Index for single test run within overall acceleration or constant speed test series i or $i+1$
k_P	-	3.9	Partial power factor
k	-	3.8	Gear ratio weighting factor
l_{ref}	m	5.1	Reference length
l_{veh}	m	5.1	Length of vehicle
l_{10}	m	3.13	Length of test section for calculation of acceleration from PP' to BB'.
l_{20}	m	3.14	Length of test section for calculation of acceleration from AA' to BB'.

TABLE 1 - SYMBOLS AND ABBREVIATIONS (CONTINUED)

Symbol	Unit	Clause	Explanation
$L_{crs(i)}$	dB	8.4.3.2	Vehicle sound pressure level at constant speed test for i gear
$L_{crs(i+1)}$	dB	8.4.3.2	Vehicle sound pressure level at constant speed test for $i+1$ gear
$L_{crs\ rep}$	dB	8.4.3.2	Reported vehicle sound pressure level at constant speed test
$L_{wot(i)}$	dB	8.4.3.2	Vehicle sound pressure level at wide open throttle test for i gear
$L_{wot(i+1)}$	dB	8.4.3.2	Vehicle sound pressure level at wide open throttle test for $i+1$ gear
$L_{wot\ rep}$	dB	8.4.3.2	Reported vehicle sound pressure level at wide open throttle
L_{urban}	dB	8.4.3.2	Reported vehicle sound pressure level representing urban operation
$m_{fa\ load\ unladen}$	kg	8.2.2.1	Unladen front axle load
$m_{ac\ ra\ max}$	kg	8.2.2.1	Maximum rear axle capacity
$m_{ra\ load\ unladen}$	kg	8.2.2.1	Unladen rear axle load
m_d	kg	8.2.2.1	Mass of driver
m_{GVW}	kg	8.2.2.1	Gross vehicle mass (weight)
m_{curb}	kg	8.2.2.1	Curb mass of the vehicle
$m_{fa\ load\ laden}$	kg	8.2.2.1	Laden front axle load
$m_{ra\ load\ laden}$	kg	8.2.2.1	Laden rear axle load
m_{ref}	kg	8.2.2.1	Curb mass + 75 kg for the driver (75 kg ± 5 kg in case of category L)
m_{ro}	kg	8.2.2.1	Mass in running order
m_t	kg	3.2	Test mass of the vehicle
m_{target}	kg	8.2.2.1	Target mass of the vehicle
$m_{unladen}$	kg	8.2.2.1	Unladen vehicle mass
m_{xload}	kg	8.2.2.1	Extra loading
$n_{PP'}$	1/min	9	Engine rotational speed of the vehicle, when the reference point passes PP'
$n_{BB'}$	1/min	8.3.2.2.1	Engine rotational speed of the vehicle, when the reference point passes BB'
PMR	-	3.2	Power-to-mass ratio index to be used for calculations
P_n	kW	3.2	Rated engine power (ISO 1585:1992; ISO 4106, SAE 1349)
PP'	-	3.13	Line perpendicular to vehicle travel which indicates location of microphones
S	1/min	3.3	Rated engine rotational speed in rpm, synonymous with the engine rotational speed at maximum power
$v_{AA'}$	km/h	5.2.1	Vehicle velocity when reference point passes line AA'. See clause 5.1 for definition of reference point.
$v_{BB'}$	km/h	5.2.1	Vehicle velocity when reference point or rear of vehicle passes line BB' . See clause 5.1 for definition of reference point.
$v_{PP'}$	km/h	5.2.2	Vehicle velocity when reference point passes line PP'. See clause 5.1 for definition of reference point.
v_{test}	km/h	8.3.1.2	Target vehicle test velocity

5. SPECIFICATION OF THE ACCELERATION FOR VEHICLES OF CATEGORIES M1, M2 HAVING A MAXIMUM AUTHORIZED MASS NOT EXCEEDING 3500 kg, AND N1

5.1   General

All accelerations are calculated using different speeds of the vehicle on the test track. The formulas given in 5.2 are used for the calculation of $a_{\text{wot } i}$, $a_{\text{wot } i+1}$ and $a_{\text{wot test}}$. The speed either at AA' ($v_{AA'}$) or PP' (v_{PP}) is defined by the vehicle speed when the reference point passes AA' or PP'. The speed at BB' (v_{BB}) is defined when the rear of the vehicle passes BB'. The method used for determination of the acceleration shall be indicated in the test report.

Due to the definition of the reference point for the vehicle the length of the vehicle is considered different in the formula below. If the reference point is the front of the vehicle, $l_{\text{ref}} = l_{veh}$ is the length of vehicle; if the reference point is the mid of the vehicle, $l_{\text{ref}} = \frac{1}{2} l_{veh}$ (i.e. 0.5 times the length of vehicle); if the reference point is the rear of the vehicle, $l_{\text{ref}}=0$.

The dimensions of the test track are used in the calculation of acceleration. These dimensions are defined as follows: l_{20} = 20 m, l_{10} = 10 m.

Due to the large variety of technologies it is necessary to consider different modes of calculation. New technologies (such as continuously variable transmission) and older technologies (such as automatic transmission) which have no electronic control, require a more specific treatment for a proper determination of the acceleration. The given possibilities for calculation of the acceleration shall cover these needs.

5.2   Calculation of Acceleration

5.2.1   Calculation procedure for vehicles with manual transmission, automatic transmission, adaptive transmission, and continuously variable transmission (CVT) tested with locked gear ratios.

The value of $a_{\text{wot test}}$ used in the determination of gear selection shall be the average of the four $a_{\text{wot test, } j}$ values during each valid measurement run.

Calculate $a_{\text{wot test, } j}$ using the equation:

$$a_{\text{wot test, } j} = [(v_{BB'}/3.6)^2 - (v_{AA'}/3.6)^2] / [2(l_{20}+l_{\text{ref}})]$$ (Eq. 2)

where

    $a_{\text{wot test, } j}$ is the numerical value of acceleration expressed in meters per second squared
    $v_{BB'}$, $v_{AA'}$ are numerical values of velocity expressed in kilometers per hour
    l_{20}, l_{ref} are numerical values of length expressed in meters

Pre-acceleration may be used.

5.2.2   Calculation procedure for vehicles with automatic transmission, adaptive transmission, and CVT tested with non-locked gear ratios.

The value of $a_{\text{wot test}}$ used in the determination of gear selection shall be the average of the four $a_{\text{wot test, } j}$ values during each valid measurement run.

If devices or measures described in 8.3.1.3.3 can be used to control transmission operation for the purpose of achieving test requirements, calculate $a_{\text{wot test, } j}$ using Equation 2.

Pre-acceleration may be used.

If no devices or measures described in 8.3.1.3.3 are used, calculate $a_{\text{wot test},\,j}$ using the equation:

$$a_{\text{wot test},\,j} = [(v_{\text{BB}'}/3.6)^2 - (v_{\text{PP}'}/3.6)^2] / [2(l_{10}+l_{\text{ref}}))$$ (Eq. 3)

where

   $a_{\text{wot test},\,j}$ is the numerical value of acceleration expressed in meters per second squared
   $v_{\text{PP}'}$, $v_{\text{AA}'}$ are numerical values of velocity expressed in kilometers per hour
   l_{20} , l_{ref} are numerical values of length expressed in meters

Pre-acceleration shall not be used.

NOTE: It would be useful for these type of vehicles to record the vehicle speeds at AA', PP', and BB' to provide information for future revision of this document.

5.3   Calculation of the Target Acceleration

Calculate a_{urban} using the equation:

$$a_{\text{urban}} = 0.63 \lg(PMR) - 0.09$$ (Eq. 4)

where

   a_{urban} is the numerical value of acceleration expressed in meters per second squared
   PMR is the dimensionless value of power to mass index

5.4   Calculation of the Reference Acceleration

Calculate $a_{\text{wot ref}}$ using the equations:

$$a_{\text{wot ref}} = 1.59 \lg(PMR) - 1.41 \quad \text{for PMR} \geq 25$$ (Eq. 5)

where

   $a_{\text{wot ref}}$ is the numerical value of acceleration expressed in meters per second squared
   PMR is the dimensionless value of power to mass index

or

$$a_{\text{wot ref}} = a_{\text{urban}} = 0.63 \lg(PMR) - 0.09 \quad \text{for PMR} < 25$$ (Eq. 6)

where

   $a_{\text{wot ref}}$ is the numerical value of acceleration expressed in meters per second squared
   a_{urban} is the numerical value of acceleration expressed in meters per second squared
   PMR is the dimensionless value of power to mass index

5.5   Partial Power Factor

Partial power factor, k_{p} , is:

$$k_{\text{p}} = 1 - (a_{\text{urban}} / a_{\text{wot test}})$$ (Eq. 7)

In cases other than a single gear test, $a_{\text{wot ref}}$ shall be used instead of $a_{\text{wot test}}$ as defined in 8.4.3.2.

6.   INSTRUMENTATION

6.1   Instruments for Acoustical Measurement

6.1.1   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.

6.1.2   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 6.1.1. 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.

6.1.3   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 61672-1shall 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.

6.2   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 ± 0.5 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.

6.3   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.

7.   ACOUSTICAL ENVIRONMENT, METEOROLOGICAL CONDITIONS, AND BACKGROUND NOISE

7.1   Test Site

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.

7.2   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 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.

7.3   Background Noise

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 background noise shall be measured for duration of 10 seconds immediately before and after a series of vehicle tests. The measurements shall be made with the same microphones and microphone locations used during the test. The maximum A-weighted sound pressure level shall be reported.

The background noise (including any wind noise) shall be at least 10 dB below the A-weighted sound pressure level produced by the vehicle under test. If the difference between the ambient sound pressure level and the measured sound pressure level is between 10 and 15 dB, in order to calculate the jth test result the appropriate correction shall be subtracted from the readings on the sound level meter, as given in Table 2.

TABLE 2 - CORRECTION APPLIED TO INDIVIDUAL MEASURED TEST VALUE

Background sound pressure level difference to measured sound pressure level in dB	Greater or equal to 10 but less than 11	Greater or equal to 11 but less than 12	Greater or equal to 12 but less than 13	Greater or equal to 13 but less than 14	Greater or equal to 14 but less than 15	Greater or equal to 15
Correction in dB	0.5	0.4	0.3	0.2	0.1	0,0

8.   TEST PROCEDURES

8.1   Microphone Positions

The distance from the microphone positions on the microphone line PP' to the perpendicular reference line CC' (see Figure A1) on the test track shall be 7.5 m $\pm$ 0.05 m.

The microphone shall be located 1.2 m $\pm$ 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'.

8.2   Conditions of the Vehicle

8.2.1   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.

The variation of results between runs may be reduced if there is a 1-min wait, at idle in neutral, between runs.

8.2.2   Test Mass of the Vehicle

8.2.2.1   General

Measurements shall be made on vehicles at the test mass m_t specified according to Table 3.

TABLE 3 - TEST MASS M_T

Vehicle Category	Vehicle Test Mass kg
M1	m_t = m_{ref} = m_{kerb} + 75 kg. The 75 kg added mass accounts for the mass of the driver according to ISO 2416.
N1[(1)(2)]	m_t = m_{ref} = m_{kerb} + 75 kg. The 75 kg added mass accounts for the mass of the driver according to ISO 2416.
N2, N3	m_{target} (per kW rated power) = 50 kg Extra loading, m_{xload}, to reach the target mass, m_{target}, of the vehicle shall be placed above the rear axle. The sum of the extra loading and the unladen rear axle load, $m_{ra\ load\ unladen}$, is limited to 75% of the maximum axle capacity, $m_{ac\ ra\ max}$, allowed for the rear axle. The target mass shall be achieved with a tolerance of ± 5%. If the center of gravity of the extra loading cannot be aligned with the center of the rear axle, the test mass, m_t, of the vehicle shall not exceed the sum of the unladen front axle load, $m_{fa\ load\ unladen}$, and unladen rear axle load plus the extra loading and the mass of driver, m_d. The test mass for vehicles with more than two axles shall be the same as for a two-axle vehicle. If the unladen vehicle mass, $m_{unladen}$, of a vehicle with more than two axles is greater than the test mass for the two-axle vehicle then this vehicle shall be tested without extra loading.
M2, M3	m_t = m_{ro}

1. N1 Category vehicles may be loaded, at the decision of the vehicle manufacturer for practical reasons during the test. This practice is acceptable, however it may lead to higher vehicle level of noise (typically one decibel).
2. If load is added to these vehicles during testing the added payload shall be noted in the test report.

8.2.2.2   Calculation Procedure to Determine Extra Loading of N2 and N3 Vehicles Only

8.2.2.2.1   Calculation of Extra Loading

The target mass m_{target} for two-axle vehicles of category N2 and N3 is specified in Table 3.

$$m_{target} \text{ (per kW rated power)} = 50 \text{ kg} \tag{Eq. 8}$$

To reach the required target mass m_{target} for a vehicle to be tested, the unladen vehicle, including the mass of the driver m_d, has to be loaded with an extra mass m_{xload} which shall be placed above the rear axle.

$$m_{target} = m_{unladen} + m_d + m_{xload} \tag{Eq. 9}$$

The target mass m_{target} shall be achieved with a tolerance of ± 5%.

The vehicle mass of the test vehicle in unladen condition $m_{unladen}$ is calculated by measuring the unladen front axle load $m_{fa \ load \ unladen}$ and the unladen rear axle load $m_{ra \ load \ unladen}$ on a scale:

$$m_{unladen} = m_{fa \ load \ unladen} + m_{ra \ load \ unladen} \tag{Eq. 10}$$

By using Equations 9 and 10 the extra loading m_{xload} is calculated:

$$m_{xload} = m_{target} - (m_d + m_{unladen}) \tag{Eq. 11}$$

$$m_{xload} = m_{target} - (m_d + m_{fa \ load \ unladen} + m_{ra \ load \ unladen}) \tag{Eq. 12}$$

The sum of the extra loading m_{xload} and the unladen rear axle load $m_{ra \ load \ unladen}$ is limited to 75% of the maximum axle capacity for the rear axle $m_{ac \ ra \ max}$.

$$0.75 \ m_{ac \ ra \ max} \geq m_{xload} + m_{ra \ load \ unladen} \tag{Eq. 13}$$

The m_{xload} is limited according to Equation 14:

$$m_{xload} \leq 0.75 \ m_{ac \ ra \ max} - m_{ra \ load \ unladen} \tag{Eq. 14}$$

If the calculated extra loading m_{xload} in Equation 12 fulfils Equation 14, then the extra loading is equal to Equation 12. The test mass m_t of the vehicle is equal to:

$$m_t = m_{xload} + m_d + m_{fa \ load \ unladen} + m_{ra \ load \ unladen} \tag{Eq. 15}$$

In this case, the test mass of the vehicle is equal to the target mass:

$$m_t = m_{target} \tag{Eq. 16}$$

If the calculated extra loading m_{xload} in Equation 12 does not fulfil Equation 14, but rather fulfils Equation 17:

$$m_{xload} > 0.75 \ m_{ac \ ra \ max} - m_{ra \ load \ unladen} \tag{Eq. 17}$$

the extra loading m_{xload} shall be equal to:

$$m_{xload} = 0.75 \ m_{ac \ ra \ max} - m_{ra \ load \ unladen} \tag{Eq. 18}$$

and the test mass m_t of the vehicle is equal to:

$$m_t = 0.75 \ m_{ac \ ra \ max} + m_d + m_{fa \ load \ unladen} \tag{Eq. 19}$$

In this case, the test mass of the vehicle is lower than the target mass:

$$m_t < m_{target} \qquad \text{(Eq. 20)}$$

8.2.2.2.2   Loading Considerations if Load Cannot be Aligned with the Center of the Rear Axle

If the center of gravity of the extra loading m_{xload} cannot be aligned with the centre of the rear axle, the test mass of the vehicle m_t shall not exceed the sum of the unladen front axle load $m_{fa\ load\ unladen}$ and the unladen rear axle load $m_{ra\ load\ unladen}$ plus the extra loading m_{xload} and the mass of the driver m_d.

This means if one measures the actual front and rear axle load on a scale when the extra loading m_{xload} is placed onto the vehicle and it is aligned with the center of the rear axle the test mass of the vehicle minus the mass of the driver is equal to:

$$m_t - m_d = m_{fa\ load\ laden} + m_{ra\ load} \qquad \text{(Eq. 21)}$$

where:

$$m_{fa\ load\ laden} = m_{fa\ load\ unladen} \qquad \text{(Eq. 22)}$$

If one cannot align the center of gravity of the extra loading with the center of the rear axle one still fulfils Equation 21 but:

$$m_{fa\ load\ laden} > m_{fa\ load\ unladen} \qquad \text{(Eq. 23)}$$

because the extra loading has partly distributed its mass to the front axle. In that case, it is not allowed to add more mass onto the rear axle to compensate for the mass moved to the front axle.

8.2.2.2.3   Test Mass for Vehicles with More Than One Axle

If a vehicle with more than two axles is tested, then the test mass of this vehicle shall be the same as the test mass for the two-axle vehicle.

If the unladen vehicle mass of a vehicle with more than two axles is greater than the test mass for the two-axle vehicle, then this vehicle shall be tested without extra loading.

8.2.3   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.

For certification and related purposes, additional requirements for the tires, defined by regulation, are necessary. The tires for such a test are selected by the vehicle manufacturer, and shall correspond to one of the tire size and type designated for the vehicle by the vehicle manufacturer. The tire shall be commercially available on the market at the same time as the vehicle. The minimum tread depth shall be at least 80% of the full tread depth.

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

8.3   Operating Conditions

8.3.1   Vehicles of Categories M1, M2 Having a Maximum Authorized Mass Not Exceeding 3500 kg, and N1

8.3.1.1   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'. If the vehicle is fitted with more than two-wheel drive, test it in the drive selection that is intended for normal road use. If the vehicle is fitted with an auxiliary manual transmission or a multi-gear axle, the position used for normal urban driving shall be used. In all cases the gear ratios for slow movements, parking or braking, shall be excluded.

8.3.1.2   Test Speed

The test speed v_{test} shall be 50 km/h $\pm$ 1 km/h. The test speed shall be reached, when the reference point according to 3.5 is at line PP'.

8.3.1.3   Gear Ratio Selection

8.3.1.3.1   General

It is the responsibility of the manufacturer to determine the correct manner of testing to achieve the required accelerations.

Appendix A gives gear selection and test run criteria in flowchart form as an aid to test operation for categories M1, M2 having a maximum authorized mass not exceeding 3500 kg, and N1.

8.3.1.3.2   Manual Transmission, Automatic Transmission, Adaptive Transmission, or Transmissions with Continuously Variable Gear Ratios (CVTs) Tested with Locked Gear Ratios

The selection of gear ratios for the test depends on the specific acceleration achieved $a_{wot, i}$ under full throttle condition according to the specification in 5.2.1 in relation to the reference acceleration $a_{wot\ ref}$ required for the full throttle acceleration test according to Equation 5 in 5.4.

The following conditions for selection of gear ratios are possible.

a.   If one specific gear ratio gives acceleration in a tolerance band of $\pm 5\%$ of the reference acceleration $a_{wot\ ref}$, not exceeding 2.0 m/s², test with that gear ratio.

b.   If none of the gear ratios give the required acceleration, then choose a gear ratio i, with an acceleration higher and a gear ratio i+1, with an acceleration lower than the reference acceleration $a_{wot\ ref}$. If the acceleration value in gear ratio i does not exceed 2.0 m/s², use both gear ratios for the test. The gear ratio weighting factor in relation to the reference acceleration $a_{wot\ ref}$ is calculated by:

$$k = (a_{wot,ref} - a_{wot,i+1})/(a_{wot,i} - a_{wot,i+1})$$
(Eq. 24)

c.   If the acceleration value of gear ratio i or i+1 exceeds 2.0 m/s², the first gear ratio shall be used that gives an acceleration below 2.0 m/s² unless gear ratio i+1 provides acceleration less than a_{urban}. The achieved acceleration $a_{wot\ test}$ during the test shall be used for the calculation of the partial power factor k_P instead of $a_{wot\ ref}$ for tests using one gear.

d.   In the case where gear ratio i+1 provides acceleration less than a_{urban}, two gears, i and i+1 shall be used, including the gear i with acceleration exceeding 2.0 m/s². The gear ratio weighting factor in relation to the reference acceleration $a_{wot\ ref}$ is calculated by Equation 24.

If the vehicle has a transmission in which there is only one selection for the gear ratio, the wide open throttle test is carried out in this vehicle gear selection. The achieved acceleration $a_{wot\ test}$ is then used for the calculation of the partial power factor k_P (see 3.9) instead of $a_{wot\ ref}$.

If rated engine speed is exceeded in a gear ratio before the vehicle passes BB', the next higher gear shall be used.

8.3.1.3.3   Automatic Transmission, Adaptive Transmissions, and Transmissions with Variable Gear Ratios Tested with Non-Locked Gear Ratios

The gear selector position for full automatic operation shall be used.

The acceleration $a_{wot\ test}$ shall be calculated by Equation 2 or 3 as specified in 5.2.2.

The test may then include a gear change to a lower range and a higher acceleration. A gear change to a higher range and a lower acceleration is not allowed. In any case, a gear shifting to a gear ratio which is typically not used at the specified condition in urban traffic shall be avoided.

Therefore, it is permitted to establish and use electronic or mechanical devices, including alternate gear selector positions, to prevent a downshift to a gear ratio which is typically not used at the specified test condition in urban traffic.

The achieved acceleration $a_{wot\ test}$ shall be greater than or equal to a_{urban}.

If possible, the manufacturer shall take measures to avoid an acceleration value $a_{wot\ test}$ greater than 2.0 m/s².

The achieved acceleration $a_{wot\ test}$ is then used for the calculation of the part power factor k_P (see 3.9) instead of $a_{wot\ ref}$.

8.3.1.4   Acceleration Test

The acceleration test shall be carried out in all gear ratios specified for the vehicle according to 8.3.1.3 with the test speed specified in 8.3.1.2.

When the front of the vehicle reaches the AA' the acceleration control unit shall be fully engaged and held fully engaged until the rear of the vehicle reaches BB'. The acceleration control unit shall then be released. Pre-acceleration may be used if acceleration is delayed beyond AA'. The location of the start of the acceleration shall be reported.

The calculated acceleration $a_{wot\ test}$ shall be noted to the second digit after the decimal place.

8.3.1.5   Constant Speed Test

The constant speed test is not required for vehicles with a $PMR \le 25$.

For vehicles with transmissions specified in 8.3.1.3.2, the constant speed test shall be carried out with the same gears specified for the acceleration test. For vehicles with transmissions specified in 8.3.1.3.3, the gear selector position for full automatic operation shall be used. If the gear is locked for the acceleration test, the same gear shall be locked for the constant speed test.

During the constant speed test the acceleration control unit shall be positioned to maintain a constant speed between AA' and BB' as specified in 8.3.1.2.

8.3.2   Vehicles of Category M2 Having a Maximum Authorized Mass Exceeding 3500 kg and Categories M3, N2, and N3

8.3.2.1   General Conditions

The path of the centreline 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' and the reference point is 5 m behind line BB'.

The test shall be conducted without a trailer or semi-trailer. If a trailer is not readily separable from the towing vehicle it shall be ignored when considering the crossing of line BB'.

If the vehicle incorporates equipment such as a concrete mixer, a compressor, etc, this equipment shall not be in operation during the test.

The test mass of the vehicle including the test payload shall be according to Table 3 defined in 8.2.2.1.

Appendix B gives gear selection criteria and test run criteria in flowchart form as an aid to test operation.

8.3.2.2   Target Conditions

8.3.2.2.1   Vehicles of Category M2 Having a Maximum Authorized Mass Exceeding 3500 kg and Category N2

When the reference point passes BB', the engine rotational speed $n_{BB'}$ shall be between 70% and 74% of speed S. The vehicle test speed v_{test} shall be 35 km/h ± 5 km/h.

8.3.2.2.2   Categories M3 and N3

When the reference point passes BB', the engine rotational speed $n_{BB'}$ shall be between 85% and 89% of speed S. The vehicle test speed v_{test} shall be 35 km/h ± 5 km/h.

8.3.2.3   Gear Selection

8.3.2.3.1   General

It is the responsibility of the manufacturer to determine the correct manner of testing to achieve the required conditions.

8.3.2.3.2   Manual Transmission

Stable acceleration condition shall be ensured. The gear choice is determined by the target conditions.

If more than one gear fulfils the target conditions, use the gear which gives vehicle velocity closest to 35 km/h at the target conditions. If no single transmission gear fulfils the target condition for v_{test}, then two gears shall be tested, one above and one below v_{test}. The target engine speed shall be reached in all conditions.

A stable acceleration condition shall be ensured. If a stable acceleration cannot be ensured in a gear, this gear shall be disregarded.

NOTE: The definition of "Stable Acceleration" is based on sound engineering judgment of the test engineer accounting for the technologies under test. Stable acceleration will have characteristics like: Linearly increasing vehicle velocity; linearly increasing engine speed, and nominally similar acceleration through the test zone.

8.3.2.3.3   Automatic Transmission, Adaptive Transmissions, and Transmissions with Variable Gear Ratios

The gear selector position for full automatic operation shall be used. The test may then include a gear change to a lower range and a higher acceleration. A gear change to a higher range and a lower acceleration is not allowed. A gear change to a gear ratio, which is not used in urban traffic, at the specified test condition, shall be avoided.

Therefore, it is permitted to establish and use electronic or mechanical devices to prevent a downshift to a gear ratio which is typically not used at the specified test condition in urban traffic.

If the vehicle includes a transmission design, which provides only a single gear selection (D), which limits engine speed during the test, the vehicle shall be tested using only a target vehicle speed.

If the vehicle uses an engine and transmission combination that does not fulfill 8.3.2.2.1 or 8.3.2.2.2, the vehicle shall be tested using only the target vehicle speed. The target vehicle speed for the test is $v_{test} = v_{BB'} = 35$ km/h ± 5 km/h. Two tests shall be performed to cover the target vehicle speed range, one with the end speed of 40 km/h ± 5 km/h, and one with the end speed of 30 km/h ± 5 km/h. A gear change to a higher range and a lower acceleration is allowed after the vehicle passes line PP'. If the vehicle uses an engine and transmission combination that cannot fulfill both the vehicle speed conditions, it shall be tested to fulfill the 40 km/h ± 5 km/h condition only.

The reported sound pressure level is that result which is related to the test with the highest engine speed for internal combustion engines or highest sound pressure level for vehicles with hybrid or electrical engines, obtained during the test from AA' to BB'.

8.3.2.4   Wide Open Throttle Test

When the reference point of the vehicle reaches AA' the acceleration control unit shall be fully engaged and held fully engaged until the rear of the vehicle passes BB', but the reference point shall be at least 5 m behind BB'. The acceleration control unit shall then be released.

8.4   Measurement Readings and Reported Values

8.4.1   General

At least four measurements for all test conditions shall be made on each side of the vehicle and for each gear ratio.

The maximum A-weighted sound pressure level indicated during each passage of the vehicle between AA' and BB' shall be noted, to the first significant digit after the decimal place (for example – XX.X). If a sound peak obviously out of character with the general sound pressure level is observed, that measurement shall be discarded.

The first four jth valid consecutive measurement results for any test condition, within 2.0 dB, allowing for the deletion of non-valid results, shall be used for the calculation of the appropriate intermediate or final result.

The speed measurements at AA' ($v_{AA'}$), BB' ($v_{BB'}$), and PP' ($v_{PP'}$) shall be noted and used in calculations to one digit after the decimal place.

8.4.2   Data Compilation

For a given test condition the results of each side of the vehicle shall be averaged separately. The average for each side shall be mathematically rounded to the first decimal place. The intermediate result is the higher value of the two averages

All further calculation to derive L_{urban} shall be done separately for the left and right vehicle side. The final value to be reported shall use the higher value of the two sides from each intermediate result.

NOTE: Using calculations for both sides of the vehicle allow for the case that the intermediate result for the cruise condition may be determined by the left side of the vehicle and the intermediate result of the acceleration condition may be determined by the right side of the vehicle, or vice versa. The final result uses the maximum result from each of the intermediate conditions to calculate the final result.

8.4.3   Vehicles of Categories M1, M2 Having a Maximum Authorized Mass Not Exceeding 3500 kg, and N1

8.4.3.1   Acceleration

The acceleration for further use is the average acceleration of the four runs.

$$a_{\text{wot test}} = 1/4 * (a_{\text{wot test(1)}} + a_{\text{wot test(2)}} + a_{\text{wot test(3)}} + a_{\text{wot test(4)}})$$ (Eq. 25)

where the numbers in brackets symbolize the test runs j.

8.4.3.2   Reported Value and Final Results

Calculate the reported value $L_{\text{wot rep}}$ for the wide open throttle test using the equation:

$$L_{\text{wot rep}} = L_{\text{wot } (i+1)} + k \left(L_{\text{wot}(i)} - L_{\text{wot } (i+1)}\right) \tag{26}$$

where k is the gear ratio weighting factor.

Calculate the reported value $L_{\text{crs rep}}$ for the constant speed test using the equation:

$$L_{\text{crs rep}} = L_{\text{crs}(i+1)} + k \left(L_{\text{crs } (i)} - L_{\text{crs } (i+1)}\right) \tag{27}$$

In the case of a single gear ratio test, the reported values are directly derived from the test result itself.

The equations used to determine the partial power factor, k_P , are as follows:

a.   In cases other than a single gear test, k_P is calculated by:

$$k_P = 1 - \left(a_{\text{urban}} / a_{\text{wot ref}}\right) \tag{28}$$

b.   If only one gear was specified for the test, k_P is given by:

$$k_P = 1 - \left(a_{\text{urban}} / a_{\text{wot test}}\right) \tag{29}$$

c.   In cases where $a_{\text{wot test}}$ is less than a_{urban}:

$$k_P = 0 \tag{30}$$

The final result is calculated by combining Equation 26 $L_{\text{wot rep}}$ and Equation 27 $L_{\text{crs rep}}$:

$$L_{\text{urban}} = L_{\text{wot rep}} - k_P \left(L_{\text{wot rep}} - L_{\text{crs rep}}\right) \tag{31}$$

8.4.4   Vehicles of Category M2 Having a Maximum Authorized Mass Exceeding 3500 kg and Categories M3, N2, and N3

When one gear is tested the final result, L_{urban} ,is the maximum value as specified in 8.4.2.

When two gears are tested the arithmetic mean of the two averages for each side of these two conditions shall be calculated. The final result, L_{urban} ,is the maximum value of the two calculated averages.

9.   TEST REPORT

The test report includes the following information:

a.   reference to this document;

b.   details of the test site, site orientation and weather conditions including wind speed, air temperature, wind direction, barometric pressure, and humidity;

c.   the type of measuring equipment, including the windscreen;

d.   the A-weighted sound pressure level typical of the background noise