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ISO/TC 43/SC 1

Title

Noise

Secretariat **DS**

Circulated to P- and O-members, and to technical committees and organizations in liaison for:

☐ discussion at
[venue/date of meeting]

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(P-members vote only: ballot form attached)

P-members of the technical committee or subcommittee concerned have an obligation to vote.

English title

Second ISO/CD 16254 "Acoustics – Measurement of minimum noise emitted by road vehicles"

French title

Reference language version: ☒ English ☐ French ☐ Russian

Introductory note

A first CD 16254, doc. ISO/TC 43/SC 1 N 1798-ISO/TC 22 N 2929 was circulated for comments by 2010-04-12 simulatenously with a NWIP (doc. ISO/TC 43/SC 1 N 1797-ISO/TC 22 N 2928), which was approved and allocated to WG 42 (Joint TC 43/SC 1-TC 22 Working Group).

The compilation of comments on the first CD is given in doc. ISO/TC 43/SC 1 N 1809-ISO/TC 22 N 2950, and the report on the comments is given in doc. 43/1 N 1897.

Based on the comments, WG 42 has prepared the present document, which is now circulated as a second CD for voting **by 2012-09-17**.

In view of the close cooperation with ISO/TC 22 "Road vehicles" members are invited to make contact with their national responsibles for TC 22 in order to establish a coordinated opinion on this document.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16254 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Introduction

The advent of road transport vehicles that rely, in whole or in part, on alternative drive trains (e.g., electromotive propulsion) are serving to significantly reduce both air and noise pollution and their adverse impacts on citizens throughout the world. However, the very positive environmental benefits achieved to date by these “hybrid or pure electric” road vehicles have resulted in the unintended consequence of removing a source of audible signal that is used by various groups of pedestrians, (e.g., in particular blind and low vision persons), to signal the approach, presence and/or departure of road vehicles.

Therefore, this International Standard has been developed to provide a method to measure the minimum noise emission of road vehicles, as well as to quantify the characteristics of any external sound-generation system installed for the purpose of conveying acoustic information about the approach, presence and/or departure of the vehicle to nearby pedestrians.

Acoustics — Measurement of minimum noise emitted by road vehicles

1 Scope

This International Standard is derived from ISO 362-1:2007 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 acoustic 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 acoustic environment. If measurements are carried out on the road in an acoustic environment which does not fulfill the requirements stated in this International Standard, the results obtained may deviate appreciably from the results obtained using the specified conditions.

In addition, this International 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 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 362-1:2007, *Acoustics – Engineering method for the measurement of noise emitted by accelerating road vehicles – Part 1: Vehicles of categories M and N*

ISO 10844:2011, *Acoustics – Test surface for road vehicle noise measurements*

ISO 3745:2012, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Precision methods for anechoic and hemi-anechoic rooms*

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

IEC 60942, *Electroacoustics – Sound calibrators*

IEC 61672-1, *Electroacoustics – Sound level meters – Part 1: Specifications*

IEC 61260-1, *Electroacoustics – Octave band and fractional octave band filters – Part 1: Specifications*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

3.1.1.2
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 test purpose

3.2.1 Reference point for gear selector indicating forward motion

The front end of the vehicle

3.2.2 Reference point for gear selector indicating rearward motion

The rear end 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

3.5 Highest audible frequency

Highest audible frequency of an external sound generation system as defined by the manufacturer

4 Symbols and abbreviated terms

Table 1 — Symbols and abbreviations and the paragraph they are first used

Symbol	Unit	Clause	Explanation
AA’	-	7.1.5.1	Line perpendicular to vehicle travel which indicates beginning of zone to record sound pressure level during test
BB’	-	7.1.5.1	Line perpendicular to vehicle travel which indicates end of zone to record sound pressure level during test
CC’	-	7.1.1	Centerline of vehicle travel
$F_{audible}$	Hz	7.1.6.4	Highest audible frequency of external sound generation system
$f_{i,speed}$,	Hz	7.2.7.1	Index for single frequency component of external sound generation system at a given vehicle speed
$f_{i,0}$	Hz	7.2.7.1	Index for single frequency component of external sound generation system at zero vehicle speed
del_f	-	7.2.4.3	Frequency shift expressed in percent of a reference frequency.
ΔF	Hx	7.2.3	Frequency resolution of narrowband analysis used to measure frequency spectrums for the purpose of determining frequency shift information.
F_s	Hz	7.2.2	Sampling frequency used by digital signal processing system
j	-	6.3.2	Index for single test run within stopped or slow speed cruise test conditions
L_{stop}	A-weighted sound pressure level	7.1.8	Stopped vehicle A-weighted sound pressure level
L_{crs}	A-weighted sound pressure level	7.1.10	Cruise vehicle A-weighted sound pressure level
L_{cm}	A-weighted sound pressure level	7.1.9	Commencing motion vehicle A-weighted sound pressure level
L_{corr}	dB	6.3.2	Background noise correction
$L_{test,j}$	A-weighted sound pressure level	6.3.2	A-weighted sound pressure level result of *j*th test run

$L_{testcorr,j}$	A-weighted sound pressure level	6.3.2	A-weighted sound pressure level result of *j*th test run corrected for background noise
L_{bgn}	A-weighted sound pressure level	6.3.1	Background A-weighted sound pressure level.
$L_{bgn,p\text{-}p}$	A-weighted sound pressure level	6.3.2	Peak-to-peak value of the representative background noise A-weighted sound pressure level
ΔL	dB	6.3.2	A-weighted sound pressure level of *j*th test result minus the A-weighted background noise level ($\Delta L = L_{test,j} - L_{bgn}$)
N	-	7.2.3	Block size of digital sample used for discrete Fourier transform or autopower spectrum analysis
PP'	-	7.1.5.2	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	7.1.5.3	Target vehicle test velocity

5 Instrumentation

5.1 Instruments for acoustic 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 ± 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.

These requirements are only valid for full vehicle testing.

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 Acoustic environment, meteorological conditions, and background noise

6.1 Test site

6.1.1 General

The specifications for the test site provide the necessary acoustic environment to carry out the full vehicle or component level tests documented in this International Standard. Outdoor and indoor test environments that meet the specifications of this International Standard provide equivalent acoustic environments and produce results that are equally valid.

6.1.2 Outdoor testing

The test site shall be substantially level. The test track construction and surface shall meet the requirements of ISO 10844:2011.

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 acoustic 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.

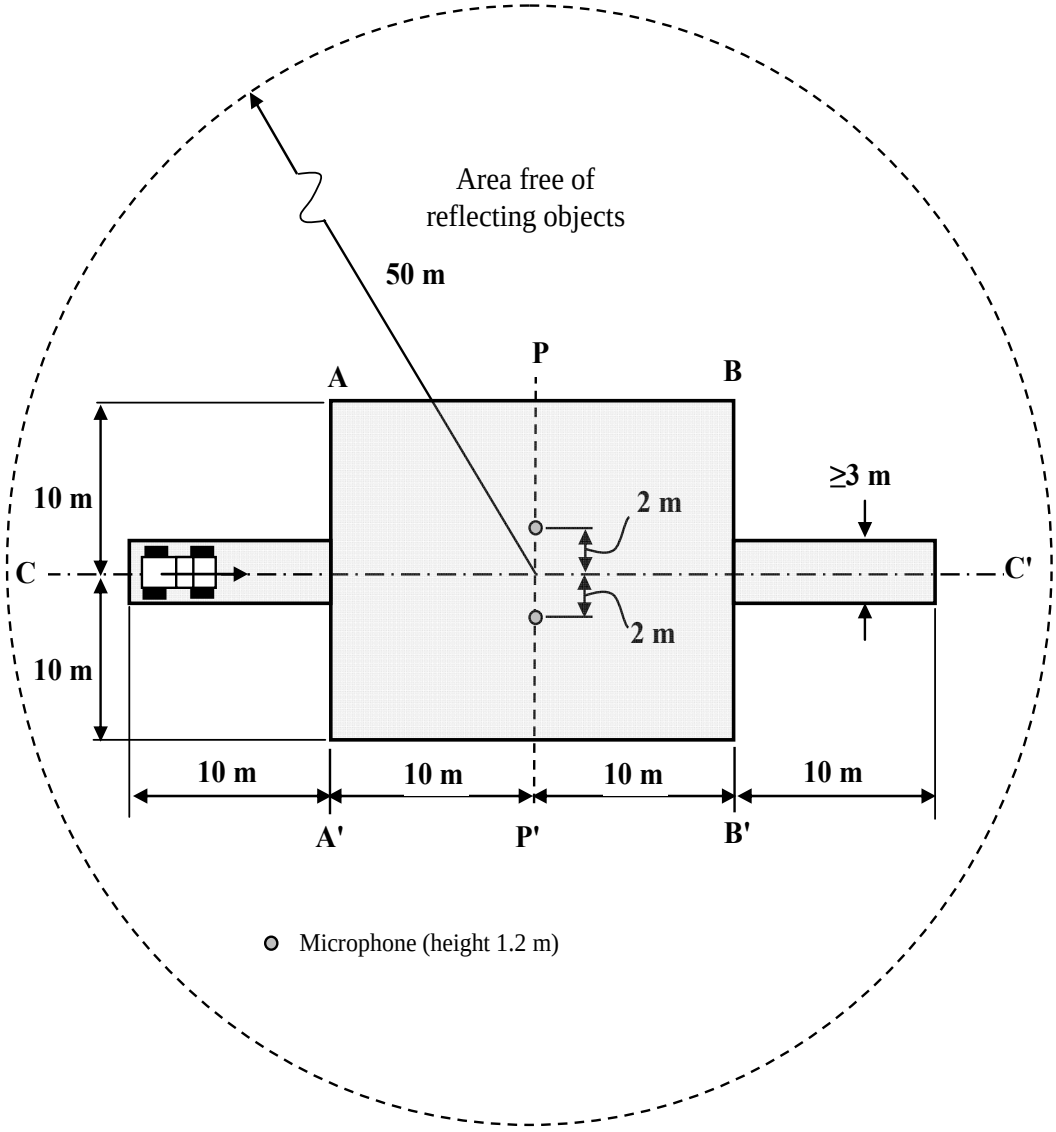

Figure 1 — Test site dimensions. Shaded area is the minimum area to be covered with a surface complying with ISO 10844

6.1.3 Full vehicle indoor hemi anechoic testing

The test facility shall have a cutoff frequency of 100 Hz or lower. When testing is conducted to measure acoustic signals below 100 Hz, the test facility shall have a cutoff frequency lower than the lowest measured frequency.

The test facility shall meet requirements of ISO 3745:2012, Annex A, or ISO 26101.

In the vicinity of the microphone, there shall be no obstacle that could influence the acoustic 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.

6.1.4 Indoor component testing

The test facility shall meet the requirements of ISO 3745:2012, Annex A.

The test facility shall have a cutoff frequency of 100 Hz or lower. When testing is conducted to measure acoustic signals below 100 Hz, the test facility shall have a cutoff frequency lower than the lowest measured frequency.

In the vicinity of the microphone, there shall be no obstacle that could influence the acoustic 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.

6.2 Meteorolgical conditions

6.2.1 General

Metrological conditions are specified to provide a range of normal operating temperatures and to prevent abnormal readings due to extreme environmental conditions.

6.2.2 Outdoor measurments

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.

6.2.3 Indoor measurements

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.

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

6.3 Background noise

6.3.1 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.

When testing in an indoor facility, the noise emitted by the roller-bench, chassis dynamometer, or other test facility equipment, without the vehicle installed or present, inclusive of the noise caused by air handling, facility vehicle cooling, shall be reported as the background noise.

The minimum A-weighted sound pressure level in the selected 10-second sample shall be reported as the background noise, L_{bgn} and the one-third-octave frequency per IEC 61260-1, Class 1, 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.

6.3.2 Vehicle measurment 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, $L_{testcorr,j} = L_{test,j} - L_{corr}$.

Table 2 — Correction for background noise level when measuring full vehicle overall sound pressure level

Correction for Background Noise			
Background Noise Level L_{bgn}	Peak-to-Peak Background Noise Level $L_{bgn,\ p\text{-}p}$	Sound Pressure Level of *j*th test result minus Background Noise Level $\Delta L = L_{test,j} - L_{bgn}$	Correction L_{corr}
> 25 A-weighted sound pressure level	See Note 1 below	> 10 dB	0 dB
	< 2 dB	8 dB to 10 dB	0,5 dB
		6 dB to 8 dB	1,0 dB
		4,5 dB to 6 dB	1,5 dB
		3 dB to 4,5 dB	2,5 dB
		< 3 dB	Do not correct, report out: $L_{testcorr,j} \leq L_{bgn}$
< 25 A-weighted sound pressure level	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 International Standard. The use of indoor test facilities may be necessary to achieve the specifications in this International Standard.

6.3.3 Component measurement background noise

When measuring a component as provided in this International Standard, the background noise shall be at least 10 dB lower than the result of the device under test.

The background, or ambient noise, shall be measured for a 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 one-third-octave frequency per IEC 61260-1, Class 1, at this level of background noise, shall be reported. For measurements where narrowband results are reported, the narrowband background noise shall be reported at the same frequency resolution as the measurement results.

7 Test procedures

7.1 Full vehicle testing

7.1.1 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 or in an indoor test facility 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'.

7.1.2 Conditions of the vehicle

7.1.2.1 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.

7.1.2.2 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.

7.1.2.3 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.

7.1.2.4 Muti-mode operation

If the vehicle is equipped with multiple driver selectable operating modes, the mode which provides the lowest noise emission during the test conditions of 7.1.5 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 International standard.

NOTE Modes include, but are not limited to: Engine operation state (on or off), driver selectable operating modes (sport, eco, winter, etc.), vehicle selectable operating modes (sport, eco, winter, etc.,), and transmission selection mode (sport, eco, winter, etc.). This does not include transmission gear selection such as Park, Drive, Reverse, or Neutral.

7.1.2.5 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.

7.1.3 Test mass of vehicle

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

7.1.4 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.

7.1.5 Operating conditions

7.1.5.1 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'.

7.1.5.2 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.

7.1.5.3 Stopped condition

7.1.5.3.1 General

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.

7.1.5.3.2 Manual transmission vehicle

The vehicle shall be tested in the appropriate stopped mode as defined in 7.1.2.4. The gear selector shall be in a gear, the clutch shall be depressed to disengage the transmission and the brake shall be depressed.

NOTE The common situation for stopped vehicle testing would be for a manual transmission vehicle to have the gear selector in neutral. However, for the purpose of this test, the intention is to place the vehicle in a state where it is ready to move.

7.1.5.3.3 Automatic transmission vehicle

The vehicle shall be tested in the appropriate stopped mode as defined in 7.1.2.4. The gear selector shall be in either forward or reverse, and the brake shall be depressed to maintain the stopped condition.

7.1.5.4 Vehicle commencing motion

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 a duration of 15 s.

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.

7.1.5.5 Slow speed cruise

7.1.5.5.1 General

The test speed v_{test} shall be 10 km/h $\pm$ 1 km/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'.

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/h and the engine rotational speed and external sound generation system controlled as to simulate operation at 10 km/h. 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/h will be equal or higher to the simulated test level.

If a vehicle is tested in an indoor facility, the vehicle shall be located with the front or rear reference point on the PP' line.

7.1.5.5.2 Automatic transmission vehicle

The gear selector shall be placed as specified by the manufacturer for normal driving.

7.1.5.5.3 Manual transmission vehicle

The gear selector shall be placed in the highest gear which can achieve the target vehicle speed with constant engine speed.

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/h and the engine rotational speed and external sound generation system controlled as to simulate operation at 10 km/h. 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/h will be equal or higher to the simulated test level.

NOTE 1 The intent of this paragraph is to operate the vehicle in such a manner as to achieve the lowest engine RPM (for internal combustion vehicles) at smooth and stable operations; free from lugging or non-steady acceleration. The gear selected will depend on the specific vehicle.

NOTE 2 Due to specific vehicle transmission and engine interaction, it may be the case that testing in a higher gear at a slightly higher vehicle speed gives a lower vehicle sound emission. In this case, it is recommended that the vehicle manufacturer carry out such procedures as deemed reasonable to estimate the minimum noise emission level at 10 km/hr.

NOTE 3 A vehicle manufacturer should maintain proper documentation of their testing methods and analysis used to estimate the minimum sound emission for their vehicle.

7.1.6 Measurement readings and reported values

7.1.6.1 General

It is recommended that persons technically trained and experienced in current sound measurement techniques select the test instrumentation and conduct the tests.

At least four measurements for all test conditions shall be made on each side of the vehicle and for each mode as defined in 7.1.2.4.

The first four *j*th 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.

NOTE Satisfying the criteria listed above requires evaluation of measured sound pressure data vs. time to select the appropriate time segments for proper analysis and reporting of measured values according to this International Standard.

7.1.6.2 Measurment of a vehicle

This paragraph specifies the requirements to measure the minimum vehicle noise emission without external sound generating systems of any kind.

The maximum A-weighted sound pressure level indicated during each passage of the vehicle between AA' and PP' ($L_{test,j}$) shall be noted, to the first significant digit after the decimal place (for example – XX,X). In the case of front engine vehicles, the maximum A-weighted sound pressure level between AA' and BB' may be noted in place of the measurement between AA' and PP'. If a sound peak obviously out of character with the general sound pressure level is observed, that measurement shall be discarded. $L_{test,j}$ shall be corrected according to 6.3.2 to obtain $L_{testcorr,j}$.

The minimum A-weighted sound pressure level indicated during each stopped run, $L_{test,j}$, 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. $L_{test,j}$ shall be corrected according to 6.3.2 to obtain $L_{testcorr,j}$.

For each A-weighted sound pressure level, the corresponding one-third-octave results per IEC 61260-1, Class 1, shall be reported. For results using paragraph 7.1.5.3, the one-third-octave results shall be averaged over the entire measurement time. For results using paragraph 7.1.5.5, the one-third-octave results shall be the result corresponding to the time when the A-weighted sound pressure level is reported.

NOTE The intent of this paragraph is to provide the measurement specification consistent with minimum noise emission of a vehicle in the absence of any additional system, device, or function that produces sound emission beyond that produced by propulsion system of the vehicle. This may be characterized as the natural noise emission level of the vehicle.

7.1.6.3 Measurment of a vehicle with external sound generation system

This paragraph specifies the requirements to measure the minimum vehicle noise emission with external sound generating systems of any kind.

The maximum A-weighted sound pressure level indicated during each passage of the vehicle between AA' and PP' ($L_{test,j}$), or during each stationary run, $L_{test,j}$, 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. $L_{test,j}$ shall be corrected according to 6.3.2 to obtain $L_{testcorr,j}$.

For each A-weighted sound pressure level, the corresponding one-third-octave results per IEC 61260-1, Class 1, shall be noted.

NOTE The intent of this paragraph is to provide the measurement specification consistent with noise emission of a vehicle equipped any additional system, device, or function that produces sound emission beyond that produced by propulsion system of the vehicle. Since such systems may be either continuous or intermittent, the maximum sound pressure level is specified for the stationary condition.

7.1.6.4 Measurement of a vehicle commencing motion

This paragraph specifies the requirements to measure the peak vehicle noise emission characteristic for a commencing motion sound.

The A-weighted sound pressure level measured during each specified test period shall be recorded to the first significant digit after the decimal place (for example – XX,X).

Measurement starts with the vehicle stopped and the propulsion system active for sufficient period to achieve stable operation, the transmission in any drive gear, and the service brakes activated to hold the vehicle stationary; for manual transmission vehicles, the clutch pedal shall also be depressed.

After 5 s ± 2 s the service brakes are released and vehicle motion is initiated to accelerate the vehicle from full stop triggering the commencing motion sound. The commencing motion sound should be recorded for a period of 3 s to 5 s.

The sustained peak A-weighted sound pressure level measured during each test shall be noted to the first decimal (see Figure 2). If a sound peak obviously out of character with the general sound pressure level is observed, that measurement shall be discarded.

The sample frequency, F_s ,shall be 2 times higher than the highest audible frequency, $F_{audible}$, in order to avoid leakage effects.

The minimum sample frequency shall be 24 000 Hz.

7.1.7 Data compilation

For a given test condition and mode (7.3.2.4) the background-corrected results, Ltestcorr,j, 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 lower value of the two averages as follows:

— For ΔL < 3 dB, and L_{bgn} p-p <= 2 dB, L_{crs} and L_{stop} shall be expressed as the lower or equal to the intermediate result;

— For all other cases, L_{crs} and L_{stop} shall be expressed as equal to the intermediate result.

If speed correction procedures were used to estimate noise emission, L_{crs} shall be expressed as greater or equal than the intermediate result.

Data compilation shall note if the results are reported for a vehicle with or without an external sound generation system.

7.1.8 Stopped result

The L_{stop} value for each mode according to 7.1.2.4 shall be the result from 7.1.5.3 using the definitions of 7.1.6.

7.1.9 Commencing motion result

The L_{cm} value for each mode according to 7.1.2.4 shall be the result from 7.1.5.4 using the definitions of 7.1.

7.1.10 Slow speed cruise result

The L_{crs} value for each mode according to 7.1.2. 4 shall be the result from 7.1.5.5 using the definitions of 7.1.6.

7.1.11 Reported value

The reported value L_{stop} and L_{crs} shall be the minimum of the L_{stop} and L_{crs} values determined according to 7.1.5.3 and 7.1.5.5 for each mode according to 7.1.2.4.

7.2 Measurement of external sound generation to determine frequency shift

7.2.1 General

The specifications contained in these sections are intended to measure the emitted acoustic information from an External Sound Generation (ESG) System installed for purposes of providing acoustic information to pedestrians in the near vicinity of a vehicle. The information so measured characterizes the frequencies emitted by the device, as well as the change in frequency as a function of vehicle operating parameters.

7.2.2 Instrumentation

The entire acoustic measurement system including microphone(s) and any subsequent measurement apparatus shall fulfill the requirements of IEC 61672 Class 1 sound level meter.

The digital sound recording system shall have at least a 16 bit quantization. The sampling rate, F_s, shall be at least twice the maximum frequency component of the measured signal. The dynamic range of the sound level measurement system shall be at least 20 dB -100 dB.

7.2.3 Signal processing requirements

The frequency resolution, ΔF, of the measurement shall be at least 1 Hz. The sound analysis system shall be capable of performing Discrete Fourier Transform and Auto Power Spectrum analysis at a frequency resolution and over the frequency range containing all frequencies of interest. The block size, N, used for subsequent signal processing shall enable the required ΔF, where $\Delta F = F_s/N$.

Analyzer settings shall be determined by the user to provide data according to these requirements.

7.2.4 Frequency shift measurement test procedure

7.2.4.1 General

The frequency shift may be measured by either a vehicle or a component based test procedure.

7.2.4.2 Component test procedure

The sound emitting component of the ESG system shall be mounted 0,5 m above the reflecting plane (floor) of the test space and the primary propagation axis of the sound emitting component shall be oriented horizontal to the reflecting plane.

The microphone shall be located 1,0 m from the center of the device at a height of 0,5 m.

Identify a frequency that is intended to change as a function of vehicle speed, which can be measured and can be tracked for operating conditions specified in this International Standard.

NOTE Typical signal analysis tools provide frequency and time coordinates of the tonal component can be obtained by using a cursor on the auto spectrum to pick frequency and time coordinates that correspond with vehicle speed or other vehicle operating parameters of interest.

7.2.4.3 Vehicle test procedure

7.2.4.3.1 Full vehicle operation

The vehicle shall be installed in an indoor test facility where the vehicle can operate in the same manner as outdoors. The test facility shall meet all acoustic requirements as specified in this International Standard and shall have the capability to simulate actual road load input to the vehicle. All microphone locations shall be as for the full vehicle test conditions.

Identify a frequency that is intended to change as a function of vehicle speed, which can be measured and can be tracked for operating conditions specified in this International Standard.

NOTE Typical signal analysis tools provide frequency and time coordinates of the tonal component can be obtained by using a cursor on the autopower spectrogram to pick frequency and time coordinates that correspond with vehicle speed.

7.2.4.3.2 Simulated vehicle operation

The vehicle shall be installed in an indoor test facility where the vehicle can accept an external vehicle speed signal simulating vehicle operation. The test facility shall meet all acoustic requirements as specified in this International Standard. All microphone locations shall be as for the full vehicle test conditions.

Identify a dominant tone that exists for all operating conditions.

NOTE Typical signal analysis tools provide frequency and time coordinates of the tonal component can be obtained by using a cursor on the autopower spectrogram to pick frequency and time coordinates that correspond with vehicle speed.

7.2.4.4 Measurement procedure

The frequency characteristics of the ESG sound generated shall be measured with an input to the ESG system corresponding to the lowest vehicle speed as specified in Table 1. Measure the sound output of the system as follows: Record at least 5 seconds of the sound. Using a Hanning window, calculate the autopower of the signal with a frequency resolution of at least 1 Hz using at least 10 overlapping averages from the 5 second time signal.

1) The main frequencies, $f_{i,speed}$, of the external signal shall be noted. At least one main frequency shall be identified for tracking as a function of vehicle speed.

2) The frequency shifting, *del_f*, shall be calculated as: del_f, = $[(f_{i,speed} - f_{i,0}) / f_{i,0}] * 10/(v_{test}/v_{ref})$

3) Table 3 provides an example of how to report the data.

Table 3 – Vehicle speed for measurment to determine frequency shift

Target Speed	Actual Speed	Frequency	Frequency Shift
Speed of lowest operation, including stopped or commencing motion conditions			Not Applicable
10 km/hr			
15 km/hr			
20 km/hr			

8 Test report

The test report includes the following information:

a) Reference to this International Standard;

b) Details of the test site, site orientation and weather conditions including wind speed, air temperature, wind direction, barometric pressure, and humidity; or if an indoor facility is used, description of the facility including dimensions and cut-off frequency of facility;

c) The type of measuring equipment, including the windscreen;

d) The A-weighted sound pressure level typical of the background noise;

e) The identification of the vehicle, its engine, its transmission system, including available transmission ratios, size and type of tires, tire pressure, tire production type, power, test mass, vehicle length and location of the reference point;

f) The auxiliary equipment of the vehicle, where appropriate, and its operating conditions;

g) All valid A-weighted sound pressure level values measured for each test, listed according to the side of the vehicle and the direction of the vehicle movement on the test site;

h) All valid frequency measurements for each test;

i) The technology content of the vehicle's propulsion system (e.g. internal combustion engine, stop/start, battery electric, hybrid, plug-in hybrid, extended-range electric, fuel cell);

j) Any special test or vehicle conditions or settings reflective of the technology content listed in i).

Annex A
(informative)

Information on development of ISO 16254

The development of this International Standard was motivated by the need to assess the minimum noise emission of a motor vehicle in an objective, reproducible, repeatable, and technically correct manner for the purposes of understanding potential safety concerns with low noise emission vehicles. Additional analyses or specification are necessary to provide correlation between the objective measures of vehicle noise emission specified in this International Standard and the subjective evaluation of human subjects to detectability, annoyance, perception, or any other psychoacoustic analysis of sound. Such psychoacoustic parameters are by their very nature subjective parameters that can only be accurately presented as percentages of a given population that will report a response to a certain sound in the presence of a specified background noise.

This test procedure was based on the existing vehicle noise emission test procedures of ISO 362-1:2007 and SAE J2805. These existing noise test procedures for maximum noise emission, which form the technical basis for global vehicle exterior maximum noise regulation, have been developed over the last 50 years to provide objective, reproducible, repeatable, and a technically correct manner for conducting exterior vehicle noise emission measurements. Issues relating to the acoustic characteristics of the measurement site, the road surface used for measurement, the instrumentation used for measurement, the environmental conditions necessary for accurate measurement, and an understanding of the sources of, and bounds on, measurement uncertainty; these have all been considered, developed, and refined in ISO 362-1 and SAE J2805.

To insure the fitness for purpose of ISO 16254, the following adaptations have been made to the ISO 362-1 and SAE J2805 specifications:

1) The microphone location has been moved from 7,5 m to 2,0 m. This change is to improve the signal to noise ratio of the measurement.

2) The specifications on the background (ambient) sound have been extended to provide conditions suitable for the typical sound pressure levels at the vehicle operating conditions specified in this International Standard. Consistent with the use of this International Standard, it is the minimum background sound level that is reported and used for determining the suitability of the test site or in any correction of measured vehicle noise emission levels.

3) The vehicle operating conditions have been modified to conditions representative of both minimum vehicle sound pressure level and conditions where minimum vehicle noise emission is highly likely to cause a safety concern. The conditions so specified cover a wide range of real world conditions of concern and are judged to provide a practical set of conditions suitable for carrying out testing with a reasonable workload.

4) The alternative of using an indoor semi-anechoic space for measurement of the specified zero vehicle speed (stopped) condition has been provided. This was later extended to also include the moving vehicle condition as information was presented to show the error due to measurement of tire/road noise on a roll was acceptable. This is in recognition that the necessary ambient noise conditions for accurate vehicle measurement are difficult to obtain in an outdoor space for vehicles with low noise emission in the stopped and moving condition.

5) The criteria for reporting the stopped condition test result is chosen as the minimum sound pressure level over the measurement period. This is consistent with the purpose of the standard.

6) The selection of the minimum, as opposed to the maximum, average of the left and right average result for reporting a vehicle test condition result is consistent with the purposes of this International Standard.

7) The selection of the lesser of (minimum) of the vehicle conditions specified as the reported minimum sound emission level of the vehicle is consistent with the purposes of this International Standard.

8) When using this International Standard for the purposes of determining the noise emission of a specific external sound pressure generating device, the measurement requirement is specified to use the maximum recorded sound pressure level to provide accurate measurement of both continuous and intermittent sources.

9) The vehicle level test procedure was extended to provide support to determine the change in frequency of a vehicle's emitted sound as a function of vehicle speed or other operating parameters. This is termed the frequency shifting of the sound.

10) This International Standard was extended to be able to measure an ESG system at a component level. Measurements of an ESG system at a component level allow for additional accuracy of measurement and control of the background noise level that are typically not available when conducting an outdoor or full vehicle measurement. Component testing measures the frequency content of an ESG system at a sufficient precision to allow for the frequency shift information to be determined.

11) For the purposes of use in a regulation, it may be necessary to determine that additional units of a production process or replacement units are sufficiently similar to an original unit. This evaluation may be accomplished by using the frequency shift measurement procedures and applying the necessary tolerances to the frequency (Hz) information and the level (dB) information.

12) This International Standard was extended to be able to measure sound at initiation, or immediately prior to initiation, of vehicle motion that may have potential value in providing information to pedestrians. This is referred to as commencing motion sound.

Annex B
(informative)

Development of frequency shift information

In motor vehicles where combustion engines provide the propulsive power, the sound emission of the vehicle naturally provides information to a pedestrian and the vehicle occupants on the operating state of the vehicle. One primary source of information is the correlation between the frequencies emitted by road vehicles and the velocity of the road vehicle. In broad terms, the acoustic characteristics of the propulsive motor generate higher frequencies at higher vehicle speeds, and humans have come to associate these characteristics to provide information on how fast a vehicle is traveling, or if a vehicle is accelerating.

As the measurement of the frequencies and/or the change of frequencies relative to vehicle speed or other vehicle operating conditions may be useful to characterize necessary pedestrian information, measurement procedures have been provided to accomplish this purpose.

The following assumptions have been taken when developing this test procedure:

1) The persons conducting the test are familiar with the latest acoustic measurement procedures, equipment and standards;

2) The persons conducting the test are trained on the test equipment to be used during the test;

3) There is at least one frequency component that may be tracked as a function of vehicle speed or other vehicle operating condition;

4) The necessary hardware and software is available to simulate vehicle operating conditions where an external sound generation system can be accurately tested as a component;

5) The persons conducting the test know what frequencies should be produced by the device or vehicle under measurement;

6) The sound is a stationary signal within all time periods used for measurement.

The procedure is specified as a manual process, but may be automated if the measurement equipment provides such capability. The process operates using the same frequency tracking principles as used for rotating machinery order tracking measurements. Figure B.1 provides an example of such a measurement process where multiple frequencies are present, and a single frequency has been chosen to provide the tracking information.

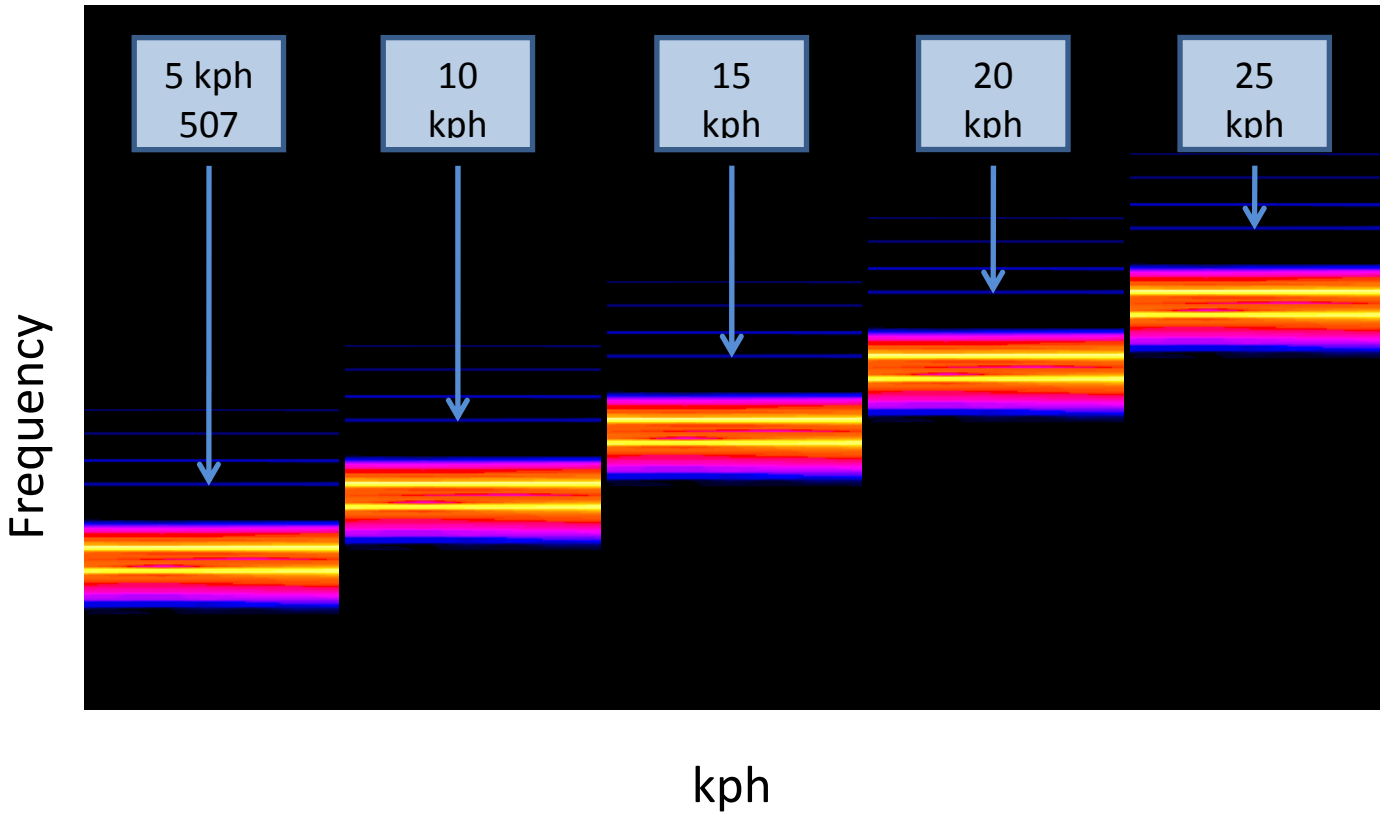

Figure B.1 — Example of measurement of frequency vs. vehicle speed information

Annex C
(informative)

Relevance of objective acoustic data to pedestrain safety

This International Standard provides measurment procedures for the following:

1) Overall Sound Pressure Level (SPL) at the full vehicle;

2) One-third-octave-frequency information at the full vehicle level;

3) Narrowband (1 Hz resolution) frequency information at the full vehicle level;

4) Narrowband (1 Hz resolution) frequency information at the component level;

5) The frequency shift of either a full vehicle or a component vs. vehicle speed or other vehicle operating parameter.

In regulatory discussions, the concepts of presence (detection), direction, location, and operation are terms used to attempt to specify the needed information transmitted from the vehicle to the pedestrian, in the case of this International Standard, transmitted by acoustic means. It is recognized that all road vehicles make some acoustic signal, the only relevant question for regulatory authorities is whether the signal is of sufficient magnitude and of a character to allow pedestrains to have necessary acoustic information to enable the pedestrian to travel safely in the presence of road vehicles. In no case has any assumption been made that pedestrians need acoustic information in all cases, and in all places, to allow them to distinguish individual road vehicles.

The primary and reasonable assumption behind the development of this International Standard is to measure the sound emission of vehicles in a range of sound emission that will correspond to road vehicle sound emissions that can be reasonably expected to be heard in a residential situation. In no case, is there any expectation that vehicles could be, or should be, heard when loud or unusual noise is present; for example, construction sites, in the presence of vehicles exceeding maximum noise regulatory limits, or in situation where the natural sound level would exceed the level where a person with normal hearing would reasonably expect to hear a road vehicle.

The term “Presence” is closely related to the acoustic term “detection”, but is not identical. Detection has a specific meaning and definition in signal processing (acoustic or electromagnetic) of sufficient signal energy in excess of natural or background signal energy. Detection is also (usually) applied to signals of assumed stationary character. Therefore, detection is specifically related to the signal energy present in relation to the background, in this case, the background noise. As this is a vehicle and component measurement standard, detection in a specific situation cannot be assessed. Presence, however, is understood in this context as the ability of a pedestrian to determine a vehicle is nearby. As such, there are multiple objective measurements that contribute to the determination of presence. The first is the overall sound pressure level, the second is the frequency content of the sound emission of the vehicle, and the third is the shifting of the frequency(ies) of the vehicle with respect to the vehicle velocity.

The overall sound pressure level (SPL, with units of Pascals (Pa), and expressed in this International Standard in A weighted decibels) provides the necessary sound energy to provide a listener with some sort of audible sound. The frequency, or frequencies of the sound emitted by the vehicle provide an additional source if information to pedestrians that can render the underlying SPL more or less effective, depending on the frequencies, and combination of frequencies, present in the signal. Finally, the frequency shifting of the sound signal as a function of the vehicle speed and/or other vehicle operating parameter provides significantly important information to a pedestrian on the vehicle speed; information on the vehicle acceleration or deceleration; and the characteristic of frequency shifting provides the means by which a wide number of undesirable sounds may be excluded from use.

The term “Direction” is used in this context to mean the ability of a pedestrian to spatially locate a sound relative to their position. Given the assumption that the sound has been detected, it is the frequency content of the sound signal that will contribute to the accurate spatial location of the vehicle. Of importance to the determination of direction is the large amount of information that can be determined by a pedestrian independent of the sound emitted by the vehicle. This comes from two basic sources; the movement of the vehicle relative to the pedestrian, and the movement of the pedestrian relative to the vehicle.

By the very nature of movement of the vehicle relative to the pedestrian, human hearing processes naturally detect the spatial change of the sound source relative to their current location. From this information, including both changes in amplitude (volume) and changes in relative angle, determinations can be made on the direction and movement of a vehicle. In addition, this process works similarly if the pedestrian moves relative to the vehicle, with the additional source of information that a human can change the orientation of their head relative to the sound, exploiting the binaural hearing capability to provide additional information on the direction of a vehicle.

The term “Location” is similar to direction, but in this usage incorporates the additional information of range in addition to spatial orientation. The development of location information uses the same process as used for direction information, with the additional integration of the frequency shifting to provide reinforcing information to the change in sound pressure level, allowing improved determinations if a vehicle is moving closer or further away, and by how much.

The term “Operation” is used in this context to mean the pedestrian understanding how the vehicle is being operated by the driver: Is the driver moving at a steady speed; is the driver braking quickly or slowing down gradually; or is the driver accelerating the vehicle? This information is provided primarily by the frequency shifting of the vehicle sound, augmented by additional information from the vehicle SPL. From both of these sources of information, a pedestrian can determine the vehicle operation, and can therefore make judgments on the action and intent of the driver.

All of the objective criteria specified in this International Standard operate independently as necessary, but not sufficient, criteria to provide adequate information to pedestrians. In combination, the criteria of SPL, frequency content, and frequency shifting, provide a set of measures which provide the necessary information to pedestrians to allow them to safely interact with vehicle traffic. Finally, the objective criteria provide a limiting set of specification that may be used by regulatory authorities to insure acceptable sounds are used and produced.

Bibliography

[1] SAE J1715, *Hybrid Electric Vehicle (HEV) & Electric Vehicle (EV) Terminology*

[2] SAE J2805, *Measurement of Noise Emitted by Accelerating Road Vehicles*