INTERNATIONAL STANDARD

ISO 362-2

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Measurement of noise emitted by accelerating road vehicles — Engineering method —

Part 2:
L category

Mesurage du bruit émis par les véhicules routiers en accélération — Méthode d'expertise —

Partie 2: Catégorie L

Reference number
ISO 362-2:2009(E)

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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 362-2 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

This first edition of ISO 362-2, together with ISO 362-1, cancels and replaces ISO 362:1998 and ISO 7188:1994, which have been technically revised.

ISO 362 consists of the following parts, under the general title *Measurement of noise emitted by accelerating road vehicles — Engineering method*:

— *Part 1: M and N categories*

— *Part 2: L category*

Introduction

From as early as 1994, the International Motorcycle Manufacturers Association (IMMA) has collected in-use data for vehicles of category L3 (two-wheeled motorcycles) to study motorcycle dynamics, rider attitude and behaviour. In 1999 and 2000, additional in-use data was collected through a tripartite project in which the Dutch Ministry of the Environment (VROM), the Dutch research institute TNO-Automotive and the IMMA took part. This project eventually led to the adoption of the Worldwide Motorcycle Exhaust Emission Test Cycle (WMTC) as a UNECE Global Technical Regulation under the 1998 Agreement (*Agreement concerning the establishing of global technical regulations for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles*).

Though the aim of the WMTC project was to collect data with which to construct an exhaust emissions test cycle for motorcycles, the in-use data was equally suitable as a basis for the definition of a more representative and performance-based urban noise test procedure. From 2002 to 2004, additional in-use data for low-performance motorcycles was added to ensure the representativity of the in-use database for small engine displacement motorcycles. Additional wide-open-throttle acceleration data from large engine displacement motorcycles was collected in the course of 2005 to upgrade the acceleration equations. Prior to preparation of this part of ISO 362, an extensive test programme was conducted to verify the practicability and technical accuracy of the new noise test.

This noise test was developed in accordance with the following set of demands:

— performance-based concept with prescribed acceleration rate prescriptions related to vehicle acceleration capability and engine speed corresponding to typical motorcycle usage in urban and conurban areas, i.e. where motorcycles are in closest proximity to the greater part of the population — this typically relates to motorcycle usage on roads with speed limits of 50 km/h and 70 km/h;

— accurate simulation of noise source distribution (intake, exhaust, engine/gearbox …) in relation to the most relevant motorcycle operations;

— comparability with other vehicle types in the same operating environment;

— independency of vehicle design to allow future propulsion technologies to be tested.

The procedure uses two operating conditions, i.e. a wide-open-throttle acceleration phase and a constant speed phase, to simulate real-life partial throttle acceleration actually used in urban traffic. The combination of these two primary operating conditions was demonstrated to be equivalent in terms of noise generation to the partial throttle and partial power (engine load) acceleration. Both primary operating conditions are also more repeatable and reproducible than partial throttle/power acceleration.

The measurement procedure for categories L4 and L5, already contained in ISO 362:1998, is retained until in-use data for these categories that suggests the need for change becomes available.

Categories L6 and L7, previously not covered in ISO 362:1998, are excluded pending in-use data becoming available and thereby allowing a representative test procedure to be considered.

Measurement of noise emitted by accelerating road vehicles — Engineering method —

Part 2: L category

1 Scope

This part of ISO 362 specifies an engineering method for measuring the noise emitted by road vehicles of categories L3, L4 and L5 under typical urban traffic conditions. It excludes vehicles of category L1 and L2, which are covered by ISO 9645, vehicles of categories M and N covered by ISO 362-1 and vehicles of categories L6 and L7.

The specifications are intended to reproduce the level of noise generated by the principal noise sources during normal driving in urban traffic, typically on roads with speed limits of 50 km/h and 70 km/h (see Annex A).

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 that is only obtained in an extensive open space. Such conditions are usually provided for

— type approval measurements of a vehicle,

— measurements at the manufacturing stage, and

— measurements at official testing stations.

NOTE 1 The results obtained by this method give an objective measure of the noise emitted under the specified test conditions. 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 conditions, culture and environmental conditions, there is a large variation and it is therefore not useful as a parameter to describe a specific vehicle condition.

NOTE 2 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 fulfil the requirements stated in this International Standard, the results obtained can deviate appreciably from the results obtained using the specified conditions.

2 Normative references

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

ISO 4106, *Motorcycles — Engine test code — Net power*

ISO 6726, *Mopeds and motorcycles with two wheels — Masses — Vocabulary*

ISO 7117, *Motorcycles — Measurement method for determining maximum speed*

ISO 10844, *Acoustics — Specification of test tracks for the purpose of measuring noise emitted by road vehicles*

IEC 60942, *Electroacoustics — Sound calibrators*

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

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6726 and the following apply.

3.1 Vehicle mass

3.1.1
kerb mass
complete shipping mass of a vehicle fitted with all equipment necessary for normal operation, plus the mass of the following elements:

— 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

NOTE 1 Adapted from ISO 362-1:2007.

NOTE 2 The definition of kerb mass may vary from country to country, but in this part of ISO 362 it refers to the definition contained in ISO 6726.

3.1.2
test mass
mass as determined by Table 1

NOTE Adapted from ISO 362-1:2007.

3.1.3
driver mass
nominal mass of a driver

[ISO 362-1:2007, definition 3.1.6]

3.2
power-to-mass ratio index
PMR
dimensionless quantity used for the calculation of acceleration according to the equation

$$\mathrm{PMR} = \frac{P_\mathrm{n}}{m_\mathrm{t}} \times 1\,000 \qquad (1)$$

where

P_n is the numerical value of the rated engine power as defined in ISO 4106, expressed in kilowatts;

m_t is the numerical value of the test mass, expressed in kilograms.

NOTE Adapted from ISO 362-1:2007.

3.3
rated engine speed
S
engine speed at which the engine develops its rated maximum net power as stated by the manufacturer

NOTE 1 If the rated maximum net power is reached at several engine speeds, S is used in this part of ISO 362 as the highest engine speed at which the rated maximum net power is reached.

NOTE 2 ISO 80000-3 defines this term as "rated engine rotational frequency". The term "rated engine speed" was retained due to its common understanding by practitioners and its use in government regulations.

[ISO 362-1:2007, definition 3.3]

3.4 Vehicle categories

3.4.1
category L
motor vehicles with fewer than four wheels

[ISO 362-1:2007, definition 3.4.1]

3.4.1.1
category L1 and L2
mopeds

[ISO 362-1:2007, definition 3.4.1.1]

NOTE See ISO 9645 for further details.

3.4.1.2
category L3
two-wheeled motor vehicles with an engine cylinder capacity greater than 50 cm^3 or maximum speed greater than 50 km/h

[ISO 362-1:2007, definition 3.4.1.2]

3.4.1.3
category L4
three-wheeled motor vehicles with an engine cylinder capacity greater than 50 cm^3 or maximum speed greater than 50 km/h, the wheels being attached asymmetrically along the longitudinal vehicle axis

[ISO 362-1:2007, definition 3.4.1.3]

3.4.1.4
category L5
three-wheeled motor vehicles with an engine cylinder capacity greater than 50 cm^3 or maximum speed greater than 50 km/h, having a gross vehicle mass rating not exceeding 1 000 kg and wheels attached symmetrically along the longitudinal vehicle axis

[ISO 362-1:2007, definition 3.4.1.4]

3.4.1.5
category L6
four-wheeled vehicles whose unladen mass is not more than 350 kg, not including the mass of the batteries in the case of electric vehicles, whose maximum design speed is not more than 45 km/h, and whose engine cylinder capacity does not exceed 50 cm^3 for spark (positive) ignition engines, or whose maximum net power output does not exceed 4 kW in the case of other internal combustion engines, or whose maximum continuous rated power does not exceed 4 kW in the case of electric engines

[ISO 362-1:2007, definition 3.4.1.5]

3.4.1.6
category L7
four-wheeled vehicles, other than those classified for the category L6, whose unladen mass is not more than 400 kg (550 kg for vehicles intended for carrying goods), not including the mass of the batteries in the case of electric vehicles, and whose maximum continuous rated power does not exceed 15 kW

[ISO 362-1:2007, definition 3.4.1.6]

3.5
reference point
front end of the vehicle

NOTE Adapted from ISO 362-1:2007.

3.6
target acceleration
acceleration at a partial throttle condition in urban traffic, derived from statistical investigations

[ISO 362-1:2007, definition 3.6]

NOTE Refer to Annex A for more detailed explanations.

3.7
reference acceleration
required acceleration for the acceleration test on the test track

[ISO 362-1:2007, definition 3.7]

NOTE Refer to Annex A for more detailed explanations.

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

[ISO 362-1:2007, definition 3.8]

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

NOTE 1 Adapted from ISO 362-1:2007.

NOTE 2 Refer to Annex A for more detailed explanations.

3.10
pre-acceleration
application of acceleration control device prior to the position AA′ for the purpose of achieving stable acceleration between AA′ and BB′

[ISO 362-1:2007, definition 3.10]

NOTE See Figure 1 for additional details.

3.11
locked gear ratio
control of transmission such that the transmission gear cannot change during a test

[ISO 362-1:2007, definition 3.11]

3.12
engine
power source without detachable accessories

[ISO 362-1:2007, definition 3.12]

3.13
test track length
l_{10}
length of test track used in the calculation of acceleration from points PP′ to BB′

[ISO 362-1:2007, definition 3.13]

3.14
test track length
l_{20}
length of test track used in the calculation of acceleration from points AA′ to BB′

[ISO 362-1:2007, definition 3.14]

4 Symbols and abbreviated terms

Table 1 lists the symbols used in this document and the clause where they are used for the first time.

Table 1 — Symbols used and corresponding clauses

Symbol	Unit	Clause	Explanation
AA′	—	3.10	line perpendicular to vehicle travel which indicates beginning of zone to record sound pressure level during test
$a_{\text{wot 50}}$	m/s^2	A.4	wide-open-throttle acceleration at 95th percentile of engine speed ratio and applicable test speed
$a_{\text{wot } i}$	m/s^2	5.1	acceleration at wide-open-throttle in gear i
$a_{\text{wot } (i+1)}$	m/s^2	5.1	acceleration at wide-open-throttle in gear $i + 1$
$a_{\text{wot test}}$	m/s^2	5.1	acceleration at wide-open-throttle in single gear test cases
$a_{\text{wot ref}}$	m/s^2	5.4	reference acceleration for the wide-open-throttle test
a_{urban}	m/s^2	5.3	target acceleration representing 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
$\delta_1 - \delta_7$	dB	B.2	input quantities to allow for any uncertainty
gear i	—	8.3.1.3.2	first of two gear ratios for use in the vehicle test
gear $(i + 1)$	—	8.3.1.3.2	second of two gear ratios, with an engine speed lower than gear ratio i
j	—	5.2.1	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
k_n	—	A.4	interpolation factor between gears
l_{ref}	m	5.1	reference length
l_{veh}	m	5.1	length of vehicle
l_{10}	m	3.13	length of test track section from PP′ to BB′ for calculation of acceleration from PP′ to BB′
l_{20}	m	3.14	length of test track section from AA′ to BB′ for calculation of acceleration from AA′ to BB′
$L_{\text{crs } i}$	dB	8.4.3.2	vehicle sound pressure level at constant speed test for gear i
$L_{\text{crs}(i+1)}$	dB	8.4.3.2	vehicle sound pressure level at constant speed test for gear $i + 1$
$L_{\text{crs rep}}$	dB	8.4.3.2	reported vehicle sound pressure level at constant speed test
$L_{\text{wot } i}$	dB	8.4.3.2	vehicle sound pressure level at wide-open-throttle test for gear i
$L_{\text{wot } (i+1)}$	dB	8.4.3.2	vehicle sound pressure level at wide-open-throttle test for gear $i + 1$
$L_{\text{wot rep}}$	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_{d}	kg	8.2.2	mass of driver
m_{kerb}	kg	8.2.2	kerb mass of the vehicle

Table 1 (*continued*)

Symbol	Unit	Clause	Explanation
m_{ref}	kg	8.2.2	kerb mass + 75 kg ± 5 kg for the driver
m_t	kg	3.2	test mass of the vehicle
n	1/min	A.3	engine speed of the vehicle
$n_{PP'}$	1/min	9	engine speed of the vehicle when the front of the vehicle passes PP′
$n_{BB'}$	1/min	9	engine speed of the vehicle when the front of the vehicle passes BB′
$(n/S)_{95}$	—	A.3	95th percentile dimensionless engine speed ratio
PMR	—	3.2	power-to-mass ratio index to be used for calculations
P_n	kW	3.2	rated engine power
PP′	—	3.13	line perpendicular to vehicle travel which indicates location of microphones
S	1/min	3.3	rated engine speed in revs per minute, synonymous with the engine speed at maximum power
$v_{AA'}$	km/h	5.1	vehicle speed when the front of the vehicle passes line AA′
$v_{BB'}$	km/h	5.1	vehicle speed when the rear of the vehicle passes line BB′
v_{max}	km/h	8.3.1.2	maximum vehicle speed as defined in ISO 7117
$v_{PP'}$	km/h	5.1	vehicle speed when front of the vehicle passes line PP′
v_{test}	km/h	8.3.1.2	target vehicle test speed

5 Specification of the acceleration for vehicles of category L3 with PMR > 25

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 $a_{wot\ i}$, $a_{wot\ (i+1)}$ and $a_{wot\ test}$. 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.

With the front of the vehicle as the reference point, $l_{ref} = l_{veh}$ is the length of vehicle.

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

Calculate $a_{\text{wot test},j}$ using Equation (2):

$$a_{\text{wot test},j} = \frac{(v_{BB'}/3{,}6)^2 - (v_{AA'}/3{,}6)^2}{2(l_{20} + l_{\text{ref}})} \quad (2)$$

where

$a_{\text{wot test},j}$ is the numerical value of acceleration, expressed in metres per second squared;

$v_{BB'}$, $v_{AA'}$ are numerical values of speed, expressed in kilometres per hour;

l_{20}, l_{ref} are numerical values of length, expressed in metres.

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 are 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 Equation (3):

$$a_{\text{wot test},j} = \frac{(v_{BB'}/3{,}6)^2 - (v_{PP'}/3{,}6)^2}{2(l_{10} + l_{\text{ref}})} \quad (3)$$

where

$a_{\text{wot test},j}$ is the numerical value of acceleration, expressed in metres per second squared;

$v_{PP'}$, $v_{BB'}$ are numerical values of speed, expressed in kilometres per hour;

l_{10}, l_{ref} are numerical values of length, expressed in metres.

Pre-acceleration shall not be used.

NOTE It would be useful for these types of vehicles to record the vehicle speeds at AA′, PP′ and BB′ to provide information for a future revision of this part of ISO 362.

5.3 Calculation of the target acceleration

Calculate a_{urban} using Equation (4) or (5):

$$a_{\text{urban}} = 1{,}37 \lg(\text{PMR}) - 1{,}08 \text{ for } 25 < \text{PMR} \leqslant 50 \quad (4)$$

$$a_{\text{urban}} = 1{,}28 \lg(\text{PMR}) - 1{,}19 \text{ for PMR} > 50 \quad (5)$$

where

a_{urban} is the numerical value of acceleration, expressed in metres per second squared;

PMR is the dimensionless value of the power-to-mass index.

5.4 Calculation of the reference acceleration

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

$$a_{\text{wot ref}} = 2{,}47 \lg(\text{PMR}) - 2{,}52 \text{ for } 25 < \text{PMR} \leqslant 50 \quad (6)$$

$$a_{\text{wot ref}} = 3{,}33 \lg(\text{PMR}) - 4{,}16 \text{ for PMR} > 50 \quad (7)$$

where

$a_{\text{wot ref}}$ is the numerical value of the reference acceleration, expressed in metres per second squared;

PMR is the dimensionless value of the power-to-mass index.

NOTE Calculations of $a_{\text{wot ref}}$ and a_{urban} for a specific vehicle are based on statistical analyses of in-use vehicle data. As such, this is not strictly a calculation of acceleration based on the independent non-dimensional variable PMR, since this is used as a function to identify the appropriate target acceleration.

5.5 Partial power factor k_{P}

Partial power factor k_{P} is:

$$k_{\text{P}} = 1 - (a_{\text{urban}} / a_{\text{wot test}}) \quad (8)$$

In cases other than a single gear test, $a_{\text{wot ref}}$ shall be used instead of $a_{\text{wot test}}$ as defined in 8.4.3.1.

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) according to 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 measuring instrument and the “A” frequency weighting curve described in IEC 61672-1. When using a system that includes 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 with 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 61672-1 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.

6.2 Instrumentation for engine and vehicle speed measurements

The engine speed shall be measured with an instrument meeting specification limits of at least ± 2 % 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 following specifications:

— ± 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. The test site dimensions are shown in Figure 1.

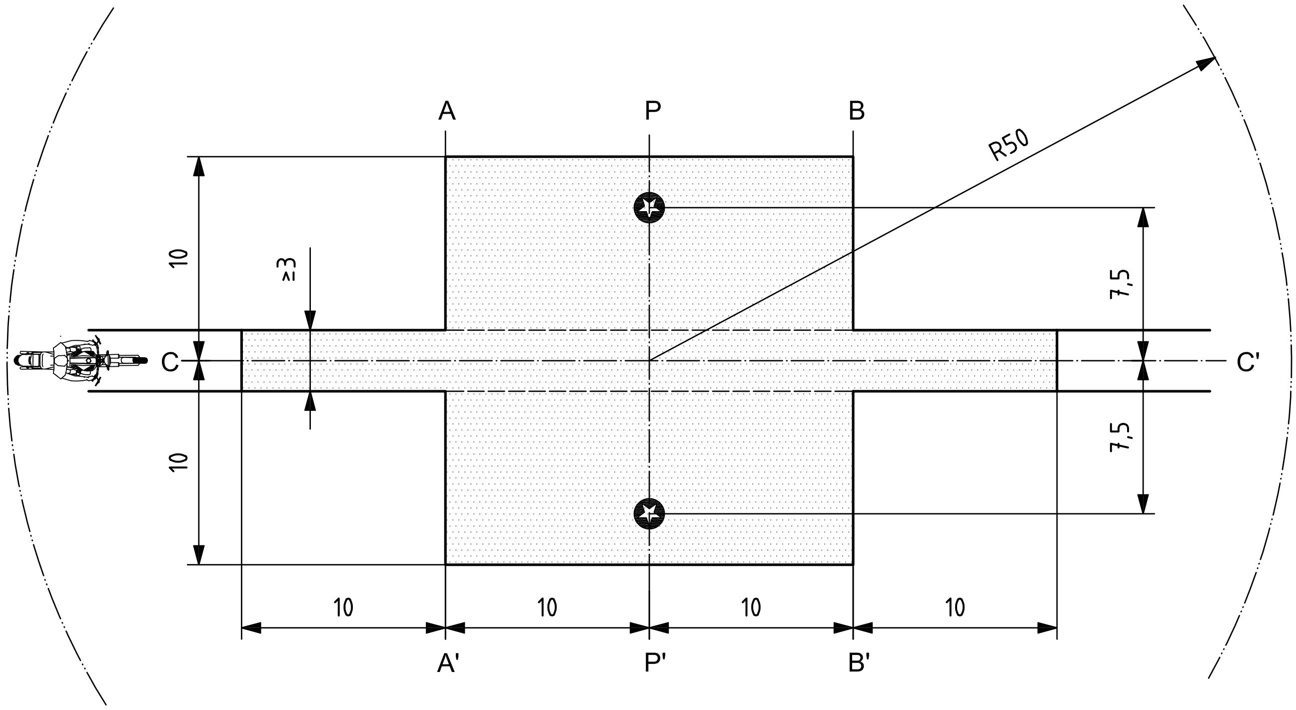
NOTE 1 The symbols in Figure 1 are directly copied from ISO 10844 and are not necessarily consistent with the symbols in this part of ISO 362.

Within a radius of 50 m around the centre of the track, the space shall be free of large reflective 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 2 Buildings outside the 50 m radius can have significant influence if their reflection focuses on the test track.

Dimensions in metres



Key

(shaded)	minimum area covered with test road surface, i.e. test area
✪	microphone positions (height 1,2 m)
AA′	test zone start
BB′	test zone end
CC′	line of vehicle travel through test zone
PP′	line perpendicular to vehicle travel between microphone locations
R50	radius of 50 m around the centre of the track

NOTE The shaded area (“test area”) is the minimum area to be covered with a surface complying with ISO 10844.

Figure 1 — Test site dimensions

7.2 Meteorological conditions

The meteorological instrumentation shall deliver data representative of 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 noise measurement interval.

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

NOTE Refer to Annex B for the effects of temperature and other factors.

7.3 Background noise

Any sound peak which appears to be unrelated to the characteristics of the general level of noise of the vehicle shall be ignored when taking the readings.

The background noise shall be measured for a duration of 10 s 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 background sound pressure level and the measured sound pressure level is between 10 dB 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 an individual measured test value

Background sound pressure level difference to measured sound pressure level, in dB	10	11	12	13	14	greater than 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 1) on the test track shall be 7,5 m ± 0,05 m.

The microphone shall be located 1,2 m ± 0,02 m above 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 an approximate 60 s wait, at idle in neutral, between runs.

8.2.2 Test mass of the vehicle

Measurements shall be made on vehicles at the test mass m_t, in kilograms, specified as:

$$m_t = m_{ref} = m_{kerb} + m_d = m_{kerb} + 75\ \text{kg} \pm 5\ \text{kg}$$

NOTE 75 kg ± 5 kg equates to mass of the driver, m_d.

8.2.3 Tyre selection and condition

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

For certification and related purposes, additional requirements for the tyres, defined by regulation, are necessary. The tyres for such a test shall be selected by the vehicle manufacturer and shall correspond to one of the tyre sizes and types designated for the vehicle by the vehicle manufacturer. The tyre 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 and pattern can have a significant influence on the test result.

8.3 Operating conditions

8.3.1 Vehicles of category L3 with PMR $>$ 25

8.3.1.1 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′ (see Figure 1). Any trailer that 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:

40 km/h $\pm$ 1 km/h for PMR $\leqslant$ 50

50 km/h $\pm$ 1 km/h for PMR $>$ 50

The test speed shall be reached when the reference point (3.5) is at line PP′. The test speed shall be reduced by decrements of 10 % of $v_{\text{PP}'}$ in case the exit speed $v_{\text{BB}'}$ exceeds 75 % of v_{max}.

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.

Annex C gives gear selection criteria and test run criteria in a flowchart form as an aid to test operation.

8.3.1.3.2 Manual transmission, automatic transmissions, adaptive transmissions 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 potential $a_{\text{wot}\,i}$ under wide-open-throttle condition according to the specification in 5.2 in relation to the reference acceleration $a_{\text{wot ref}}$ required for the wide-open-throttle acceleration test according to Equation (6) or Equation (7) in 5.4.

The following conditions for selection of gear ratios are possible.

a) If there are two gear ratios that give acceleration in a tolerance band of ± 10 % of the reference acceleration, $a_{\text{wot ref}}$, both gear ratios shall be used for the test with the gear ratio weighting factor calculated as shown below.

b) If only one specific gear ratio gives acceleration in a tolerance band of ± 10 % of the reference acceleration, $a_{\text{wot ref}}$, the test shall be performed with that gear ratio.

c) 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 $a_{\text{wot ref}}$. Use both gear ratios for the test. The gear ratio weighting factor in relation to the reference acceleration $a_{\text{wot ref}}$ is calculated by:

$$k = [a_{\text{wot ref}} - a_{\text{wot }(i+1)}] / [a_{\text{wot } i} - a_{\text{wot }(i+1)}] \quad (9)$$

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, $a_{\text{wot test}}$, is then used for the calculation of the partial power factor k_{P} (see 3.9) instead of $a_{\text{wot ref}}$.

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 $a_{\text{wot test}}$ shall be calculated by either Equation (2) or Equation (3) as specified in 5.2.

The test may then include a gear change to a lower gear ratio 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 alternative 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, $a_{\text{wot test}}$, shall be greater or equal to a_{urban}.

The achieved acceleration, $a_{\text{wot test}}$, is then used for the calculation of the partial power factor, k_{P} (see 3.9) instead of $a_{\text{wot ref}}$.

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 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, $a_{\text{wot test}}$, shall be mathematically rounded to the nearest second decimal place.

8.3.1.5 Constant speed test

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 L3 with PMR $\leqslant$ 25

The only operating condition is a wide-open-throttle acceleration test. The general conditions specified in 8.3.1.1 shall apply. The initial test speed shall be as specified in 8.3.1.2. The test speed shall be reduced by decrements of 10 % of the initial test speed, v_{test}, in case the exit speed $v_{BB'}$ exceeds 75 % of v_{max} or in case the engine speed exceeds the rated engine speed, S, at BB′. The selected gear ratio shall be the lowest one without exceeding the rated engine speed, S, during the test. The final test conditions are determined by the lowest possible gear ratio at the highest possible test speed without exceeding 75 % of v_{max} and the rated engine speed, S, at BB′.

8.3.3 Vehicles of categories L4 and L5

8.3.3.1 General

The only operating condition is a wide-open-throttle acceleration test.

8.3.3.2 Automatic transmission

8.3.3.2.1 Approach speed

The vehicle shall approach AA′ at a constant speed corresponding to the lower of the following speeds:

— 50 km/h;

— the vehicle speed corresponding to an engine speed equal to 75 % of S.

If there is a downshift to first gear during the test, the vehicle speed can be increased up to a maximum of 60 km/h to avoid the downshift.

8.3.3.2.2 Gear ratio selection

The test shall be performed with the manual selector in the highest position. If an automatic downshift occurs to the first gear ratio, it shall be excluded. If an automatic downshift occurs to the highest gear ratio minus 1 or the highest gear ratio minus 2, the selector shall be placed in the highest position allowing the test to be performed without an automatic downshift.

If an electronic transmission cannot be tested, a programme shall be established and used that prevents a downshift to a gear not normal for urban driving.

8.3.3.3 Manual transmission

8.3.3.3.1 Approach speed

The vehicle shall approach AA′ at a constant speed corresponding to the lower of the following speeds:

— 50 km/h;

— the vehicle speed corresponding to an engine speed equal to 75 % of S.

8.3.3.3.2 Gear ratio selection

Vehicles fitted with a gearbox having not more than four gears shall be tested in second gear. If the engine speed at BB′ exceeds S, test in the next higher gear ratio.

Vehicles fitted with five or more gears shall be tested in the following gears.

— Vehicles fitted with an engine having a cylinder capacity not exceeding 175 cm^3 shall be tested only in third gear.

— Vehicles fitted with an engine having a cylinder capacity exceeding 175 cm^3 shall be tested in second gear and in third gear.

— If the engine speed at the line BB′ exceeds S, test only in third gear.

8.3.3.4 Other automatic transmissions

Vehicles without a manual selector shall approach AA′ at the various uniform speeds of 30 km/h, 40 km/h and 50 km/h, or at 75 % of v_{max} if this value is lower.

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′ (see Figure 1) shall be mathematically rounded to the nearest first decimal place (e.g. 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 mathematically rounded to the nearest first 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 intermediate result shall be the higher value of the two averages mathematically rounded to the first decimal place.

All further calculations to derive L_{urban} shall be done separately for the left and right vehicle side. The final value to be reported as the test result shall be the higher value of the two sides.

8.4.3 Vehicles of category L3 with PMR > 25

8.4.3.1 Acceleration

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

$$a_{wot\ test} = 1/4\ (a_{wot\ test\ 1} + a_{wot\ test\ 2} + a_{wot\ test\ 3} + a_{wot\ test\ 4}) \qquad (10)$$

where the numbers in brackets symbolize the test runs j.

8.4.3.2 Reported value and final results

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

$$L_{wot\ rep} = L_{wot\ (i+1)} + k\ [L_{wot\ i} - L_{wot\ (i+1)}] \qquad (11)$$

where k is the gear ratio weighting factor.

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

$$L_{crs\ rep} = L_{crs\ (i+1)} + k\,[L_{crs\ i} - L_{crs\ (i+1)}] \tag{12}$$

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

$$k_P = 1 - (a_{urban} / a_{wot\ ref}) \tag{13}$$

b) if only one gear was specified for the test, k_P is given by

$$k_P = 1 - (a_{urban} / a_{wot\ test}) \tag{14}$$

c) in cases where $a_{wot\ test}$ is less than a_{urban}

$$k_P = 0 \tag{15}$$

The final result is calculated by combining Equation (11) for $L_{wot\ rep}$ and Equation (12) for $L_{crs\ rep}$:

$$L_{urban} = L_{wot\ rep} - k_P\,(L_{wot\ rep} - L_{crs\ rep}) \tag{16}$$

8.4.4 Vehicles of category L3 with PMR ⩽ 25

The intermediate result in 8.4.2 shall be the final result.

8.4.5 Vehicles of categories L4 and L5

The final result shall be

a) the intermediate result in 8.4.2 in the case of vehicles tested in a single gear,

b) the arithmetic average of the intermediate results for each gear in the case of vehicles tested in two gears,

c) the highest intermediate result in the case of vehicles tested at multiple speeds.

8.5 Measurement uncertainty

The measurement procedure described in 8.4 is affected by several parameters (e.g. ISO 10844 surface texture variation, environmental conditions, measurement system uncertainty, etc.) that lead to variation in the resulting level observed for the same subject. The source and nature of these perturbations are not completely known and sometimes affect the end result in a non-predictable way. The uncertainty of results obtained from measurements according to this part of ISO 362 can be evaluated by the procedure given in ISO/IEC Guide 98-3 or by interlaboratory comparisons in accordance with ISO 5725 (parts 1 to 6). Since extensive inter- and intra-laboratory data were not yet available, the procedure given in ISO/IEC Guide 98-3 was followed to estimate the uncertainty associated with this part of ISO 362. The uncertainties given below were based on existing statistical data, analysis of tolerances stated in this part of ISO 362 and engineering judgement. The uncertainties so determined were grouped as follows:

a) variations expected within the same test laboratory and slight variations in ambient conditions found within a single test series (run-to-run);

b) variations expected within the same test laboratory but with variation in ambient conditions and equipment properties that can normally be expected during the year (day-to-day);

c) variations between test laboratories where, apart from ambient conditions, equipment, staff and road surface conditions will also be different (site-to-site).

If reported, the expanded uncertainty together with the corresponding coverage probability as defined in ISO/IEC Guide 98-3 shall be given. Information on the determination of the expanded uncertainty is given in Annex B.

NOTE Annex B gives a framework for analysis in accordance with ISO/IEC Guide 98-3, which can be used to conduct future research on measurement uncertainty for this part of ISO 362.

The data given in Table 3 express the variability of results for vehicles of category L for a coverage probability of 80 %. These data do not cover product variation.

Table 3 — Variability of measurement results for a coverage probability of 80 %

Run-to-run dB	**Day-to-day** dB	**Site-to-site** dB
0,5	0,9	1,4

Until more specific knowledge is available, the data for site-to-site variability might be used in test reports to state the expanded measurement uncertainty for a coverage probability of 80 %.

9 Test report

The test report shall include the following information:

a) reference to this part of ISO 362;

b) details of the test site, site orientation and weather conditions, including wind speed and 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;

e) the identification of the vehicle, its engine, its transmission system, including available transmission ratios, size and type of tyres, tyre pressure, tyre production type, power, test mass, power-to-mass ratio and vehicle length;

f) the transmission gears or gear ratios used during the test;

g) the vehicle speed and engine speed at the beginning of the period of acceleration, and the location of the beginning of the acceleration;

h) the vehicle speed ($v_{PP'}$, $v_{BB'}$) and engine speed ($n_{BB'}$, $n_{PP'}$) at PP′ and at end of the acceleration;

i) the method used for calculation of the acceleration;

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

k) 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.

Annex A
(informative)

Technical background for development of vehicle noise test procedure based on in-use operation in urban conditions

A.1 Introduction

This annex provides technical background information on the development process of the vehicle noise test procedure derived from actual vehicle in-use data. This annex uses examples drawn from the actual in-use studies, but does not present the full in-use databases.

The procedure described in this part of ISO 362 represents a measure of the vehicle noise emission which is controllable by the vehicle manufacturer. Other — often significant — contributors to the traffic noise situation are outside the control of vehicle manufacturers. These items include road surfaces, traffic regulations, aftermarket part control, in-use noise emission monitoring and effective enforcement mechanisms.

A.2 The need for a new test procedure

The present procedure that supports regulation in most global markets is specified in ISO 362:1998. The measurement is performed on a specified test surface (see ISO 10844). The vehicle drives with wide-open-throttle, in second and/or third gear. The entry speed 10 m prior to the microphone position is 50 km/h. The resulting sound pressure level is the result of the single gear test for 2nd or 3rd gear only, and the average of the measured sound pressure levels for the 2nd and 3rd gear test. With the support of this procedure, the regulated limit has been strongly reduced (from 86 dB to 80 dB between 1980 and 1999 in the EU).

Historically, there has been recognition within the legislative community and the motorcycle industry that the existing noise test procedure for motorcycles as specified in ISO 362:1998 is deficient, as it is unable to simulate typical motorcycle behaviour and is not sufficiently robust in terms of cycle-bypassing or sub-optimization. (See References [8], [9], [10], [11], [12], [13], [14], [15].)

The in-use data show that the vast majority of real in-use motorcycle usage is partial throttle operation and not wide-open-throttle operation. Therefore, the new noise test procedure is made to approximate partial throttle operation through the mathematical interpolation of a wide-open-throttle and steady state, constant speed test. Such interpolation is necessary since actual partial throttle acceleration presents control problems. This is why the new noise test procedure prescribes wide-open-throttle and constant speed test conditions related to vehicle acceleration capability and vehicle and engine speed corresponding to typical motorcycle usage in urban areas. This combination of repeatable and reproducible tests ensures consistency and equality across the entire spectrum of motorcycle types.

A.3 In-use data collection and analysis

The vehicle noise depends mainly on three vehicle parameters:

1) vehicle speed;

2) vehicle acceleration (engine load);

3) engine speed n (for internal combustion engines only).

Tyre/road noise is incorporated by its dependence on vehicle speed and vehicle acceleration and can be neglected in case of category L vehicles. Two of the three parameters, vehicle speed and vehicle acceleration, describe driving behaviour. The vehicle parameters depend on the driver's commands (input), but also on the vehicle performance and the traffic environment.

The third condition, engine speed, is an additional parameter which results from vehicle acceleration and vehicle speed. Thus, the urban traffic study has to identify the independent parameters of

a) vehicle speed, and

b) vehicle acceleration.

In order to obtain this information, a study of actual urban driving has been performed, which started with the collection of motorcycle in-use data in terms of vehicle and engine speed. The in-use data used for the development of the Worldwide Motorcycle Exhaust Emission Test Cycle (WMTC) under the auspices of the UN’s Economic Commission for Europe was complemented with additional data collected specifically for the purpose of developing a new noise test procedure.

In-use data was collected in locations throughout Europe, Asia and the US with the following particulars:

— 43 vehicles (11 in Europe; 5 in the US; 27 in Asia);

— 490 trips;

— 10 706 driving modules;

— 22 210 km driving distance.

To ensure optimum consistency with the WMTC development process, the same driving module characterization criteria were used as shown in Table A.1.

Table A.1 — Characterization criteria for driving modules

Allocation of driving	
Part 1	0 km/h to 60 km/h ⩾ 80 %
	90+ km/h = 0 %
	v_{max} ⩽ 80 km/h
	Additionally: length of sequence ⩾ 1 m
Part 2	0 km/h to 60 km/h ⩽ 70 %
	60 km/h to 90 km/h ⩾ 30%
	90+ km/h ⩽ 50 %
	v_{max} ⩽ 110 km/h
Part 3	0 km/h to 60 km/h ⩽ 20 %
	90+ km/h ⩾ 50 %

The aim has been to develop a new noise test procedure that replicates the typical motorcycle operating conditions where motorcycles are in closest proximity to the greater part of the population most of the time. This resulted in the decision to focus on the Part 1 driving modules for further analysis. Applying the characterization criteria in Table A.1, 5 978 driving modules representing 3 965 km of driving distance were identified as belonging to Part 1.

Analysis of these modules resulted in the following median vehicle speeds:

40 km/h for PMR $\leqslant$ 50

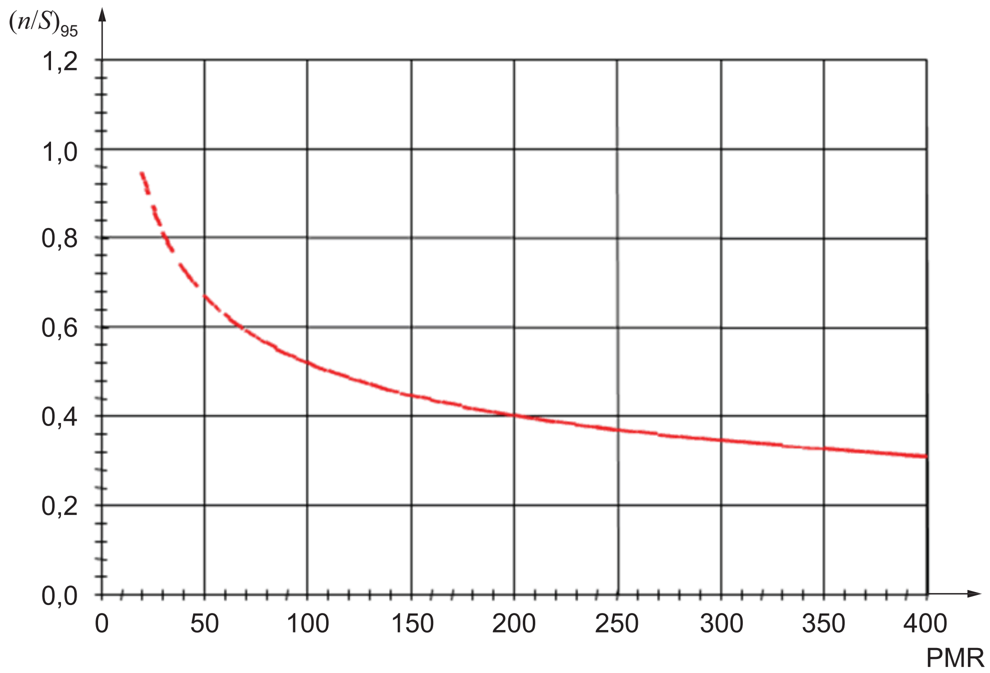
50 km/h for PMR $>$ 50

These median vehicle speeds defined the following vehicle speed windows:

40 km/h $\pm$ 5 km/h for PMR $\leqslant$ 50

50 km/h $\pm$ 5 km/h for PMR $>$ 50

Within these windows, the in-use data was analyzed in terms of engine speed ratio, $(n/S)_{95}$, and urban traffic acceleration, a_{urban}, as a function of power-to-mass ratio as shown in Figures A.1 and A.2.

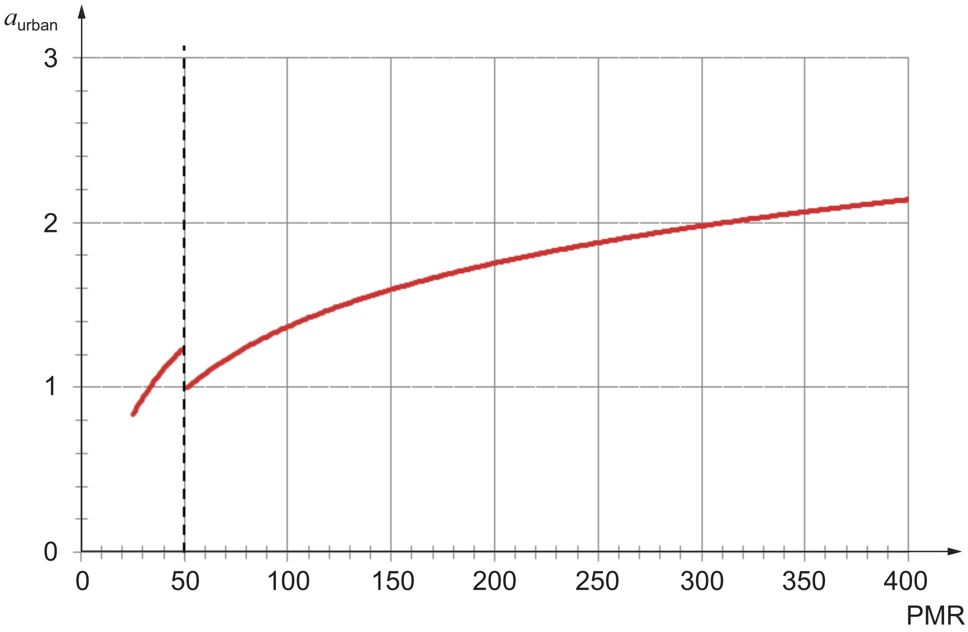


Key

PMR power-to-mass ratio

$(n/S)_{95}$ 95th percentile engine speed ratio

Figure A.1 — Regression curve $(n/S)_{95} = f(\text{PMR})$



Key

PMR power-to-mass ratio

a_{urban} urban traffic acceleration

Figure A.2 — Regression curve $a_{urban} = f(\text{PMR})$

A.4 Determination of wide-open-throttle acceleration

The relationship that exists between engine speed ratio and power-to-mass ratio was used to establish a relationship between vehicle acceleration and power-to-mass ratio. This allows making the new noise test procedure independent of engine speed so that it can be applied to all types of propulsion technologies — including those not relying on an internal combustion engine.

To this end, test track measurements were performed on 36 motorcycles with wide-open-throttle acceleration. This involved the use of gears i and $(i + 1)$ in the case of manual transmission motorcycles, which result in accelerations $a_{\text{wot }i}$ and $a_{\text{wot }(i+1)}$ and vehicle speeds $v_{(n/S)95\ i}$ and $v_{(n/S)95\ (i+1)}$ at the engine speed for the given PMR below and above the applicable test speed, v_{test}, respecting.

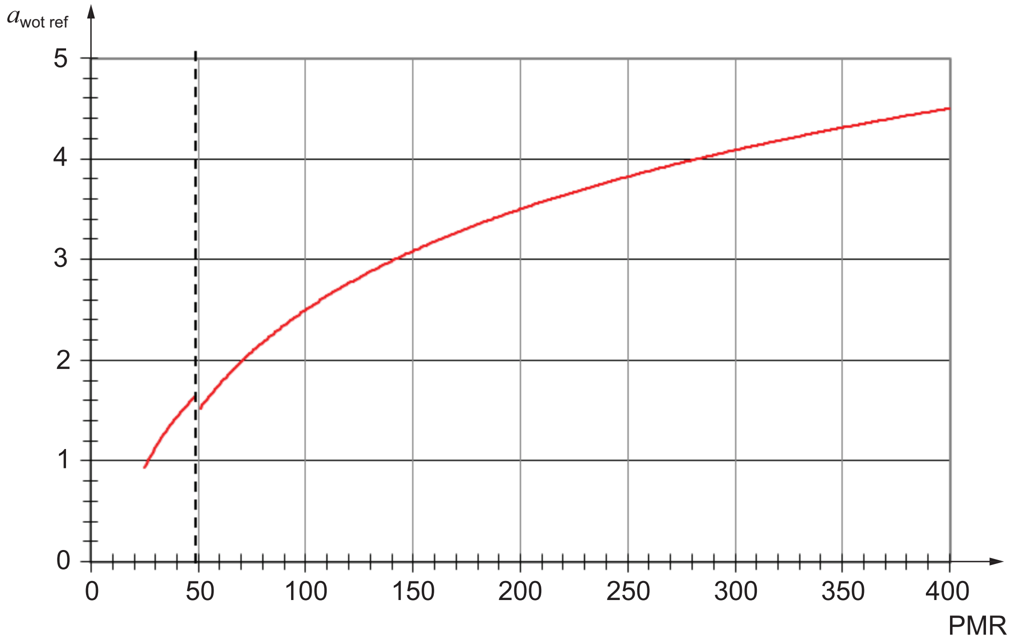
The interpolation factor, k_n, between gears i and $(i + 1)$ was then calculated as shown below, using the statistical value of $(n/S)_{95}$:

$$k_n = [v_{(n/S)95\ (i+1)} - v_{test}] / [v_{(n/S)95\ (i+1)} - v_{(n/S)95\ i}]$$

Finally, the wide-open-throttle acceleration $a_{\text{wot }50}$ was calculated:

$$a_{\text{wot}50} = a_{\text{wot }(i+1)} + k_n\ [a_{\text{wot }i} - a_{\text{wot }(i+1)}]$$

Regression analysis for all values of $a_{\text{wot }50}$ results in $a_{\text{wot ref}}$ as a function of power-to-mass ratio as represented in Figure A.3.



Key

PMR power-to-mass ratio

$a_{\text{wot ref}}$ reference acceleration for the wide-open-throttle test

Figure A.3 — Regression curve $a_{\text{wot ref}} = f(\text{PMR})$

A.5 Determination of L_{urban}

The vehicle noise emission, L_{urban}, for partial power is simulated by the combination of two test results using the hypothesis that for one vehicle speed and one engine speed, the vehicle sound pressure level is proportional to the engine torque:

— the wide-open-throttle test in which the vehicle acceleration reaches the $a_{\text{wot ref}}$ acceleration and emits the measured level of noise, $L_{\text{wot rep}}$;

— the constant speed test with the vehicle emitting the measured level of noise, $L_{\text{crs rep}}$.

The final result is given by the weighted average of these two results:

$$L_{\text{urban}} = L_{\text{wot rep}} - k_{\text{P}}(L_{\text{wot rep}} - L_{\text{crs rep}})$$

The wide-open-throttle acceleration, $a_{\text{wot ref}}$, is simulated by the combination of the $a_{\text{wot }i}$ and $a_{\text{wot }(i+1)}$ accelerations corresponding to the two i and $(i + 1)$ gears with

$$a_{\text{wot }(i+1)} < a_{\text{wot ref}} < a_{\text{wot }i} \text{ and}$$

$$k_n = [a_{\text{wot ref}} - a_{\text{wot }(i+1)}] / [a_{\text{wot }i} - a_{\text{wot }(i+1)}]$$

where k_n is defined as the interpolation factor between the i and $(i + 1)$ gears.

The wide-open-throttle level of noise, $L_{\text{wot rep}}$, or constant speed level of noise, $L_{\text{crs rep}}$, of a vehicle is a combination of the measured level of noise for the i and $(i + 1)$ gears at wide-open-throttle and at constant speed, using the hypothesis that noise is proportional to engine speed if vehicle speed and engine load are constant.

$$L_{\text{wot rep}} = L_{\text{wot }(i+1)} + k_n[L_{\text{wot }i} - L_{\text{wot }(i+1)}]$$

$$L_{\text{crs rep}} = L_{\text{crs }(i+1)} + k_n[L_{\text{crs }i} - L_{\text{crs }(i+1)}]$$

Noise frequency spectrum analysis was used to show that the noise test procedure prescribed in ISO 362:1998 results in noise emission patterns that are significantly different from what the in-use data presents as real-world motorcycle operation (i.e. predominantly partial throttle acceleration). Noise frequency spectrum analysis applied to exhaust, air intake and tyre noise was used to prove that the noise test procedure, combining wide-open-throttle acceleration with constant speed tests, correctly simulates actual partial throttle acceleration noise emissions. These findings substantiate earlier claims related to the usefulness of the new noise test in identifying the noise sources that are most relevant in an urban and conurban context. As a consequence, it can also be argued that noise limits defined on the basis of the new test procedure should be more effective in reducing the noise impact of motorcycles.

Annex B
(informative)

Measurement uncertainty — Framework for analysis according to ISO/IEC Guide 98-3

B.1 General

The measurement procedure is affected by several factors causing disturbance that lead to variation in the resulting level observed for the same subject. The source and nature of these perturbations are not completely known and sometimes affect the end result in a non-predictable way. The accepted format for expression of uncertainties generally associated with methods of measurement is that given in ISO/IEC Guide 98-3. This format incorporates an uncertainty budget, in which all the various sources of uncertainty are identified and quantified, and from which the combined standard uncertainty can be obtained. Uncertainties are due to the following factors:

— variations in measurement devices, such as sound level meters, calibrators and speed-measuring devices;

— variations in local environmental conditions that affect sound propagation at the time of measurement of L_{urban};

— variations in vehicle speed and in vehicle position during the pass-by run;

— variations in local environmental conditions that affect the characteristics of the source;

— effect of environmental conditions that influence the mechanical characteristics of the source, mainly engine performance (air pressure, air density, humidity, air temperature);

— effect of environmental conditions that influence the sound production of the propulsion system (air pressure, air density, humidity, air temperature) and the roiling noise (tyre and road surface temperature, humid surfaces);

— test site properties (test surface texture and absorption, surface gradient).

The uncertainty determined according to 8.5 represents the uncertainty associated with this part of ISO 362. It does not cover the uncertainty associated with the variation in the production processes of the manufacturer. The variations in the urban sound pressure level of identical units of a production process are outside the scope of this part of ISO 362.

The uncertainty effects may be grouped in the three areas composed of the following sources (see 8.5):

a) uncertainty due to changes in vehicle operation within consecutive runs, small changes in weather conditions, small changes in background noise levels, and measurement system uncertainty: referred to as run-to-run variations;

b) uncertainty due to changes in weather conditions throughout the year, changing properties of a test surface over time, changes in measurement system performance over longer periods, and changes in the vehicle operation: referred to as day-to-day variations;

c) uncertainty due to different test site locations, measurement systems, road surface characteristics and vehicle operation: referred to as site-to-site variations.

The site-to-site variation comprises uncertainty sources from a), b) and c). The day-to-day variation comprises uncertainty sources from a) and b).

B.2 Expression for the calculation of sound pressure levels of vehicles in urban operation

The general expression for the calculation of the urban-operation sound pressure level, L_{urban}, is given by the following equation:

$$L_{\text{urban}} = L_{\text{wot rep}} - k_{\text{P}}(L_{\text{wot rep}} - L_{\text{crs rep}}) + \delta_1 + \delta_2 + \delta_3 + \delta_4 + \delta_5 + \delta_6 + \delta_7 \quad \text{(B.1)}$$

where

$L_{\text{wot rep}}$ is the A-weighted sound pressure level from wide-open-throttle tests;

$L_{\text{crs rep}}$ is the A-weighted sound pressure level from constant speed tests, if applicable;

k_{P} is the partial power factor, if applicable;

δ_1 is an input quantity to allow for any uncertainty in the measurement system;

δ_2 is an input quantity to allow for any uncertainty in the environmental conditions that affect sound propagation from the source at the time of measurement;

δ_3 is an input quantity to allow for any uncertainty in the vehicle speed and position;

δ_4 is an input quantity to allow for any uncertainty in the local environmental conditions that affect characteristics of the source;

δ_5 is an input quantity to allow for any uncertainty in the effect of environmental conditions on the mechanical characteristics of the power unit;

δ_6 is an input quantity to allow for any uncertainty in the effect of environmental conditions on the sound production of the propulsion system and the tyre/road noise;

δ_7 is an input quantity to allow for any uncertainty in the effect of test site properties, primarily related to road surface characteristics.

NOTE 1 The inputs included in Equation (B.1) to allow for uncertainties are those thought to be applicable according to the state of knowledge at the time when this part of ISO 362 was being prepared, but further research could reveal that there are others.

NOTE 2 The estimated values of the delta functions may be principally positive or negative although they are considered to be zero for the given measurement (see Table B.1). Their uncertainties are not additive for the purpose of determining a measurement result.

B.3 Uncertainty budget

Table B.1 — Uncertainty budget for determination of urban sound pressure level

Quantity	**Estimate** dB	**Standard uncertainty**, u_i dB	**Probability distribution**	**Sensitivity coefficient**, c_i	**Uncertainty contribution**, $u_i c_i$ dB
$L_{\text{wot rep}}$	$L_{\text{wot rep}}$			1	
k_{P}	k_{P}			$L_{\text{wot rep}} - L_{\text{crs rep}}$	
$L_{\text{wot rep}} - L_{\text{crs rep}}$	$L_{\text{wot rep}} - L_{\text{crs rep}}$			k_{P}	
δ_1	0			1	
δ_2	0			1	
δ_3	0			1	
δ_4	0			1	
δ_5	0			1	
δ_6	0			1	
δ_7	0			1	

From the individual uncertainty contributions, $u_i c_i$, the combined standard uncertainty, u, can be calculated according to the rules of ISO/IEC Guide 98-3, taking into account potential correlations between various input quantities.

NOTE The uncertainty evaluation described represents a framework that provides useful information to users of this part of ISO 362. This information represents the state of technical information at this time. Further work is necessary to provide uncertainty information on all terms in Equation (B.1) and all interactions between such terms.

B.4 Expanded uncertainty of measurement

The expanded uncertainty, U, is calculated by multiplying the combined standard uncertainty, u, with the appropriate coverage factor for the chosen coverage probability as described in ISO/IEC Guide 98-3.

Annex C
(informative)

Flowchart of the procedure for category L3 with PMR > 25

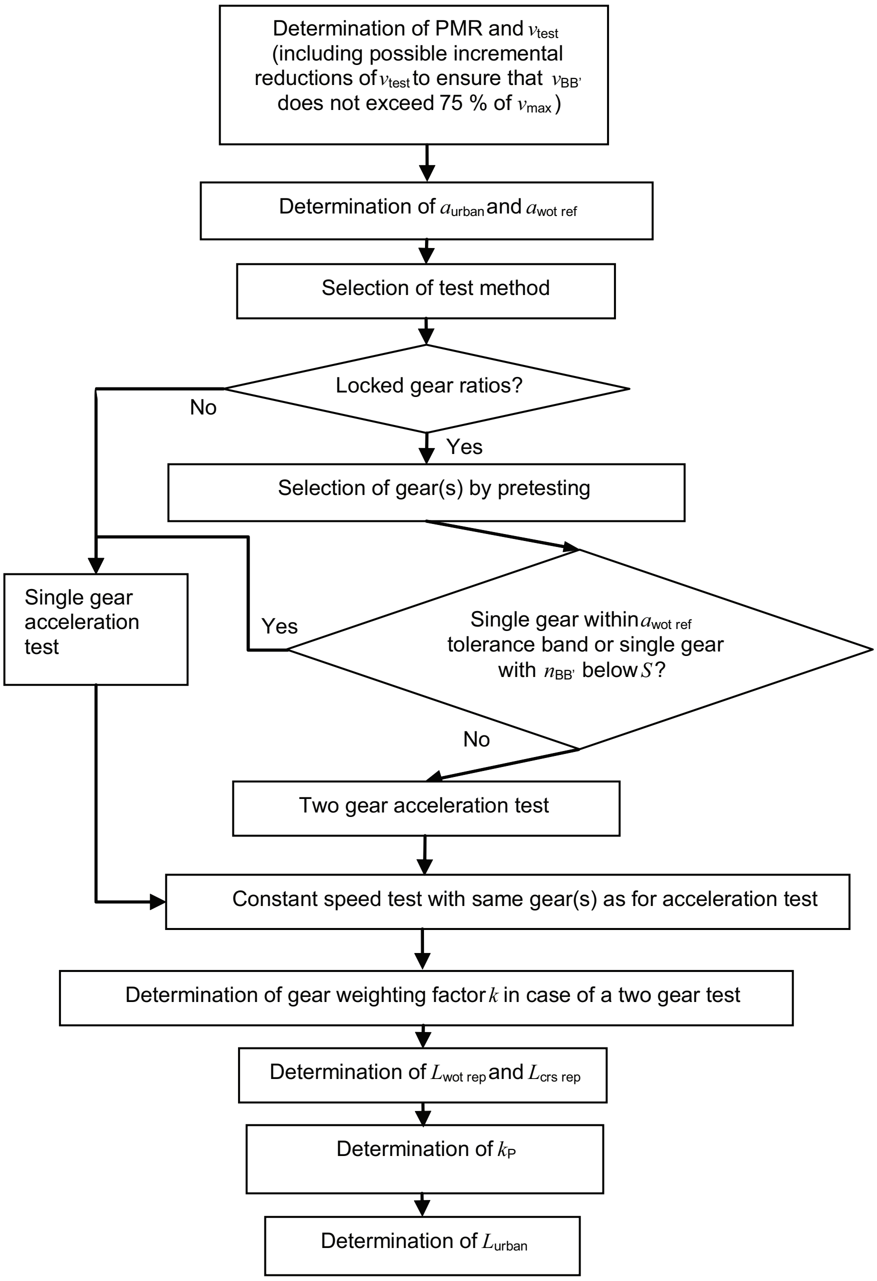


Figure C.1 — Flowchart

Annex D
(informative)

Flowchart for vehicles of category L3 with PMR ⩽ 25

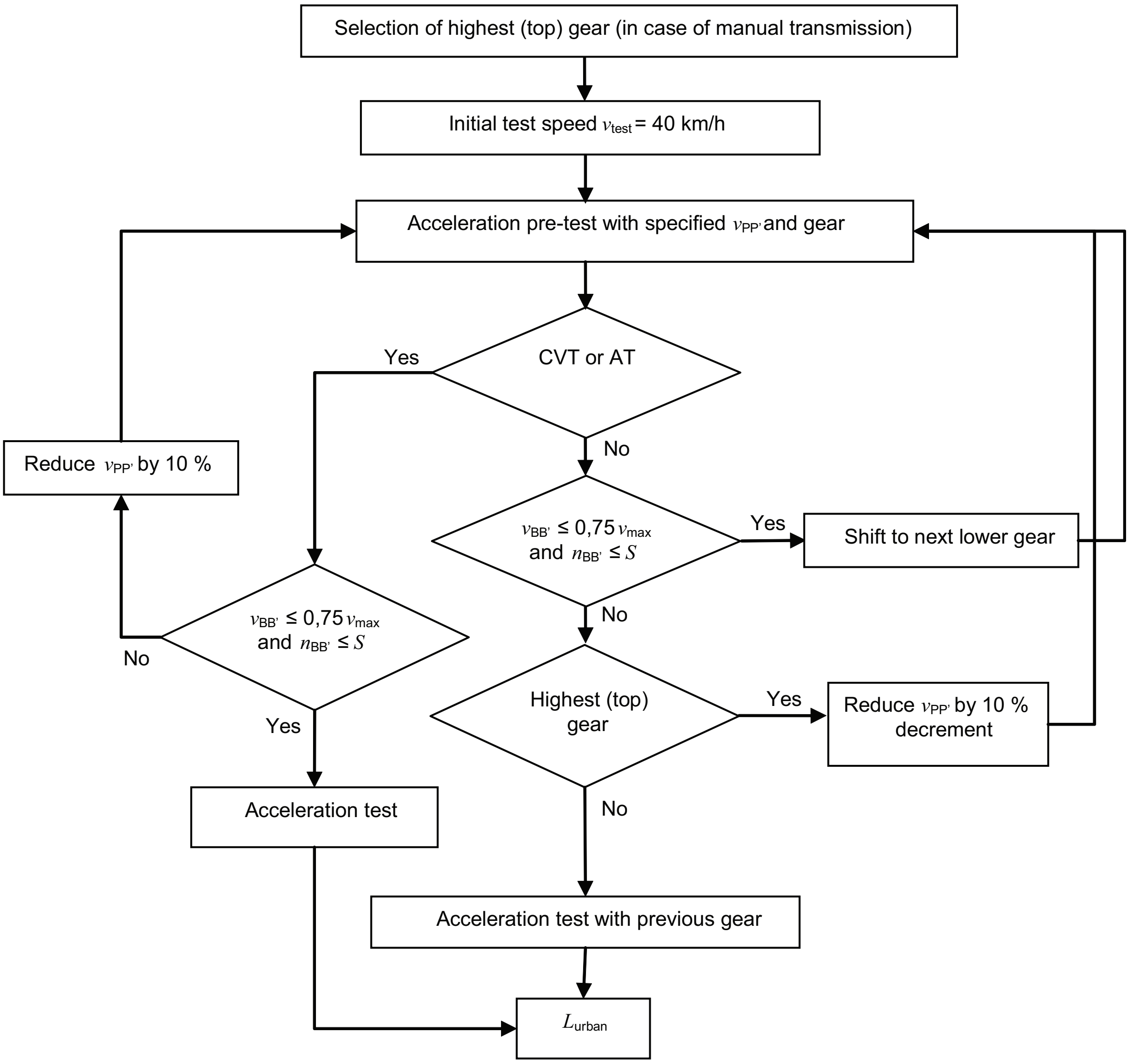


Figure D.1 — Flowchart

Annex E
(informative)

Flowchart for vehicles of categories L4 and L5

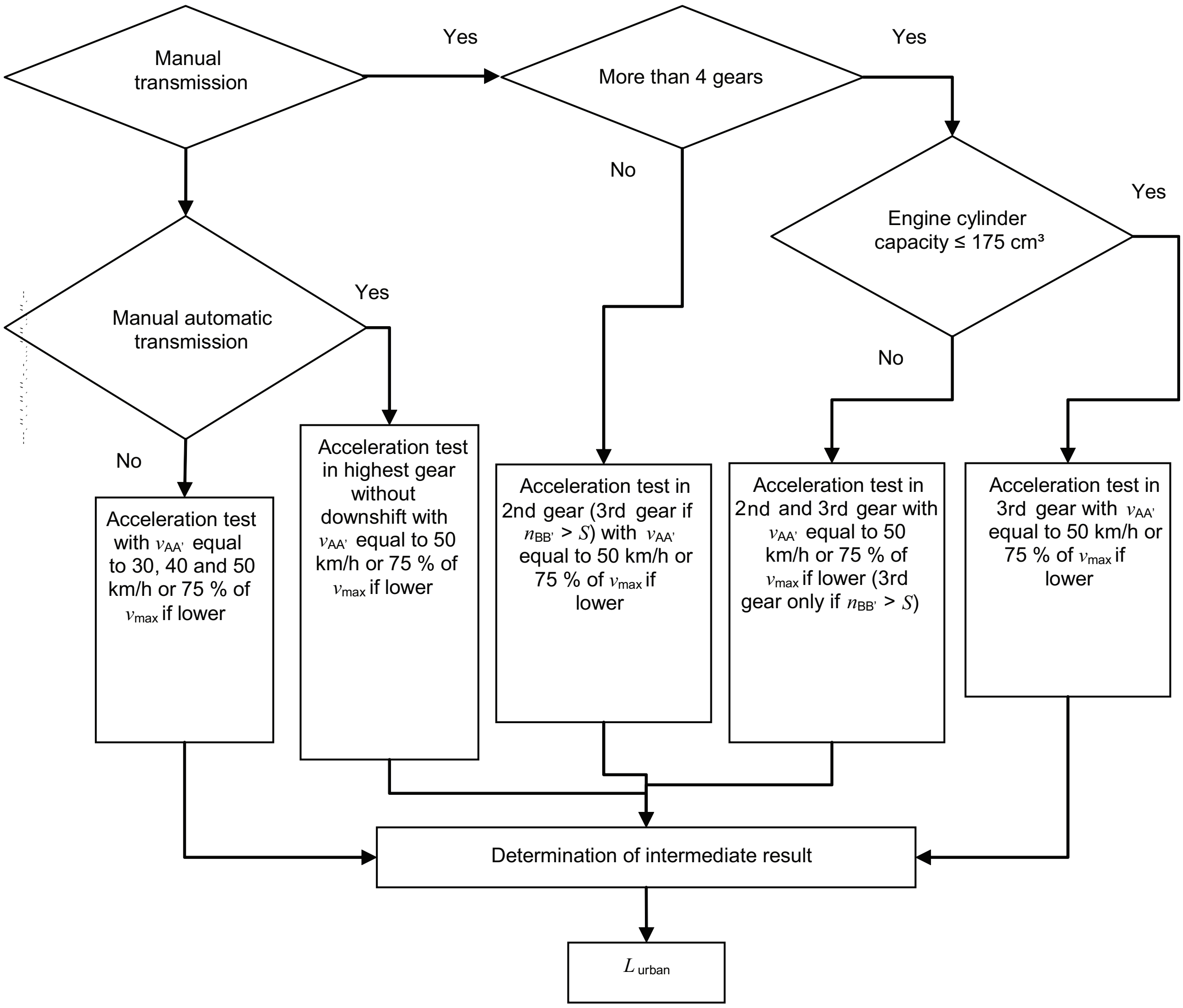


Figure E.1 — Flowchart

Annex F
(informative)

Indoor test operation

F.1 General

With the technological advancements in room acoustics, vehicle dynamometer simulation and digital signal processing typically available in today's marketplace, it is possible to conduct vehicle exterior noise measurements indoors with a high degree of accuracy. Testing conducted at various indoor facilities has shown good correlation to similar tests performed at a conventional open-air test site. Conducting testing, as described in this part of ISO 362, in an indoor environment eliminates constraints due to ambient conditions such as weather and background noise. In addition, indoor testing can provide significant time savings during vehicle development programmes in which many iterative tests are performed.

The information given in this annex outlines the basic requirements for such an indoor test facility, as well as information to improve correlation of indoor and open-air testing.

F.2 Concept

The exterior noise test operation described in this part of ISO 362 is designed to measure the noise radiated from a vehicle to a stationary bystander on the street during an urban driving cycle. One of the principal criteria of this part of ISO 362 is that testing be performed in an acoustic free field or, more precisely, a hemi-anechoic space. This acoustic criterion can be reproduced in a laboratory by installing sound absorbing wedges in a sufficiently large dynamometer room to provide a hemi-anechoic space with the same effective propagation characteristics as an open-air space.

A dynamometer test bench is used to simulate the road operation of the vehicle. The vehicle's radiated noise is measured using a roving microphone or microphone array, which collects time-based acoustic data. Movement of the vehicle past the stationary measurement point, as in open-air testing, is simulated using digital signal processing techniques and a synchronized sampling of the time-based acoustic data.

F.3 Room requirements

The determining factor in the room width is the desired low-frequency cut-off of the hemi-anechoic space. As a general rule, the microphones should be a quarter wavelength from the absorptive walls, and the absorptive media should be nominally a quarter of the wavelength of the lowest frequency of interest. As an example, if a 4-cylinder engine being tested has a lower engine speed of 1 000, then the lowest firing frequency of the engine is approximately 34 Hz. To design a hemi-anechoic room with a low-frequency cut-off of 34 Hz, the wedge thickness would nominally be 2,6 m. For this example, the outer dimension of the test room should be approximately 18 m for a single-sided facility, or 27 m for a dual-sided facility.

The length of the room depends on the length of the longest vehicle to be tested, plus the length of the test track (20 m), plus the space for the absorbing wedges and microphone placement. For a typical vehicle of 5 m in length, the room should be 36 m long.

The height of the room follows a similar set of requirements; however, a nominal value used is 7,5 m to the wedge face (which equates to an outside dimension of 10,1 m).

All room dimensions should be adjusted to meet the specific application for the products being tested.

F.4 Dynamometer requirements

There are many dynamometer drive systems available for this use. The unit should be capable of applying a road load to the drive wheels of the vehicle, in many cases all four. The unit should also be designed to be quiet enough to be 15 dB below the lowest level being measured in the test cell. In general, a dynamometer with an operating A-weighted sound pressure level of near 50 dB will meet most requirements. In practice, many facilities exhibit ambient A-weighted sound pressure levels as low as 34 dB. A full acoustic spectrum analysis should be made of the facility to ensure the acoustic quality of the test space.

Finally, the dynamometer unit should be able to follow the rapid transient of the vehicle acceleration cycle. In many cases, the operation of the vehicle is controlled using a computerized throttle application. If the vehicle is to be driven by human control, extra care should be taken in the design of the facility air-handling system (see F.5). However, note that human variation increases the variation of the total measurement system.

F.5 Air-handling system requirements

To fully simulate the open-air vehicle noise test as described in this part of ISO 362, the vehicle should be tested with its exhaust system fully exposed to the acoustic space. This type of testing can lead to the dangerous collection of high levels of carbon monoxide and other harmful gases. For this reason, the laboratory test chamber should be sufficiently sealed to prevent leakage of these harmful gases to surrounding occupied spaces. In addition, the facility should include an exhaust system able to move sufficient clean air into the test space to remove the vehicle exhaust fumes. Such a system should be designed to be quiet if run on an automatic schedule. The facility should also be equipped with a carbon monoxide level monitoring system.

Vehicle cooling should be addressed for prolonged testing. Typically, a large volume fan can be fitted in front of the vehicle to provide sufficient airflow around the vehicle. Such fans can, however, be very noisy and should only be operated in between test runs. The control of the ambient temperature within the test facility is also a consideration. Generally, an ambient level of (20 ± 3) °C is feasible for most applications.

F.6 Microphone placement

Typical facilities currently in use utilize 15 to 20 microphones placed in a line on either one side or both sides of the vehicle. The microphone array is placed at a distance of 7,5 m from the longitudinal centreline of the vehicle. In most cases, the array is evenly spaced along the line with the array extending from 10 m in front of the vehicle microphone to 10 m behind the rear of the vehicle.

F.7 Data analysis

Acoustical data from each of the measuring microphones are acquired and stored to computer memory as time histories. At the same time, data are acquired to quantify the vehicle speed and engine speed during the test. These various sources of information are combined, based on a trigger signal relating to line AA′ of the test track when the accelerator throttle is applied. The time data from each of the microphones are sequenced over time, based on the speed of the vehicle and its simulated position along the test track. Through the process of combining these signals, a virtual sweep is made of the microphone array to represent the movement of the vehicle past a single microphone. The digital signal processing system provides a single plot of the overall sound pressure level of the vehicle as a function of its position along the "course". In addition, typical commercially available systems generally have the capability to provide additional time-based analysis of each of the individual microphones. This enhances the capability of defining specific noise sources, such as the level from the microphone directly in line with the exhaust outlet or at the centreline of the vehicle front axle. Most data processing systems offer an array of analysis tools that provide a detailed mapping of the vehicle noise information.

F.8 Measurement capability

Typical facilities in use today demonstrate good correlation between open-air road tests and indoor dynamometer tests for the powertrain portion of overall vehicle noise. These facilities have become valuable tools for many vehicle manufacturers.

Unfortunately, correlation for the full vehicle continues to be problematic. The primary issue remaining in the correlation of indoor test facilities to open-air facilities is the proper measurement of the tyre/road noise component of overall vehicle noise. For most facilities, when a production tyre is placed on an average diameter dynamometer roll, its contact patch is modified such that the level of noise produced increases significantly from that produced on the flat test road surface. This situation is highly dependent on the tyre size and construction and does not necessarily affect all vehicle types in the same fashion.

To improve test correlation, the use of tyres with no tread (blank tread tyres) can be used and have been shown to provide good results. The noise produced by the tyre/road interface should then be accounted for by other means. Research is under way by some organizations to measure vehicle tyre/road noise independently and then combine the results of the two tests to determine the full vehicle level of noise.

Even with the current limitation to full vehicle correlation, the ability to conduct exterior noise tests of vehicles in an indoor environment has been shown to be beneficial. The indoor method eliminates restrictions due to ambient conditions, especially in areas where rain, snow and wind conditions result in significant time loss. Significant time is also saved in the development of vehicle components and sub-systems where iterative testing is required. Additionally, indoor testing can be used to provide validation data to verify that a component change, other than tyres, will not alter the type approval sound pressure level of a vehicle.

Bibliography

[1] ISO 362:1998, *Acoustics — Measurement of noise emitted by accelerating road vehicles — Engineering method*

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

[3] ISO 5725 (all parts), *Accuracy (trueness and precision) of measurement methods and results*

[4] ISO 9645, *Acoustics — Measurement of noise emitted by two-wheeled mopeds in motion — Engineering method*

[5] ISO 80000-3, *Quantities and units — Part 3: Space and time*

[6] MOORE, D.B. *Evaluation of the Revised ISO 362 Standard for Vehicle Exterior Noise Measurement.* Paper No. 2005-01-2417, Society of Automotive Engineers, 2005

[7] MORGAN, P.A., NELSON, P.M. and STEVEN, H. *Integrated assessment of noise reduction measures in the road transport sector.* Project report PR SE/652/03 for the European Commission, 2003

[8] SANDBERG, U. *Noise Emission from Powered Two-Wheeled Vehicles.* Position paper for the European Commission Working Group on Road Traffic Noise, 2002

[9] STENSCHKE, R. *Auswirkung von Massnahmen zur Geräuschminderung an motorisierten Zweirädern auf die Geräuschemission im realen Verkehr.* VDI BERICHT No. 1159, 1994

[10] Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit. *Motorrad und Umwelt.* Bericht der BMU — Projektgruppe "Motorrad und Umwelt", 1999

[11] Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit. *Macht Lärm Motorradfahren erst schön?*, various presentations and papers at BMU Symposium, 2002

[12] European Union Green Paper, COM(1996) 540, 1996

[13] International Institute of Noise Control Engineering. *Noise emissions of road vehicles — effect of regulations.* Final Report 01-1, 2001

[14] International Motorcycle Manufacturers Association. Motorcycle Noise: *The Curious Silence.* Report by the motorcycle industry, 1996

[15] United Nations Economic Commission for Europe. *Report on the development of a global technical regulation concerning worldwide harmonized motorcycle emissions certification procedure (WMTC).* ECE/TRANS/180/Add.2/Appendix 1, 2005

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