
**Acoustics — Engineering method for
measurement of noise emitted by
accelerating road vehicles —**

**Part 1:
M and N categories**

*Acoustique — Méthode d'ingénierie pour le mesurage du bruit émis
par les véhicules routiers en accélération —*

Partie 1: Catégories M et N





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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This third edition cancels and replaces the second edition (ISO 362-1:2015), which has been technically revised.

The main changes compared to the previous edition are as follows:

- Clarification on the measurement zone to provide equivalent results between hand held sound level meters and digital data acquisition systems.
 - Clarification of original intent of ISO 362-1 on M1/N1 gear ratio selection to account for practical lessons learned.
 - Clarification and examples of measures used to control vehicle operation so as to provide the specified accelerations of ISO 362-1
 - Addition of and clarification of tolerances, measurement precision, vehicle operation, vehicle physical attributes, and calculation methods where multiple interpretations could be possible.
 - Addition of a representative virtual vehicle for N3.
 - Update to measurement uncertainty.

A list of all parts in the ISO 362 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

An extensive review was conducted of actual in-use vehicle operations, beginning with data from the TUV Automotive study in the early 1990s and continuing with data developed through other committee members from 1996 through 2000. It includes nearly 100 vehicles operated on a variety of urban roads in Europe and Asia. The primary focus of the in-use measurements was to determine how vehicles are driven with a variety of vehicles, driving behaviours, and traffic situations. The in-use behaviour determined from these studies was successfully correlated to urban traffic use in the United States by evaluation of the fuel economy test cycles used by the United States Environmental Protection Agency (USEPA). The resulting test specifications are therefore valid for all global urban use conditions.

The procedure defined here provides a measure of the sound pressure level from vehicles under controlled and repeatable conditions. The definitions have been made according to the requirements of vehicle categories. In cases of vehicles other than very heavy trucks and buses, the working group found that attempts to conduct a partial load test as in actual use resulted in considerable run-to-run variability that significantly interfered with the repeatability and reproducibility of the test cycle. Therefore, two primary operating conditions (i.e. a wide-open-throttle acceleration phase and a constant speed phase) were used to guarantee simplicity. The combination was found to be equivalent to the partial throttle and partial power (engine load) actually used.

As a further consequence of the investigation of the requirements for an efficient test, it was decided to design a test which was independent of vehicle design and therefore safe and adaptable for future technologies, as well as for future traffic conditions. The test guarantees an excitation of all relevant noise sources, and the final test result reflects a combination of these sources as a compromise between normal urban use and “worst case”.

In 2004, the given test for M and N category vehicles was evaluated for technical accuracy and practical considerations by test programmes carried out by the Japan Automobile Standards Internationalization Center (JASIC), the European Automotive Manufacturers Association (ACEA), and the Society of Automotive Engineers, Inc. (SAE) in the United States. Over 180 vehicles were included in these tests. The reports of these test programmes were considered prior to preparation of this document.

This document was developed following demands for a new test procedure considering the following:

- “The test procedure (ISO 362) doesn't reflect realistic driving conditions” (1996 EU Green Paper);
- “In the case of motor vehicles, other factors are also important such as the dominance of tyre noise above quite low speeds (50 km/h)” (1996 EU Green Paper).
- “A new measurement procedure should require that the major noise sources of a vehicle be measured” (2001 Noise Emission of Road Vehicles – I-INCE).

This document, while maintaining the same technical procedures as the previous edition, has been revised based on practical experience to provide additional clarification where multiple interpretations were possible, to provide additional equivalent test modes for heavy commercial vehicles, and to incorporate provisions for addressing and including in the measurement external sound systems for M1 and N1 category vehicles.

Acoustics — Engineering method for measurement of noise emitted by accelerating road vehicles —

Part 1: M and N categories

1 Scope

This document specifies an engineering method for measuring the noise emitted by road vehicles of categories M and N under typical urban traffic conditions. It excludes vehicles of category L1 and L2, which are covered by ISO 9645, and vehicles of category L3, L4, and L5, which are covered by ISO 362-2.

The specifications are intended to reproduce the level of noise generated by the principal noise sources during normal driving in urban traffic (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 obtained only 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 conditions of test. It is necessary to consider the fact that the subjective appraisal of the noise annoyance of different classes of motor vehicles is not simply related to the indications of a sound measurement system. As annoyance is strongly related to personal human perception, physiological human 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 that does not fulfil the requirements stated in this document, the results obtained can deviate appreciably from the results obtained using the specified conditions.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 362-3, *Acoustics – Measurement of noise emitted by accelerating road vehicles – Engineering method, Part 3: Indoor testing M and N categories*

ISO 1176, *Road vehicles — Masses — Vocabulary and codes*

ISO 2416, *Passenger cars — Mass distribution*

ISO 10844, *Acoustics — Specification of test tracks for measuring sound emitted by road vehicles and their tyres*

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

IEC 60942, *Electroacoustics — Sound calibrators*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1176 and ISO 2416 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 Vehicle mass

3.1.1

kerb mass

complete shipping mass of a vehicle fitted with all standard equipment necessary for normal operation plus the mass of the following elements for M1, N1, and M2 having a maximum authorized mass not exceeding 3 500 kg:

- lubricants, coolant (if needed), washer fluid;
- fuel (tank filled to at least 90 % of the capacity specified by the manufacturer);
- other equipment if included as basic parts for the vehicle, such as spare wheel(s), wheel chocks, fire extinguisher(s), spare parts, and tool kit

Note 1 to entry: The definition of kerb mass can vary from country to country, but in this part of ISO 362, it refers to the definition contained in ISO 1176.

[SOURCE: ISO 1176:1990, 4.4 and 4.6 — modified.]

3.1.2

maximum authorized mass

kerb mass (3.1.1) plus the maximum allowable payload

3.1.3

unladen vehicle mass

nominal mass of a complete N2, N3, or M2 vehicle having a *maximum authorized mass* (3.1.2) greater than 3 500 kg or an M3 vehicle as determined by the following conditions:

- mass of the vehicle includes the bodywork and all factory-fitted equipment and electrical and auxiliary equipment for normal operation of the vehicle, including liquids, tools, fire extinguisher, standard spare parts, chocks, and spare wheel, if fitted;
- the fuel tank is filled to at least 90 % of rated capacity and the other liquid-containing systems (except those for used water) are filled to 100 % of the capacity specified by the manufacturer

3.1.4

mass of the driver

nominal mass of a driver

3.1.5

mass in running order

nominal mass of a vehicle as determined by the following conditions:

- a) the mass is taken as the sum of the *unladen vehicle mass* (3.1.3) and the driver's mass;
- b) in the case of category M2 and M3 vehicles that include seating positions for additional crewmembers, their mass is incorporated in the same way and equal to that of the driver
- c) mass in running order mathematically rounded, reported, and used for calculations to a precision of 10 kg (xxxx0)

Note 1 to entry: The driver's mass is calculated in accordance with ISO 2416.

3.1.6

maximum axle (group of axles) capacity

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

3.1.7

unladen axle load

actual mass carried by the axle (or group of axles) in an unladen condition, either in the front or the rear of the vehicle

Note 1 to entry: The unladen vehicle mass is equal to the sum of the unladen axles (or group of axles) load.

3.1.8

extra loading

mass which is added to the *unladen vehicle mass* (3.1.3)

3.1.9

laden axle load

actual mass carried by the axle (or group of axles) in a laden condition, either in the front or the rear of the vehicle

3.2

power-to-mass ratio index

PMR

dimensionless quantity used for the calculation of acceleration according to the following formula:

$$\text{PMR} = \frac{P_n}{m_{ro}} \cdot 1\,000$$

where

P_n is the numerical value of total engine power, expressed in kilowatts;

m_{ro} is the numerical value of the mass in running order, expressed in kilograms;

3.2.1

total engine power

sum of all power from available propulsion sources

3.3

rated engine speed

S

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

Note 1 to entry: If the rated maximum net power is reached at several engine speeds, S used in this document is the highest engine speed at which the rated maximum net power is reached.

Note 2 to entry: 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.

3.4 Vehicle categories

3.4.1

category L

motor vehicles with fewer than four wheels

Note 1 to entry: United Nations Economic Commission for Europe (UNECE) document TRANS/WP.29/78/Rev.1/Amend.4 (26 April 2005) extended the L category to four-wheeled vehicles as defined by L6 and L7.

3.4.1.1

category L1 and L2

mopeds

Note 1 to entry: See ISO 9645 for further details.

3.4.1.2

category L3

two-wheeled motor vehicles with an engine cylinder capacity greater than 50 cm³ or maximum speed greater than 50 km/h

3.4.1.3

category L4

three-wheeled motor vehicles with an engine cylinder capacity greater than 50 cm³ or maximum speed greater than 50 km/h, the wheels being attached asymmetrically along the longitudinal vehicle axis

3.4.1.4

category L5

three-wheeled motor vehicles with an engine cylinder capacity greater than 50 cm³ 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

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 cm³ 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

3.4.1.6

category L7

four-wheeled vehicles, other than those classified as *category L6* ([3.4.1.5](#)), whose unladen mass is not more than 400 kg or 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

3.4.2

category M

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

3.4.2.1

category M1

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

3.4.2.2**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 5 000 kg

Note 1 to entry: In this definition, "maximum mass" is equivalent to "maximum authorized mass" used elsewhere in this document.

3.4.2.3**category M3**

vehicles used for the carriage of passengers and comprising more than eight seats in addition to the driver's seat and having a maximum mass exceeding 5 000 kg

Note 1 to entry: In this definition, "maximum mass" is equivalent to "maximum authorized mass" used elsewhere in this document.

3.4.2.4**incomplete vehicle of category M2 or M3**

incomplete vehicle with just chassis rails or tube assembly, power train, and axles, which is intended to be completed with bodywork, customized to the needs of the transport operator

3.4.3**category N**

power-driven vehicles having at least four wheels and used for the carriage of goods

3.4.3.1**category N1**

vehicles used for the carriage of goods and having a *maximum authorized mass* (3.1.2) not exceeding 3 500 kg

3.4.3.2**category N2**

vehicles used for the carriage of goods and having a *maximum authorized mass* (3.1.2) exceeding 3 500 kg but not exceeding 12 000 kg

3.4.3.3**category N3**

vehicles used for the carriage of goods and having a *maximum authorized mass* (3.1.2) exceeding 12 000 kg

3.5**reference point**

point depending on the design and category of the vehicle

- for category M1 and N1 vehicles and M2 having a maximum authorized mass not exceeding 3 500 kg point on the vehicle as follows:
 - for front-engine vehicles, the front end of the vehicle;
 - for mid-engine vehicles, the centre of the vehicle;
 - for rear-engine vehicles, the rear end of the vehicle

Note 1 to entry: For vehicles having multiple propulsion sources, the reference point is determined by the position of the propulsion source having the highest power. If there are multiple propulsion sources of equivalent power, then the position of the most forward propulsion source shall prevail.

- for category M2 having a maximum authorized mass exceeding 3 500 kg, M3, N2, and N3 vehicles point on the vehicle as follows:
 - for front-engine vehicles, the front end of the vehicle;
 - for all other vehicles, the border of the engine closest to the front of the vehicle

3.6

target acceleration

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

Note 1 to entry: Refer to [Annex A](#) for more detailed explanations.

3.7

reference acceleration

required acceleration during the acceleration test on the test track

Note 1 to entry: 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

3.9

partial power factor

k_p

dimensionless quantity used for the weighted combination of the test results of the acceleration test and the constant-speed test for vehicles of categories M1, N1, and M2 having a *maximum authorized mass* ([3.1.2](#)) not exceeding 3 500 kg

Note 1 to entry: 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'

Note 1 to entry: See [Figure 1](#) for additional details.

3.11

locked gear ratio

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

3.12

engine

power source without detachable accessories

Note 1 to entry: power source includes in this context all sources of motive power; for example, electric or hydraulic power sources used alone or in combination with other power sources.

3.13

test track length

l_{10}

length of test track used in the calculation of acceleration from points PP' to BB'

3.14

test track length

l_{20}

length of test track used in the calculation of acceleration from points AA' to BB'

3.15**target engine rotational speed** $n_{\text{target BB'}}$

interval between 70 % and 74 % of the speed S for vehicles of category M2 having a *maximum authorized mass* (3.1.2) exceeding 3 500 kg and N2 and an interval between 85 % and 89 % of the speed S for vehicles of category M3 and N3

3.16**target vehicle speed** $v_{\text{target BB'}}$

vehicle speed of 35 km/h $\pm$ 5 km/h

3.17**kickdown**

driver activated automated gearshift to a test condition outside the target conditions

Note 1 to entry: The target conditions are defined in this document.

3.18**prevention of downshift**

measure by the vehicle manufacturer to ensure that the vehicle is tested within its specific target conditions

3.19**stable acceleration**

acceleration which avoids unsteady accelerations such as lugging, jerking, hesitation, delays, or other similar effects. When acceleration is calculated as part of the measurement, stable acceleration means a consistent acceleration over the complete measurement distance between AA' and BB' plus the vehicle length.

3.20**exterior sound enhancement system**

any system installed on the vehicle for producing sound

Note 1 to entry: Exterior sound enhancement systems may be integrated into other components, such as the exhaust, or may be independent units.

4 Symbols, terms and abbreviated terms

Table 1 lists the symbols, terms, and abbreviated terms used in this document and the subclause where they are used for the first time.

Table 1 — Symbols and abbreviated terms used and corresponding clauses

Symbol	Unit	Subclause	Explanation
AA'	—	3.10	Line perpendicular to vehicle travel which indicates beginning of zone in which to record sound pressure level during test
a_i	m/s ²	A.2.6	Partial throttle acceleration in gear ratio i ; value to be reported and used for calculations to the second decimal place (x,xx)
a_{max}	m/s ²	A.2.2.3	Maximum acceleration during an acceleration phase measured in in-use studies
$a_{\text{max},90}$	m/s ²	A.2.3.1	90 th percentile of maximum acceleration during an acceleration phase measured in in-use studies
a_{acc}	m/s ²	A.2.2.1	In-use acceleration measured in urban traffic for a specific vehicle
$a_{\text{acc},50}$	m/s ²	A.2.8.1	Acceleration at 90 th percentile of noise emission and 50 km/h vehicle velocity for a specific vehicle
$a_{\text{acc},i}$	m/s ²	5.1	Acceleration in gear ratio i ; value to be reported and used for calculations to the second decimal place (x,xx)

Table 1 (continued)

Symbol	Unit	Subclause	Explanation
$a_{acc(i+1)}$	m/s ²	5.1	Acceleration in gear ratio $(i + 1)$; value to be reported and used for calculations to the second decimal place (x,xx)
$a_{acc,test}$	m/s ²	5.1	Acceleration in single gear ratio test cases; value to be reported and used for calculations to the second decimal place (x,xx)
$a_{acc,ref}$	m/s ²	5.4	Reference acceleration for the acceleration test; value to be reported and used for calculations to the second decimal place (x,xx)
a_{urban}	m/s ²	5.3	Target acceleration representing urban traffic acceleration; value to be reported and used for calculations to the second decimal place (x,xx)
BB'	—	3.10	Line perpendicular to vehicle travel which indicates end of zone in which is 10,00 m behind line PP'
CC'	—	8.1	Centre line of vehicle travel through test surface as defined in ISO 10844
$\delta_1 - \delta_7$	dB	B.2	Input quantities to allow for any uncertainty
gear ratio i	—	8.3.1.3.2	Gear ratio which provides an acceleration within the 5 percent tolerance of the reference acceleration $a_{acc,ref}$ or greater than the reference acceleration $a_{acc,ref}$
gear ratio $(i + 1)$	—	8.3.1.3.2	The second of two gear ratios, with an acceleration lower than gear ratio i
gear ratio $i+2$, $i+3$, ...	—	8.3.1.3.2	Gear ratios selectable, if gear ratio i and gear ratio $i + 1$ exceed an acceleration of 2,0 m/s ²
gear x	—	8.3.2.3.2	First of two gear ratios used for testing of M2 having a maximum authorized mass of more than 3 500 kg, M3, N2, and N3 where certain criteria on test conditions are met
gear y	—	8.3.2.3.2	Second of two gear ratios used for testing of M2 having a maximum authorized mass of more than 3 500 kg, M3, N2, and N3 where certain criteria on test conditions are met
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; value to be reported and used for calculations to the second decimal place (x,xx)
k	—	3.8	Gear ratio weighting factor; value to be reported and used for calculations to the second decimal place
k_n	—	A.2.8.1	Interpolation factor between gears
l_{ref}	m	5.1	Reference length
l_{veh}	m	5.1	Length of vehicle; value to be reported and used for calculations to a precision of 0,01 m (1 cm)
l_{10}	m	3.13	Length of test section for calculation of acceleration from PP' to BB'
l_{20}	m	3.14	Length of test section for calculation of acceleration from AA' to BB'
$L_{crs,i}$	dB	8.4.3.2	Vehicle sound pressure level at constant speed test for gear i ; value to be reported and used for calculations to the first decimal place (xx,x)
$L_{crs(i+1)}$	dB	8.4.3.2	Vehicle sound pressure level at constant speed test for gear $(i + 1)$; value to be reported and used for calculations to the first decimal place (xx,x)
$L_{crs,rep}$	dB	8.4.3.2	Reported vehicle sound pressure level at constant speed test; value to be reported and used for calculations to the first decimal place (xx,x)
$L_{acc,i}$	dB	8.4.3.2	Vehicle sound pressure level at acceleration test for gear i ; value to be reported and used for calculations to the first decimal place (xx,x)

Table 1 (continued)

Symbol	Unit	Subclause	Explanation
$L_{acc(i+1)}$	dB	8.4.3.2	Vehicle sound pressure level at acceleration test for gear $(i + 1)$; value to be reported and used for calculations to the first decimal place (xx,x)
$L_{acc,rep}$	dB	8.4.3.2	Reported vehicle sound pressure level at acceleration; value to be reported and used for calculations to the first decimal place (xx,x)
L_{urban}	dB	8.4.3.2	Reported vehicle sound pressure level representing urban operation; value to be reported mathematically rounded to the nearest integer (xx)
$m_{ac,ra,max}$	kg	8.2.2.1	Maximum rear axle capacity
$m_{ac,ra,max} \text{ (chosen)}$	kg	8.2.2.2.4	Technically permissible maximum laden mass allowed for the chosen rear axle (as defined in 8.2.2.2.4)
$m_{chassisM2M3}$	kg	8.2.2.1	Mass of the incomplete vehicle (M2 or M3)
m_d	kg	8.2.2.1	Mass of the driver
$m_{fa,load,laden}$	kg	8.2.2.2.2	Laden front axle load
$m_{fa,load,unladen}$	kg	8.2.2.1	Unladen front axle load
$m_{fa,(vrf),load,unladen}$	kg	8.2.2.2.4	Measured unladen front axle load of the virtual vehicle with more than two axles
$m_{ra,load,laden}$	kg	8.2.2.2.2	Laden rear axle load
$m_{ra,load,unladen}$	kg	8.2.2.1	Unladen rear axle load
m_{ro}	kg	8.2.2.1	Mass in running order
M_t	kg	3.2	Test mass of the vehicle
$m_t \text{ (2 axles virtual)}$	kg	8.2.2.2.4	Test mass of a virtual vehicle with two axles (4×2 or 4×4)
m_{target}	kg	8.2.2.1	Target mass of the vehicle
$m_{unladen}$	kg	8.2.2.1	Unladen vehicle mass
$m_{unladen} \text{ (2 axles virtual)}$	kg	8.2.2.2.4	Unladen vehicle mass of the virtual vehicle with two axles
m_{xload}	kg	8.2.2.1	Extra loading
$m_{xload} \text{ (2 axles virtual)}$	kg	8.2.2.2.4	Extra loading for the virtual vehicle with two axles
$m_{xloadM2M3}$	kg	8.2.2.1	Extra load to be added to the incomplete vehicle (M2 or M3) to reach the mass of the vehicle in running order as chosen by the manufacturer
n	—	8.3.1.3.2	Gear index number (see Note 3)
n	1/min	A.2.4	Engine rotational speed of the vehicle
$n_{pp'}$	1/min	9	Engine rotational speed of the vehicle when the reference point passes PP'; value to be reported and used for calculations to a precision of 10 min ⁻¹ (xxx0)
$n_{BB'}$	1/min	8.3.2.1	Engine rotational speed of the vehicle when the reference point passes BB'; value to be reported and used for calculations to a precision of 10 min ⁻¹ (xxx0)
$n_{BB',i}, i=1,2$	1/min	8.3.2.3.3	engine rotational speed when the reference point passes BB' when certain conditions are met
$n_{max'}$	1/min	8.3.1.3.2	Maximum engine rotational speed permitted for M1, N1, and M2 less than 3 500 kg; value to be reported and used for calculations to a precision of 10 min ⁻¹ (xxx0)
$n_{target BB'}$	1/min	8.3.2.2	Target engine rotational speed of the vehicle when the reference point has to pass line BB' (see 5.1 for definition of reference point)

Table 1 (continued)

Symbol	Unit	Subclause	Explanation
$(n/S)_{a\ 90}$	—	A.2.8.1	Dimensionless engine rotational speed ratio at 90 th percentile acceleration
$(n/S)_{L\ 90}$	—	A.2.6	Dimensionless engine rotational speed ratio at 90 th percentile noise emission
$(n/S)_i$	—	A.2.8.1	Dimensionless engine rotational speed ratio at maximum acceleration of i gear
$(n/S)_{(i+1)}$	—	A.2.8.1	Dimensionless engine rotational speed ratio at maximum acceleration of $(i+1)$ gear
PMR	—	3.2	Power-to-mass ratio index to be used for calculations (abbreviation); value to be reported and used for calculations to the first decimal place (xxx,x)
P_n	kW	3.2	Rated total engine power (see ISO 1585 for combustion engines)
PP'	—	3.13	Line perpendicular to vehicle travel that indicates location of microphones
S	1/min	3.3	Rated engine rotational speed in revolutions per minute, synonymous with the engine rotational speed at maximum power
$v_{AA'}$	km/h	5.1	Vehicle velocity when reference point passes line AA' (see 5.1 for definition of reference point); value to be reported and used for calculations to the first decimal place
$v_{BB'}$	km/h	5.1	Vehicle velocity when reference point or reference length passes line BB' (see 5.1 for definition of reference length and see 3.5 for definition of reference point); value to be reported and used for calculations to the first decimal place
$v_{BB'1}$	km/h	8.3.2.3.3	Target vehicle velocity when certain conditions are met
$v_{BB'2}$	km/h	8.3.2.3.3	Target vehicle velocity when certain conditions are met
$v_{PP'}$	km/h	5.1	Vehicle velocity when reference point passes line PP' (see 5.1 for definition of reference point); value to be reported and used for calculations to the first decimal place
$v_{\text{target } BB'}$	km/h	8.3.2.2	Target vehicle velocity when it is necessary that the reference point pass line BB' (see 5.1 for definition of reference point)
v_{test}	km/h	8.3.1.2	Target vehicle test velocity
$v_{a,\text{max } 50}$	km/h	A.2.3.1	50 th percentile vehicle velocity at maximum acceleration during an acceleration phase measured in in-use studies
$v_{a,\text{max } 90}$	km/h	A.2.3.1	90 th percentile vehicle velocity at maximum acceleration during an acceleration phase measured in in-use studies
vrf	—	8.2.2.2.4	Vehicle with more than two axles representing the vehicle family

5 Specification of the acceleration for vehicles of categories M1 and M2 having a maximum authorized mass not exceeding 3 500 kg and of category N1

5.1 General

All accelerations are calculated using different speeds of the vehicle on the test track. The formulae given in [5.2](#) are used for the calculation of $a_{\text{acc},i}$, $a_{\text{acc},(i+1)}$, and $a_{\text{acc},\text{test}}$. 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' or the front of the vehicle passes BB' + 5 m if l_{ref} is chosen as 5 m. The method used for determination of the acceleration shall be indicated in the test report

Due to the definition of the reference point for the vehicle, the length of the vehicle is considered to be different in [Formulae \(1\)](#) and [\(2\)](#). If the reference point is the front of the vehicle, $l_{\text{ref}} = l_{\text{veh}}$, i.e. the length

of vehicle; if the reference point is the midpoint of the vehicle, $l_{\text{ref}} = 0,5 l_{\text{veh}}$ (i.e. 0,5 times the length of vehicle); if the reference point is the rear of the vehicle, $l_{\text{ref}} = 0$.

At the choice of the vehicle manufacturer, front engine vehicles may use $l_{\text{ref}} = 5$ m, and mid engine vehicles may use $l_{\text{ref}} = 2,5$ m

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

Due to the large variety of technologies, it is necessary to consider different modes of calculation. New technologies (such as continuously variable transmission) and older technologies (such as automatic transmission) that 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 requirements.

5.2 Calculation of acceleration

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

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

Calculate $a_{\text{acc,test},j}$ using [Formula \(1\)](#):

$$a_{\text{acc,test},j} = \frac{(v_{\text{BB}',j} / 3,6)^2 - (v_{\text{AA}',j} / 3,6)^2}{2(l_{20} + l_{\text{ref}})} \quad (1)$$

where

- $a_{\text{acc,test},j}$ is the numerical value of the acceleration, expressed in metres per second squared;
- $v_{\text{BB}',j}, v_{\text{AA}',j}$ are numerical values of the velocity, expressed in kilometres per hour;
- l_{20}, l_{ref} are numerical values of the test track length and reference length, expressed in metres.

Pre-acceleration can be used.

Each $a_{\text{acc,test},j}$ shall be reported to two significant digits after the decimal place (x,xx). Calculation of $a_{\text{acc,test}}$ shall use each $a_{\text{acc,test},j}$ and the final reported $a_{\text{acc,test}}$ shall be reported to two significant digits after the decimal place (x,xx). The final reported $a_{\text{acc,test}}$ shall be used in all subsequent calculations.

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

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

If the devices or measures described in [8.3.1.3.3](#) are used to control transmission operation for the purpose of achieving test requirements, calculate $a_{\text{acc,test},j}$ using [Formula \(1\)](#).

Pre-acceleration can be used.

If the devices or measures described in [8.3.1.3.3](#) are not used, calculate $a_{\text{acc,test},j}$ using [Formula \(2\)](#):

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

where

- $a_{\text{acc,test},j}$ is the numerical value of the acceleration, expressed in metres per second squared;
- $v_{\text{PP}'}, v_{\text{BB}'}$ are numerical values of the velocity, expressed in kilometres per hour;
- l_{10}, l_{ref} are numerical values of the test track length and reference length, expressed in metres.

Pre-acceleration shall not be used.

Each $a_{\text{acc,test},j}$ shall be reported to two significant digits after the decimal place (x,xx). Calculation of $a_{\text{acc,test}}$ shall use each $a_{\text{acc,test},j}$ and the final reported $a_{\text{acc,test}}$ shall be reported to two significant digits after the decimal place (x,xx). The final reported $a_{\text{acc,test}}$ shall be used in all subsequent calculations.

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 document.

5.3 Calculation of the target acceleration

Calculate a_{urban} using [Formula \(3\)](#):

$$a_{\text{urban}} = 0,63 \lg(\text{PMR}) - 0,09 \quad (3)$$

where

- a_{urban} is the numerical value of the acceleration, expressed in metres per second squared;
- PMR is the dimensionless value of the power-to-mass index.

The calculated a_{urban} value shall be reported to two significant digits (x,xx) after the decimal place. The reported a_{urban} shall be used in all subsequent calculations.

5.4 Calculation of the reference acceleration

Calculate $a_{\text{acc,ref}}$ using [Formula \(4\)](#) and [Formula \(5\)](#):

$$a_{\text{acc,ref}} = 1,59 \lg(\text{PMR}) - 1,41 \text{ for } 25 < \text{PMR} \quad (4)$$

or

$$a_{\text{acc,ref}} = a_{\text{urban}} = 0,63 \lg(\text{PMR}) - 0,09 \text{ for } 25 > \text{PMR} \quad (5)$$

where

- $a_{\text{acc,ref}}$ is the numerical value of the reference acceleration, expressed in metres per second squared;
- a_{urban} is the numerical value of the acceleration relative to urban traffic, expressed in metres per second squared;
- PMR is the dimensionless value of the power-to-mass index.

The calculated $a_{\text{acc,ref}}$ value shall be reported to two significant digits (x,xx) after the decimal place. The reported $a_{\text{acc,ref}}$ shall be used in all subsequent calculations.

NOTE Calculations of $a_{\text{acc,ref}}$ 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.

NOTE Calculations of $a_{\text{acc,ref}}$ and a_{urban} use the logarithm function $\lg(x)$ which is the logarithm to the base 10.

5.5 Partial power factor k_p

Partial power factor k_p is

$$k_p = 1 - (a_{\text{urban}} / a_{\text{acc,test}}) \quad (6)$$

In cases other than a single gear test, $a_{\text{acc,ref}}$ shall be used instead of $a_{\text{acc,test}}$, as defined in [8.4.3.2](#).

The final reported k_p value shall be mathematically rounded to two significant digits (x,xx) after the decimal place. The final reported k_p shall be used in all subsequent calculations.

6 Instrumentation

6.1 Instruments for acoustical measurement

6.1.1 General

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

When no general statement or conclusion can be made about conformance of the sound level meter, the system shall be checked according to IEC 61672-3.

The entire measurement system shall be checked by means of a sound calibrator that fulfils the requirements of class 1 sound calibrators in accordance with 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 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.

NOTE For systems where microphones are connected to data acquisition systems, the microphone and preamp typically have a certificate of calibration, and the data acquisition system typically have a certificate of calibration. It is not necessary to have a certificate of calibration for connecting cables.

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.

For indoor testing using ISO 362-3, the entire measurement system shall be checked at the beginning and at the end of a series of sessions.

A qualified calibration method (i.e. electrical calibration) is recommended to be provided by the hardware supplier and, in that case, shall be implemented in the measurement software used. Simulation algorithms using sound source localization detection should deactivate that feature for these tests

6.1.3 Conformity with requirements

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

6.2 Instrumentation for speed measurements

The maximum permissible uncertainties for instruments used for rotational engine speed measurements shall be:

$\pm 2\%$ at the engine speeds required for the measurements being performed.

The road speed measurement device shall be a continuous speed measurement device. Maximum permissible uncertainties shall be:

$\pm 0,5$ km/h

The minimum update rate for the continuous speed device shall be 20 Hz.

6.3 Meteorological instrumentation

The maximum permissible uncertainties for instruments used for meteorological measurements shall be:

- ± 1 °C for a temperature measuring device;
- $\pm 1,0$ m/s for a wind speed measuring device;
- ± 5 hPa for a barometric pressure measuring device;
- $\pm 5\%$ for a relative humidity measuring device.

Monitoring of wind speed is not required for indoor testing.

7 Acoustical environment, meteorological conditions, and background noise

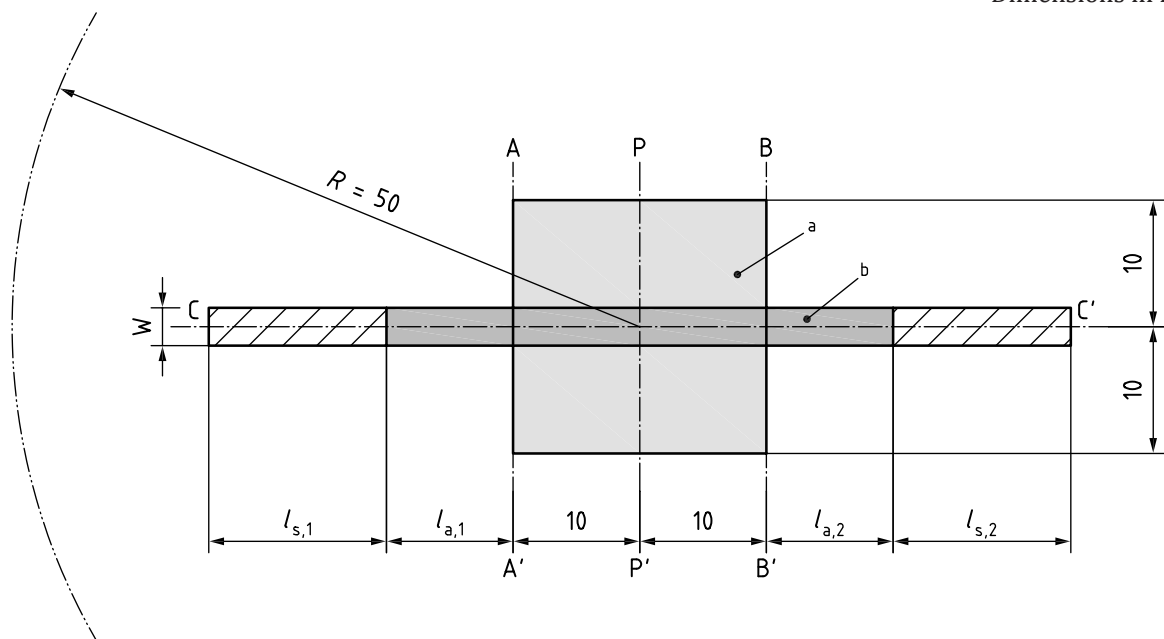
7.1 Test site

The test site shall be substantially level. The test track construction and surface shall meet the requirements of ISO 10844. The test site dimensions reflecting ISO 10844 are shown in [Figure 1](#).

Within a radius of 50 m around the centre 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 can 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.

Dimensions in metres

**Key**

- $l_{s,1}$ entrance construction run-up section (diagonal hatch area), in metres
 $l_{s,2}$ exit construction run-up section (diagonal hatch area), in metres
 (length of entrance and exit construction run-up sections can differ)
 $l_{a,1}$ entrance drive lane extension beyond propagation area, in metres
 $l_{a,2}$ exit drive lane extension beyond propagation area, in metres
 (length of entrance and exit drive lane extensions can differ)
 w drive lane width, in metres
 AA' entrance to propagation area 10 m before line PP'
 BB' exit from propagation area 10 m after line PP'
 CC'' drive lane centre line (longitudinal axis)
 PP microphone line (transverse axis)
 a Propagation area.
 b Drive lane.

NOTE 1 Buildings outside the 50 m radius can have significant influence if their reflection focuses on the test track.

NOTE 2 Shaded area ("test area") is the minimum area that it is required to be covered with a surface complying with ISO 10844.

Figure 1 — Test site dimensions

For outdoor testing, two lines, AA' and BB' , parallel to line PP' and situated respectively $10\text{ m} \pm 0,05\text{ m}$ forward and $10\text{ m} \pm 0,05\text{ m}$ rearward of line PP' shall be marked out on the test runway.

Measurements in indoor facilities complying with ISO 362-3 may also be used as equivalent to outdoor measurements.

For indoor testing using ISO 362-3, the virtual line AA' indicates the beginning of the test track, PP' indicates the virtual position of the two pass-by microphones, and BB' indicates the end of the test track. The simulated vehicle speed at AA' , $v_{AA'}$, or vehicle speed at PP' , $v_{PP'}$, is defined by the roller speed when the reference point of the vehicle passes the virtual line AA' or PP' , respectively. The simulated vehicle speed at BB' , $v_{BB'}$, is defined when the rear of the vehicle passes the virtual line BB' .

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 of $1,20\text{ m} \pm 0,02\text{ m}$.

The measurements shall be made when the ambient air temperature is within the range from 5 °C to 40 °C and the test surface temperature within the range from 5 °C to 60 °C .

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

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

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

NOTE 1 The measurement results are influenced by the temperature. The measurement uncertainty can be reduced by conducting measurements within a temperature range of 15 °C to 25 °C . For practical reasons to cover the range of testing conditions in various locations, the range of 5 °C to 40 °C is specified. Testing at lower temperatures is expected to produce higher measurement results due to the hardening effect of the rubber in the tyres.

NOTE 2 Refer to [Annex B](#) for the effects of temperature and other factors.

7.3 Background noise

Any sound peak that appears unrelated to the characteristics of the general sound level 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 ambient sound pressure level and the measured sound pressure level is between 10 dB and 15 dB , in order to calculate the j th test result, the appropriate correction shall be subtracted from the readings on the sound level meter, as given in [Table 2](#).

For indoor testing, background noise shall take into account noise emissions produced by the dynamometer rollers, ventilation systems, and facility exhaust gas systems.

Table 2 — Correction applied to an individual measured test value

Background sound pressure level difference to measured sound pressure level dB	Correction dB
10	0,5
11	0,4
12	0,3
13	0,2
14	0,1
≥ 15	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 $7,5 \text{ m} \pm 0,05 \text{ m}$.

The microphones shall be located on both sides of the CC' line $1,2 \text{ m} \pm 0,02 \text{ m}$ above the ground level. The reference direction for free-field conditions (see IEC 61672-1) shall be horizontal and directed perpendicularly towards the path of the vehicle line CC'.

8.2 Conditions of the vehicle

8.2.1 General conditions

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

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

NOTE Variation can be reduced by maintaining stable vehicle component temperatures, for example, exhaust systems, coolant systems, and lubrication systems.

8.2.2 Test mass of the vehicle

8.2.2.1 General

Measurements shall be made on vehicles at the test mass m_t specified in [Table 3](#).

When testing indoors using ISO 362-3, the test mass, m_t shall be utilized by the control system of the dyno roller. Actual mass of the vehicle has no effect on results and it is permitted to load the vehicle as necessary to prevent slip between the tyres and the dyno rolls. To detect excessive slip, it is recommended to control the ratio of engine rotational speed and vehicle speed between the acceleration phase and the constant-speed status. To avoid slip, it is possible to increase the axle load.

Target mass, m_{target} , is used to denote the mass that N2 and N3 vehicles should be tested at. The actual test mass can be less due to limitations on vehicle and axle loading.

Table 3 — Test mass, m_t

Vehicle category	Vehicle test mass kg
M1	The test mass, m_t , of the vehicle shall be between $0,9m_{ro} \leq m_t \leq 1,2 m_{ro}$
N1 ^{ab}	The test mass, m_t , of the vehicle shall be between $0,9m_{ro} \leq m_t \leq 1,2m_{ro}$
^a N1 category vehicles may be loaded, at the discretion of the vehicle manufacturer, for practical reasons during the test. This practice is acceptable; however, it can lead to a higher level of vehicle noise (typically 1 dB).	
^b If load is added to these vehicles during testing, the added payload shall be noted in the test report.	

Table 3 (continued)

Vehicle category	Vehicle test mass kg
N2, N3	$m_{\text{target}} = 50 \text{ kg/kW} \cdot P_n$. Extra loading, m_{xload}, to reach the target mass, m_{target}, of the vehicle shall be placed above the rear axle(s). If the test mass m_t is equal to the target mass m_{target}, the test mass m_t shall be $0,95m_{\text{target}} \leq m_t \leq 1,05m_{\text{target}}$. The sum of the extra loading and the unladen rear axle load, $m_{\text{ra,load,unladen}}$, is limited to 75 % of the maximum axle capacity, $m_{\text{ac,ra,max}}$, allowed for the rear axle. The target mass shall be achieved with a tolerance of $\pm 5 \%$. If the test mass m_t is lower than the target mass m_{target}, the test mass m_t shall be achieved with a tolerance of $\pm 5 \%$. If the centre of gravity of the extra loading cannot be aligned with the centre of the rear axle, the test mass, m_t, of the vehicle shall not exceed the sum of the front axle in an unladen condition, $m_{\text{fa,load,unladen}}$, and the rear axle load in an unladen condition, $m_{\text{ra,load,unladen}}$ plus the extra loading, m_{xload}, and the mass of the driver m_d. The test mass for vehicles with more than two axles shall be the same as for a two-axle vehicle. If the unladen vehicle mass, m_{unladen}, of a vehicle with more than two axles is greater than the test mass for the two-axle vehicle, then this vehicle shall be tested without extra loading. If the unladen vehicle mass, m_{unladen}, of a vehicle with two axles is greater than the target mass, then this vehicle shall be tested without extra loading.
M2 ($M \leq 3,500 \text{ kg}$)	The test mass, m_t , of the vehicle shall be between $0,9m_{\text{ro}} \leq m_t \leq 1,2m_{\text{ro}}$.
Complete M2 ($M > 3,500 \text{ kg}$), M3	If the tests are carried out with a complete vehicle having a bodywork, $m_{\text{target}} = 50 \text{ kg/kW} \cdot P_n$ is calculated either in conformity with conditions above (see N2, N3 category) or the test mass m_t of the vehicle shall be $0,9 m_{\text{ro}} \leq m_t \leq 1,1 m_{\text{ro}}$.
Incomplete M2 ($M > 3,500 \text{ kg}$), M3	If the tests are carried with an incomplete vehicle not having a bodywork, $m_{\text{target}} = 50 \text{ kg/kW} \cdot P_n$ is calculated either in conformity with conditions above (see N2, N3 category), or the test mass m_t of the vehicle shall be $0,9 m_{\text{ro}} \leq m_t \leq 1,1 m_{\text{ro}}$. where $m_{\text{ro}} = m_{\text{chassisM2M3}} + m_{\text{xloadM2M3}}$
^a N1 category vehicles may be loaded, at the discretion of the vehicle manufacturer, for practical reasons during the test. This practice is acceptable; however, it can lead to a higher level of vehicle noise (typically 1 dB). ^b If load is added to these vehicles during testing, the added payload shall be noted in the test report.	

8.2.2.2 Calculation procedure to determine extra loading of N2 and N3 vehicles only

8.2.2.2.1 Calculation of extra loading

The target mass, m_{target} , for two-axle vehicles of category N2 and N3 is specified in [Table 3](#):

$$m_{\text{target}} = 50 \text{ kg/kW} \cdot P_n \quad (7)$$

To reach the required test mass, m_t , for a vehicle being tested, the unladen vehicle, including the mass of the driver, m_d , shall be loaded with an extra mass, m_{xload} , which shall be placed above the rear axle as given in [Formula \(8\)](#):

$$m_{\text{target}} = m_{\text{unladen}} + m_d + m_{\text{xload}} \quad (8)$$

The vehicle mass of the test vehicle in the unladen condition, m_{unladen} , is calculated by measuring on a scale the unladen front axle load, $m_{\text{fa,load,unladen}}$, and the unladen rear axle load, $m_{\text{ra,load,unladen}}$, as given in [Formula \(9\)](#):

$$m_{\text{unladen}} = m_{\text{fa,load,unladen}} + m_{\text{ra,load,unladen}} \quad (9)$$

By using [Formulae \(8\)](#) and [\(9\)](#), the extra loading, m_{xload} , is calculated as given in [Formulae \(10\)](#) and [\(11\)](#):

$$m_{\text{xload}} = m_{\text{target}} - (m_d + m_{\text{unladen}}) \quad (10)$$