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PROPOSAL FOR A MEASURING PROCEDURE TO BE INCORPORATED INTO REGULATION No. 51 (Noise of M and N categories of vehicles)

Transmitted by the Expert from the
International Organization for Standarization (ISO)

Note: This document is a reproduction of the Working Draft ISO 362:2000 (E), as revised on 31 October 2000; it is reproduced as received, however the classification of the vehicles in paragraph 4 was corrected by the secretariat to comply with Consolidated Resolution R.E.3, Annex 7 (TRANS/WP.29/78/Rev.1/Amend.2).

Note: This document is distributed to the Experts on Noise only.

A. INTRODUCTION TO AN ISO WORKING DRAFT

The enclosed document is working draft of the ISO working group on “measurement of noise emitted from accelerating road vehicles”. The committee has done an extensive review of actual in-use vehicle operation beginning with data from the TUV Automotive study in the early 1990’s and has continued with data developed through other committee members in 1996 through 2000. In 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 the vehicles were being driven with a variety of vehicles, driving behaviours and traffic situations.

The procedure proposed here is an attempt provide a measure of the sound level from vehicles in several operating cycles under controlled conditions that when combined represent the equivalent of the urban driving measured in the community. The use of two primary operations an acceleration and a cruise are combined to be equivalent to the partial throttle and partial power (engine load) actually used. The committee found that attempts to conduct a partial load test as in actual use resulted in significant run to run variability that significantly interfered with the repeatability and reproducibility of the test cycle.

Although this cycle is also included in a composite paper being made available in the GRB by the German delegation this document is offered as a complete cycle that is cohesive and deals with all the elements of the test cycle. It will also include background and related information in the annex section.

While this paper has been provided to the GRB for review there will be changes as additional information and further testing becomes available. The sections in square brackets [ ] will probably be changed. In addition there are other sections which further testing may show need further work. This paper is submitted at this time to encourage comments to allow the ISO to review the comments and answer the questions that may arise.

Thank you in advance for whatever response you have to this Working Draft.

* * *

ISO 362: Acoustics - Measurement of noise emitted by accelerating road vehicles - Engineering method

1. SCOPE

This International Standard specifies an engineering method for measuring the noise emitted by [accelerating road vehicles] vehicles under urban traffic condition.

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 specifications are intended to reproduce the noise levels which are produced during [the use of intermediate gears with full utilisation of the engine power available as may occur in urban traffic] normal driving in urban traffic. (See Annex C – still under development).

The test method requires an acoustical environment which can only be obtained in an extensive open space. Such conditions can usually be provided for:

(a) type approval measurements of vehicle,
(b) measurements at the manufacturing stage,
(c) measurements at official testing stations.

NOTE: It should be noted that spot checking of vehicles chosen at random can rarely be made in an ideal acoustical environment. If measurements have to be carried out on the road in an acoustical environment which does not fulfil the requirements stated in this International Standard, it should be recognized that the results obtained may deviate appreciably from the results obtained using the specified conditions.

2. NORMATIVE REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 10844:1994	Acoustics - Test surface for road vehicle noise measurements
IEC 60651:1979	Sound level meters
IEC 60942:1988	Sound calibrators
ISO 1176:	Kerb Mass

3. DEFINITIONS AND SYMBOLS USED

For the purposes of this International Standard, the following definitions apply:

3.1. Automatic Downshift

Gear change to a lower gear (higher transmission ratio) which can be initiated at the will of the driver.

NOTE: An automatic downshift may be initiated, for example, by a change of pressure on or position of the accelerator control, thereby activating a special program which effects downshifts to gears which are lower than those normally used in urban driving.

3.2. Intermediate Result

Value calculated from the test series measurements and used to determine the reported value.

3.3. Kerb mass

Complete shipping mass of a vehicle fitted with all equipment necessary for normal operation plus the mass of the following elements:

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

NOTE: The definition of kerb mass may vary from country to country, but in this standard it refers to the definition contained in ISO 1176.

3.4. Rated Engine Speed, S

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

3.5. Reference Point

[Depending on the design of the vehicle the following definitions for the reference point shall be used:

3.5.1. Vehicles Category M1 [, N1]

(a) for front engine vehicles the reference point is at the front end of the vehicle
(b) for mid engine vehicles the reference point is the centre of the vehicle
(c) for rear engine vehicles the reference point is at the rear end of the vehicle]

3.5.2. Vehicles Category M2, M3, N2, N3

(a) The reference point is the border of the engine closest to the front of the vehicle

3.5.3. Vehicles Category L

(a) The reference point is the centre of the vehicle.

3.6. Symbols used

All symbols used are listed in paragraph 8 or below:

$v_{AA'}$	vehicle speed at the approach of line AA in km/h,
$v_{BB'}$	vehicle speed at the end of the test track in km/h,
$n_{AA'}$	engine rotation speed at the approach of the line AA in min^{-1},
$n_{BB'}$	engine rotational speed at the end of the test truck in min^{-1},
S	rated engine speed in min^{-1}, [synonymous with the engine speed at maximum power],
P_n	rated engine power (ECE Regulation No. 85) in kW,
m_t	test mass of the vehicle in kg,
P_n/m	power to mass ratio in W/kg,
l_{veh}	length of vehicle in m,
$L_{wot}rep$	reported vehicle noise at wide open throttle (WOT),
L_{wot}	vehicle noise at wide open throttle (WOT),
$a_{wot}ref$	target acceleration rate for the wide open throttle (WOT) test
P_n/m_{ref}	power to mass ratio to be used for calculations,
a_{urban}	urban traffic acceleration,
m_{ref}	kerb mass + 75 kg,
v_{PP}	speed at microphone position,
gear ratio i	gear ratio with an engine speed higher than gear ratio i+1 try this “gear ratio of the first gear selected for the vehicle test”,
gear ratio i+1	gear ratio with an engine speed lower than gear ratio i.

4. VEHICLE CATEGORIES

4.1. Category L, motor vehicles with less than four wheels

L1: a two-wheeled vehicle with an engine cylinder capacity in the case of thermic engine not exceeding 50 cm^3 and whatever the means of propulsion a maximum design speed not exceeding 50 km/h,

L2: a three-wheeled vehicle of any wheel arrangement with an engine cylinder capacity in the case of thermic engine not exceeding 50 cm^3 and whatever the means of propulsion a maximum design speed not exceeding 50 km/h,

L3: a two-wheeled vehicle with an engine cylinder capacity in the case of thermic engine exceeding 50 cm^3 and whatever the means of propulsion a maximum design speed exceeding 50 km/h,

L4: a vehicle with three wheels asymmetrically arranged in relation to the longitudinal median plane with an engine cylinder capacity in the case of thermic engine exceeding 50 cm^3 and whatever the means of propulsion a maximum design speed exceeding 50 km/h (motor cycles with sidecars),

L5: a vehicle with three wheels symmetrically arranged in relation to the longitudinal median plane with an engine cylinder capacity in the case of thermic engine exceeding 50 cm^3 and whatever the means of propulsion a maximum design speed exceeding 50 km/h.

4.2. Category M, motor vehicles with at least four wheels used for the carriage of passengers

M1: vehicles used for the carriage of passengers and comprising not more than eight seats in addition to the driver’s seat,

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 tonnes,

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 tonnes.

4.3. Category N, motor vehicles with at least four wheels used for the carriage of goods

N1: vehicles used for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes,
N2: vehicles used for the carriage of goods and having a maximum mass exceeding 3.5 tonnes but not exceeding 12 tonnes,
N3: vehicles used for the carriage of goods and having a maximum mass exceeding 12 tonnes.

5. GENERAL CONSIDERATIONS

5.1. Driving conditions

This International Standard is based on a test with vehicles in motion. Measurements shall be related to operating conditions of the vehicle which give the representative noise level under urban acceleration. Therefore, a combined test of acceleration and constant speed driving related to a stated vehicle speed is specified.

5.2. Interpretation of Results

The results obtained by this method give an objective measure of the noise emitted under the specified conditions of test.

NOTE: 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.

6. INSTRUMENTATION

6.1. Instruments for acoustical measurement

6.1.1. General

The sound level meter or the equivalent measuring system, including the windscreen recommended by the manufacturer shall at least meet the requirements of Type 1 instruments in accordance with IEC 60651.

The measurements shall be made using the frequency weighting A, and the time weighting F.

When using a system that includes a periodic monitoring of the A-weighted sound pressure level, a reading should be made at a time interval not greater than 30 ms.

6.1.2. Calibration

At the beginning and at the end of every measurement session, the entire measurement system shall be checked by means of a sound calibrator that fulfils the requirements for sound calibrators of at least precision Class 1 according to IEC 60942. Without any further adjustment the difference between the readings of two consecutive checks 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

The compliance of the sound calibration device with the requirements of IEC 60942 shall be verified once a year and the compliance of the instrumentation system with the requirements of IEC 60651 shall be verified at least every 2 years, by a laboratory which is authorized to perform calibrations traceable to the appropriate standards.

6.2. Instrumentation for speed measurements

The rotational speed of the engine and the road speed of the vehicle during the constant speed approach shall be measured with instruments meeting specification limits of ± 2% or less.

6.3. Meteorological instrumentation

The meteorological instrumentation used to monitor the environmental conditions during the test shall include the following:

(a) a temperature measuring device meeting specification limits of + 1 °C or less,
(b) a wind speed measuring device meeting specification limits of + 1,0 m/s,
(c) a barometric pressure measuring device meeting specification limits of ± 5 hPa
(d) a humidity measuring device meeting specification limits of [± xx %]

7. ACOUSTICAL ENVIRONMENT, METEOROLOGICAL CONDITIONS AND BACKGROUND NOISE

7.1. Test site

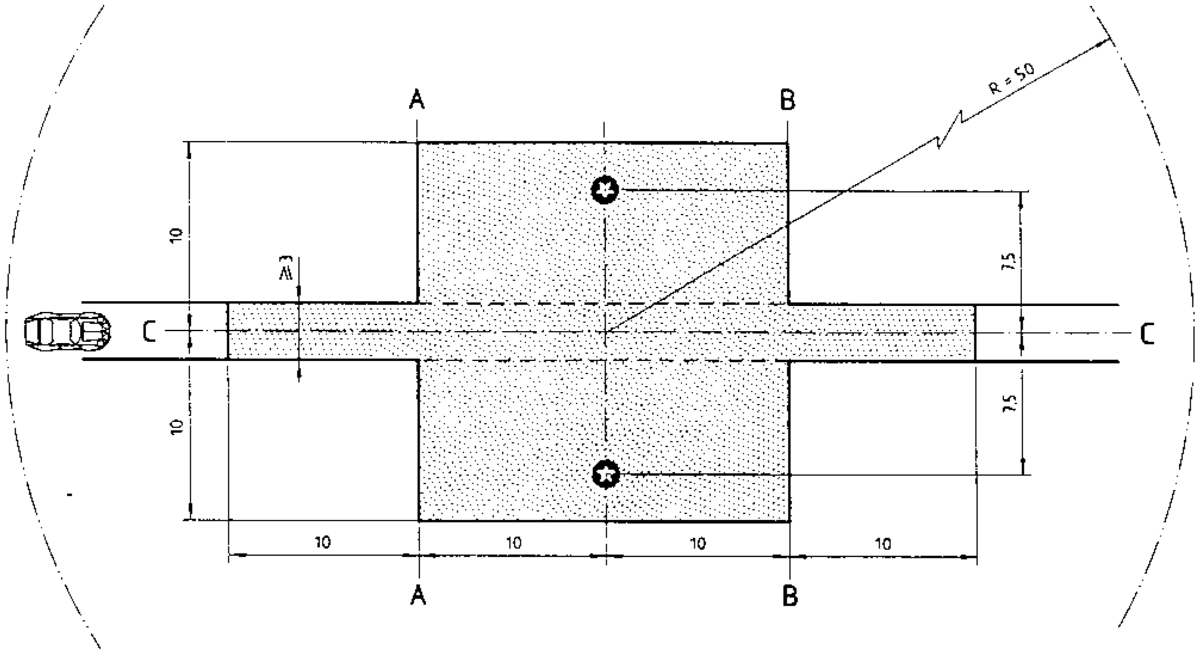
The test site shall be substantially level. The surface of the test track shall be dry and its texture such that it does not cause excessive tyre noise. The test track construction and surface shall meet the requirements of ISO 10844.

The test site shall be such that when a small omni-directional noise source is placed in its surface at the central point (intersection of the microphone line and the centre of the vehicle lane) see Figure 1, deviations from hemispherical divergence shall not exceed ± 1 dB.
This condition is deemed to be satisfied if the following requirements are met:

(a) 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.
(b) The test track and the surface of the site shall be dry and free from absorbing materials such as powdery snow, or loose debris.
(c) 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: It is recommended that the test area be a substantially flat plane, particularly in the portion of the area between the vehicle path and the microphone location (see Figure 1).

Dimensions in metres



Key: Minimum area covered with test road surface, i.e. test area

Microphone positions (height 1,2 m)

NOTE 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 should be positioned adjacent to the test area at a height representative of the site, except as noted below.

The measurements shall be made when the ambient air temperature is within the range from [0] 5 °C to 40 °C. (according to 92/23/EEC)

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

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

NOTE: When comparing data under different environmental conditions, the effects of temperature and other factors should be considered.

7.3. Background noise

It is [recommended] that the A-weighted background noise (including any wind noise) be 15 dB below the emissions produced by the vehicle under test, but it shall always be at least 10 dB below.

8. TEST PROCEDURE

8.1. Microphone positions

The distance from the microphone positions on the microphone line PP’, perpendicular to the 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 the ground level. The reference axis for free field conditions (see IEC 60651) shall be horizontal and directed perpendicularly towards the path of the vehicle line CC’. Calibration of the microphone has to be done before and after a test session. Results have to be refused, if the values have a variation of more than 0.5 dB(A).

8.2. Number of measurements

Make at least four measurements on each side of the vehicle for each driving condition.

8.3. Conditions of the vehicle

The vehicle shall be supplied with fuel, spark plugs, a fuel supply system, etc., as specified by the vehicle manufacturer.

Measurements shall be made on vehicles at the [test mass specified for each category]. Except for the case of non-separable vehicles, measurement shall be made without a trailer or semi-trailer.

The tyres used for the test are selected by the vehicle manufacturer. They shall correspond to one of the tyre size designated for the vehicle by the vehicle manufacturer. It is recommended that the tyre is commercially available. The tyres shall be inflated to the pressure recommended by the manufacturer for the test mass of the vehicle.

Before the measurements are started, the vehicle shall be brought to its normal operating conditions with respect to temperatures and tuning.

8.4. Operating conditions

8.4.1. Vehicles Category L

8.4.1.1. General conditions

The vehicle shall approach the line AA’ with the path of its centreline following as closely as possible the line CC’ (see Figure 1) [Section for motorcycles is not developed to a point where a proposal can be presented here. It does follow a similar pattern]

8.4.2. Vehicles Category M1 [, N1]

8.4.2.1. General conditions

The vehicle shall approach the line AA’ with the path of its centreline following as closely as possible the line CC (see Figure 1).

Any trailer which is not readily separable from the towing vehicle shall be ignored when considering the crossing of the line BB’.

If the vehicle is fitted with more than two-wheel drive, test it in the drive selection which 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.

It is necessary to perform two different tests.

A wide open throttle acceleration test and a constant speed test.
The combination of both tests simulates urban traffic acceleration given by:

[$a_{urban} = 0.0050 * P_c / m_{ref} + 0.6651$ Equation 8.4.2.-1]

8.4.2.2. Wide open throttle test

When the front of the vehicle reaches the line AA' the accelerator control shall be fully engaged (without operating the automatic downshift to a lower range than normally used in urban driving) and held fully engaged until the rear of the vehicle reaches line BB'. The accelerator control shall then be released.

8.4.2.3. Constant speed test

During the constant speed test the accelerator control shall be held fixed in such a position as will maintain between AA' and BB' the constant speed specified in paragraph 8.4.2.5.

8.4.2.4. Target values

8.4.2.4.1. Test speed

The test speed is 50 km/h ± 1km/h.

8.4.2.4.2. Acceleration Test

During each run of the wide open throttle test the reference acceleration is given by:

[$a_{wot\ ref} = 0.0092 * P_n / m_{ref} + 0.6318$ Equation 8.4.2.-2]

The final result is calculated by combining $L_{wot\ rep}$ and $L_{cst\ rep}$

The equation is:

[$L_{urban} = L_{wot} - k_P * (L_{wot} - L_{cst})$ Equation 8.4.2.-3]

The weighting factor k_P gives the part power factor for urban driving and is calculated by

[$k_P = 1 - (a_{urban} / a_{wot})$ Equation 8.4.2.-4]

8.4.2.4.3. Wide Open Throttle Test

The test speed must be reached when the reference point of the vehicle is at line PP′ with the tolerance ± 1 m.

The acceleration test requires the vehicle accelerate through the test course from line AA′ until the rear of the vehicle passes the line BB′. The vehicle shall approach the start line at a speed such that as the vehicle accelerates the vehicle speed at line PP′ is equal to the test speed noted in 8.4.2.4.1.

The selection of gear ratio depends on the reference acceleration (requested) required ($a_{wot\ ref}$) for the full throttle acceleration test. The calculation of the acceleration for a gear ratio i has to be done in the following way:

[$a_i = ((v_{BB'} / 3.6)^2 - (v_{AA'} / 3.6)^2) / 2 * (20 + l_{ref})$ Equation 8.4.2.-5]

The following conditions for selection of gear ratios are possible:

(a) if one specific gear ratio gives an acceleration in a tolerance band of ±5% of the reference acceleration $a_{wot\ ref}$, test with that gear ratio.
(b) If none of the gear ratios give the requested 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. If the acceleration value in gear ratio i does not exceed [1.8m/s²], use both gear ratios for the test. The weighting ratio in relation to the reference acceleration $a_{wot\ ref}$ is calculated by:

[$k = (a_{wot\ ref} - a_{(i+1)}) / (a_i - a_{(i+1)})$ Equation 8.4.2.-6]

(c) if the acceleration value of gear ratio i exceeds [1.8m/s²], it is recommended to perform the tests by selecting gear ratios i and i+1 with lower acceleration than [1.8m/s²]. The weighting factor k is also calculated according to.
(d) If the gear ratio is a fixed design parameter and not tuneable, the full throttle test is carried out in this vehicle condition. The achieved acceleration is then used for the calculation of the part power factor k_P (see) instead of $a_{wot\ ref}$.
(e) For vehicles with variable gears ratios (e.g. automatics, continuously variable, electric vehicles) it is recommended to establish and use an electronic or mechanic control to prevent downshifts to gears lower than those used in normal urban driving as defined by the manufacture and to fulfil above defined acceleration requirements.

[If a vehicle does not have a selectable gear range then the vehicle propulsion system should be adjusted to allow the vehicle to accelerate at the target rate specified for the vehicle category being tested. If a precise setting cannot be obtained the setting closest to the target shall be used. If the rate is higher than the target other measures may be needed to mitigate the influence of the high acceleration such as tyres.

Vehicles with automatic (or continuously variable) transmissions in which it is difficult to control (lock in a specific range) shall be tested in the normal gear selected for urban driving. This may include drive with a change to a lower range. However the other conditions shall be met.]

8.4.2.5. Constant Speed Test

Perform the constant speed test with the same gear ratios used according 8.4.2.4.3. according to the test speed specified under 8.4.2.4.1.

8.4.3. Vehicle of category M2, M3, [N2 < 7,5 tonnes], N2 > 7,5 tonnes, N3

8.4.3.1. General conditions

The vehicle shall approach the line AA' with the path of its centreline following as closely as possible the line CC (see figure 1).

The test has to be conducted without a trailer or semitrailer. If a trailer is not readily separable from the towing vehicle this one has to be ignored when considering the crossing of line BB'.

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

8.4.3.2. Loading conditions

8.4.3.2.1. For vehicles of categories M2 and M3

Measurements shall be made at kerb mass plus the driver and measurement equipment.

8.4.3.2.2. For vehicles of categories [N2 < 7,5 tonnes], N2 > 7,5 tonnes and N3

[The total vehicle test weight should be 50 kg per kW. The extra loading should be placed above the rear axle. However, the extra loading should be limited to 75% of the max. weight allowed for the rear axle.

The total weight for vehicles with more than two axles should be the same as for a two-axle vehicle. The weight should be placed above the driven rear axle(s).]

8.4.3.3. Wide open throttle test

When the reference point of the vehicle reaches the line AA' the accelerator control shall be fully engaged (without operating the automatic downshift to a lower range than normally used in urban driving) and held fully engaged until the reference point is 5 m behind line BB'. The accelerator control shall then be released.

8.4.3.4. Target values

8.4.3.4.1. Engine speed at line BB'

When the reference point passes line BB, the engine revolution shall be between 85% and 89% of speed S at which the engine develops its rated maximum power.

8.4.3.4.2. Gear selection

The gear choice is determined by the gear that is the closest to 35 km/h when the engine revolution is 85% of speed S at which the engine develops its rated maximum power. If the difference in speed exceeds 5 km/h, then two gears should be tested, one above and one below 35 km/h.

8.4.3.4.3. Engine speed at line AA'

When the acceleration starts, the engine speed must be at least 1000 min^{-1}. If that condition cannot be fulfilled, then the next higher gear has to be used.

8.5. Readings to be taken and reported values

8.5.1. General

At least four measurements shall be made on each side of the vehicle and gear ratio respectively.

The maximum A-weighted sound pressure level indicated during each passage of the vehicle between the two lines AA' and BB' (see Figure 1) shall be noted. If a sound peak obviously out of character with the general sound pressure level is observed, the measurement shall be discarded.

The results shall be considered valid when four consecutive measurements on each side of the vehicle are within 2 dB. If not, additional runs shall be made until four consecutive measurements on either side are within 2 dB of each other.

NOTE: The spread of results between runs may be reduced if there is a 1 minute long wait, at idle in neutral, between runs.

Average the results of each side separately. Take as the intermediate result the higher of the two averages.

The final reported value for the vehicle is as indicated below.

8.5.2. Vehicles of category L

(Still under development.)

8.5.3. Vehicles of category M1 [, N1]

The calculated reporting value $L_{wot\ rep}$ for the wide open throttle test then is:

[$L_{wot\ rep} = L_{wot\ (i+1)} + k * (L_{wot(i)} - L_{wot\ (i+1)})$ Equation 8.5.3.-1]

gear ratio test the reporting value is directly derived from the test result itself.

The calculated reporting value $L_{cst\ rep}$ for the constant speed test is:

[$L_{cst\ rep} = L_{cst\ rep\ (i+1)} + k * (L_{cst\ (i)} - L_{cst\ (i+1)})$ Equation 8.5.3.-2]

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

The final result is calculated by combining $L_{wot\ rep}$ and $L_{cst\ rep}$

The equation is:

[$L_{urban} = L_{wot} - k_P * (L_{wot} - L_{cst})$ Equation 8.5.3.-3]

The weighting factor kP gives the part power factor for urban driving and is calculated by:

[$k_P = 1 - (a_{urban} / a_{wot})$ Equation 8.5.3.-3]

8.5.4. Vehicles of category M2, M3, [N1, N2,] N3

When one gear is tested the final result is the highest value of the two averages.

When two gears are tested the arithmetic mean of the two averages for each side of these two conditions shall be calculated. The final result is the highest value of the two calculated averages.

8.6. Measurement uncertainty

Measurements made in conformity with this international standard result in levels that are influenced by climatic conditions. The climatic conditions, as there is temperature, humidity, wind speed, air pressure and temperature of the asphalt surface, can affect the performance of the vehicle powertrain, modify the sound level of the tyres, and disturb the propagation path of the sound. In addition, the use of the asphalt test surface specified in ISO 10844 has reduced, but not eliminated, the variations traditionally encountered from different sites. Tests of a vehicle at the same site, in similar climatic conditions will result in sound pressure levels that are within ± 2 dB(A). However, testing over the entire range of temperature and wind conditions allowed in this standard may result in larger variation. This standard encourages the acquisition of additional environmental conditions, to develop a better understanding of these factors on the measurement, and offers some suggestions to reduce the variations. Refer to Annex A.

9. TEST REPORT

The test report shall include the following information:

(a) reference to this International Standard;
(b) details of the test site, site orientation and weather conditions including wind speed and air temperature; wind direction, barometric pressure, humidity and track surface temperature are optional measurements but should also be recorded if available;
(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 tread depth, tyre production type, test mass 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 and engine speed at the end of the acceleration;
(i) the auxiliary equipment of the vehicle, where appropriate, and its operating conditions;

(j) all valid A-weighted sound pressure level values measured, listed according to the side of the vehicle and the direction of the vehicle movement on the test site.

Annex A

MEASUREMENT UNCERTAINTY

This International Standard has been modified, in relation to ISO 362:1994, to improve the repeatability and reproducibility of the measurements. The procedure still does not require a higher level of precision for some test parameters, because there is insufficient data to justify tighter tolerance or limits on these requirements.

The use of the asphalt surfacing specified in ISO 10844 has reduced the variation typical in earlier measurements. However, ISO and Society of Automotive Engineers (SAE) test programs (see Annex B) have indicated that there is still some variation in sound pressure level measurements of identical vehicles on surfaces meeting the site qualifications. In addition to the site variation, there are vehicle and measurement variations attributable to climatic conditions. A reduction of the temperature range to 10 °C to 30 °C generally produces better agreement in the results (see annex B, ref. [4]). Likewise it should be noted that temperature, humidity and atmospheric pressure can have a significant influence on engine performance and microphone response. There is also a level of uncertainty introduced by the wind disturbance of the propagation path.

More precise calibration, better instrument specifications and test operation criteria in this revised edition reduces the variations in sound pressure levels. Also, the variations that will occur may be easier to explain since this International Standard now requires or recommends important meteorological parameters be recorded. However, there remain variations that cannot be accounted for within the allowed ranges. Tests from one site to another and during different, but accepted, climatic conditions will normally vary around +1 dB, but in extreme cases variations of +2 dB may occur. Test data of identical products should be evaluated taking into account these factors if the measurements are found to be out of the range that would be anticipated from previous measurements.

[Some regulatory organisations specify a reduction of the measured level, by 1 dB, to account for this type of variation. However, such modification of measured levels are out of the scope of the ISO engineering standards. The variations also support the idea of rounding the measured level to the nearest integer in cases where the test parameters are not closely controlled. Engineering comparisons where meteorological and other parameters are restricted or controlled, will reduce this variation to where reporting levels to the nearest 0,1 dB may be significant.]

Annex B (informative)

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Annex C (informative)

TECHNICAL BACKGROUND INFORMATION

(Still under development.)

Annex D (informative)

[Flow Chart of the Procedure]

Definition of the New Test Procedure

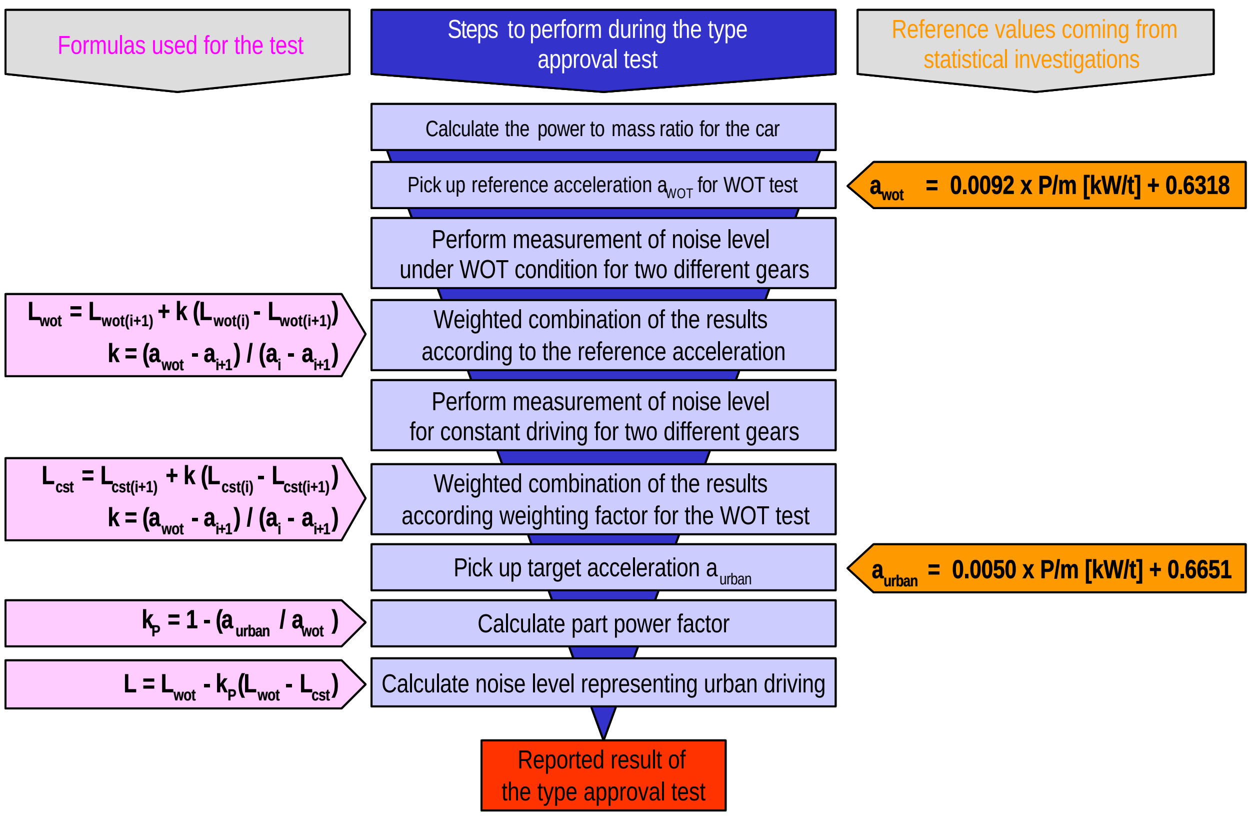

Figure 1

[Annex E (informative)

INDOOR TEST OPERATION]

1. Concept

The exterior noise test operation described in this standard is designed to measure the noise radiated from the vehicle to the bystander on the street during an urban driving cycle. One of the principal criteria of the standard is that it be done in an acoustic free field or more precisely a hemi-anechoic space. These criteria can be reproduced in a laboratory by installing absorbing wedges in a large dynamometer room providing the same effective propagation media.

2. Room Requirements

The microphones can be placed at a distance of 7.5 m from the center of the vehicle if the room is approximately 14 meters wide for a single side facility or 27 m for a dual sided facility. The determining factor in the width dimension is the low frequency cut-off. As a general rule the microphones must be ¼ wavelength from the absorptive walls and the absorptive media must be nominally ¼ wavelength of the lowest frequency of interest. As an example, if the 4 cylinder engines being tested have a low engine speed of 1000 min^{-1} then the lowest frequency is approximately 34 Hz and the wedge depth is nominally 2.6 m. The length of the longest vehicle of course determines the room length. For a typical vehicle of 5m length the room should be 36 m long. The height follows a similar set of requirements however a nominal value used is 7.5 m to the wedge face. The size can be adjusted to meet the specific application for the products being tested.

3. Dynamometer Requirement

There are any numbers of dynamometer drive systems available for this use. The unit must be capable of applying a road load to the drive wheels of the vehicle, in many cases all four. The unit must 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 level of near 50 dB(A) will meet most requirements. In general the 1/3 octave or other spectrum analysis should be made to ensure the overall usability of the facility for design work. In addition to the acoustic considerations, the facility should also be able move sufficient air to remove dangerously fatal exhaust fumes that are part of the test during open exhaust development work. The control of the ambient temperature is also a consideration. Generally an ambient level of 20 ± 3°C is feasible for most applications. Finally the dynamometer unit must be able to follow the rapid transient of the acceleration cycle. The operation of the vehicle is most often a computerized throttle application but if the air extraction system allows for remote extraction of the exhaust a person can operate the throttle. However human variation increases the variation of the total measurements.

4. Microphone Placement

Typical facilities currently in use have from 15 to 20 microphone placed in a line on each side at a distance 7.5 m from the longitudinal centerline of the vehicle. In most cases the array is evenly spaced along the line, however in some instances the microphones are concentrated at a close spacing of near 1 meter with the array extending from 10 meters in front of the vehicle microphone to 10 meters behind the rear of the vehicle.

5. Measurement Capability

The current facilities have demonstrated a good correlation between road tests and dynamometer tests for the powertrain portion of the vehicle noise. The problem with the total vehicle measurements is related to the dominance of the measurement by the tyre rolling noise. When a production tyre is placed on the dynamometer rolls its contact patch is modified such that the levels increase significantly from on the flat test road surface. The problem can be significantly reduced by replacing the production tyre with a slick (tyre without any tread) or tyres up to 1.6 mm for some applications. This limitation is significant enough to prevent good correlation with current outdoors-full vehicle measurements. There is work being done by some organizations to determine alternatives that may reduce this problem.

However even with this limitation the capability to develop components and subs-systems is extremely valuable. The indoor method eliminates dependence on weather restrictions especially in areas where rain, snow and wind conditions result in significant time loss. In addition it can be used to verify that a component change, other than tyres will not alter the type approval sound level.

Used of the facilities along with an increased study of the tyre/roll interface will lead to better use of this type of facility. The process may show the room levels to be a quantifiable difference that can be added to the powertrain component for the total vehicle level.

6. Data Analysis

The data analysis is the same as used in any multi-channel measurement system. In general the data is acquired on a time basis from each of the microphones. As the vehicle is accelerated following the procedure outlined in the main body of this standard a position signal is acquired, generally from the dynamometer roll to synchronize the measurement channels with vehicle position and the acceleration, engines speed and vehicle speed. Through the process of combining these signals a sweep is made of the microphone array to represent the movement of the vehicle past a single microphone. The digital processing systems provide a single plot of the overall sound level at each position along the “course”. In addition the systems generally have the capability to provide a time-based analysis of the individual microphones. This enhances the capability of defining the noise sources such as the level from the microphone directly in line with the exhaust outlet or at the centerline of the vehicle front axle. Most data processing systems offer an array of spectral band, order tracking and other analysis that provide a detailed map of the vehicle noise information.

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