80 Quiet road transport vehicles

Refer to: R138 00 (Pause function is prohibited)

80.1 Effective date and Scope:

80.1.1 From 2019/7/1, the new electric vehicle type of category symbols M and N, and from 2021/7/1 all electric vehicle types of category symbols M and N shall comply with this regulation.

80.1.2 Applicants applying for low volume safety approval and applying for vehicle-by-vehicle low volume, it could exempt form paragraphs 80.4.1.3, 80.4.1.4, 80.4.1.6 and 80.4.1.11.

80.2 Definitions:

80.2.1 “Acoustic Vehicle Alerting System” (AVAS) means a component or set of components installed to vehicles with the primary purpose to fulfill the requirements of this Regulation.

80.2.2 “Frequency Shift” means the variation of the frequency content of the AVAS sound as a function of the vehicle speed.

80.2.3 “Electrified vehicle” means a vehicle with a powertrain containing at least one electric motor or electric motor-generator.

80.2.3.1 “Pure Electric Vehicle” (PEV) means a motor vehicle with an electric motor as its sole mean of propulsion.

80.2.3.2 “Hybrid Electric Vehicle” (HEV) means a vehicle with a powertrain containing at least one electric motor or electric motor generator and at least one internal combustion engine as propulsion energy converters.

80.2.3.3 “Fuel Cell vehicle” (FCV) means a vehicle with a fuel cell and an electric machine as propulsion energy converters.

80.2.3.4 “Fuel Cell Hybrid Vehicle” (FCHV) means a vehicle with at least one fuel storage system and at least one Rechargeable Electric Energy Storage System (REESS) as propulsion energy storage system.

80.2.4 “Mass in running order” means the mass of the vehicle, with its fuel tank(s) filled to at least 90% of its or their capacity/ies, including the mass of the driver (75 kg), of the fuel and liquids, fitted with the standard equipment in accordance with the

manufacturer's specifications and, when they are fitted, the mass of the bodywork, the cabin, the coupling and the spare wheel(s) as well as the tools;

80.2.5 "Pause function" means a mechanism to halt temporarily the operation of an AVAS.

80.2.6 "Front plane of the vehicle" means a vertical plane tangent to the leading edge of the vehicle.

80.2.7 "Rear plane of the vehicle" means a vertical plane tangent to the trailing edge of the vehicle.

80.2.8 Symbols and abbreviated terms and the paragraph in which they are first used.

Table 1: Symbols and Abbreviations

Symbol	Unit	Paragraph	Explanation
ICE	-	6.2.	Internal Combustion Engine
AA'	-	Annex 3 para.3	Line perpendicular to vehicle travel which indicates the beginning of the zone to record sound pressure level during test
BB'	-	Annex 3 para.3	Line perpendicular to vehicle travel which indicates end of the zone to record sound pressure level during test
PP'	-	Annex 3 para 3	Line perpendicular to vehicle travel which indicates location of microphones
CC'	-	Annex 3 para.3	Centreline of vehicle travel
v_{test}	km/h	Annex 3 para.3	Target vehicle test velocity
j	-	Annex 3 para.3	Index for single test run within standstill or constant speed test conditions
$L_{reverse}$	dB(A)	Annex 3 para.3	Vehicle A-weighted sound pressure level for reversing test
$L_{crs,10}$	dB(A)	Annex 3 para.3	Vehicle A-weighted sound pressure level for constant speed test at 10 km/h.
$L_{crs,20}$	dB(A)	Annex 3 para.3	Vehicle A-weighted sound pressure level for constant speed test at 20 km/h.
L_{corr}	dB(A)	Annex 3 para.2.3.2	Background noise correction
$L_{test,j}$	dB(A)	Annex 3 para.2.3.2	A-weighted sound pressure level result of j^{th} test run
$L_{testcorr,j}$	dB(A)	Annex 3 para.2.3.2	A-weighted sound pressure level result of j^{th} test run corrected for background noise
L_{bgn}	dB(A)	Annex 3 para.2.3.1	Background A-weighted sound pressure level.
delta $L_{bgn, p-p}$	dB(A)	Annex 3 para.2.3.2	Range of maximum to minimum value of the representative background noise A-weighted sound pressure level over a defined time period.
delta L	dB(A)	Annex 3 para.2.3.2	A-weighted sound pressure level of j^{th} test result minus the A-weighted background noise level (delta $L = L_{test,j} - L_{bgn}$)
v_{ref}	km/h	Annex 3 para.4	Reference vehicle velocity used for calculating frequency shift percentage.
$f_{j, speed}$	Hz	Annex 3 para.4	Single frequency component at a given vehicle speed per sample segment, e.g. $f_{1, 5}$
f_{ref}	Hz	Annex 3 para.4	Single frequency component at reference vehicle speed
f_{speed}	Hz	Annex 3 para.4	Single frequency component at a given vehicle speed, e.g. f_5
l_{veh}	m	Annex 3, Appendix	Length of vehicle

80.3 Quiet road transport vehicles shall according to suitable type and range of principle:

80.3.1 The same vehicle brand and vehicle type series.

80.3.2 The same shape and the materials of the bodywork of the vehicle which affect the sound level emitted.

80.3.3 The principle of the drivetrain (from the batteries to the wheels). Notwithstanding the vehicles which differ with respect to overall gear ratios, battery type or the fitment of a range extender may be considered vehicles of the same type.

80.3.4 If applicable, the number and type(s) of sound emitting devices (hardware) of AVAS fitted on the vehicle.

80.3.5 If applicable, the position of the AVAS on the vehicle.

80.4 General provisions

80.4.1 Applicants apply for certification test shall provide at least one representative vehicle (or the essential part of vehicle for test) and submit the documents as below:

80.4.1.1 Vehicle specification documents, drawings and / or photographs described in paragraph 80.3.

80.4.1.2 Propulsion principle of electrical vehicle (such as PEV/HEV/FCV/FCHV).

80.4.1.3 Manufacturer of the engine(s) and Manufacturer's engine code(s)(or type code).

80.4.1.4 If applicable, a list of the components constituting the AVAS.

80.4.1.5 If applicable, a drawing of the assembled AVAS and an indication of its position on the vehicle.

80.4.1.6 Each sounds which can be selected by the driver(refer to para. 80.4.2.5).

80.4.1.7 All key functionalities(refer to para. 80.5.3.2.2).

80.4.1.8 Determine the correct manner of testing to achieve the minimum sound emission (refer to para. 80.5.3.2.3).

80.4.1.9 Tyre sizes and -types designated for the vehicle(refer to para. 80.5.3.2.5).

80.4.1.10 For automatic transmission vehicle, the gear selector shall be placed for normal driving (refer to para. 80.5.3.3.2.1 and

80.5.3.3.3.1).

80.4.1.11 Frequency shift outlined in 80.4.2.3 of the main body shall be checked using one of the following test methods to be selected (refer to para. 80.5.4.1).

80.4.1.12 The AVAS of equipment shall be mounted rigidly in an indoor facility (refer to para. 80.5.4.3.4).

80.4.1.13 Required documents for carry out the test of this regulation.

80.4.2 Acoustics characteristics

The sound emitted by the vehicle type submitted for approval shall be measured by the methods described in paragraph 80.5 to this Regulation

The speed range for operation is the range of greater than 0 km/h up to and inclusive 20 km/h.

If the vehicle that is not equipped with an AVAS fulfils the overall levels as specified in table 2 below with a margin of +3 dB(A), the specification for one-third octave bands and the frequency shift do not apply.

80.4.2.1 Constant speed tests

80.4.2.1.1 The test speeds for approval are 10 km/h and 20 km/h.

80.4.2.1.2 When tested under the conditions of paragraph 80.5.3.3.2, the vehicle shall emit a sound

- that has a minimum overall sound pressure level for the applicable test speed according to Table 2 of paragraph 80.4.2.9;

- that has at least two of the one-third octave bands according to Table 2 of paragraph 80.4.2.9. At least one of these bands shall be below or within the 1600 Hz one-third octave band;

- with minimum sound pressure levels in the chosen bands for the applicable test speed according to Table 2 of paragraph 80.4.2.9 column 3 or column 4.

80.4.2.1.3 If after a vehicle is tested in accordance with paragraph 80.5.3.3.2., for ten consecutive times within a series of measurements without recording a valid measurement because the vehicle's ICE remains active or restarts and interferes with the measurements, the vehicle is exempted from this particular test and 80.4.2.3 test.

80.4.2.2 Reversing test

80.4.2.2.1 When tested under the conditions of paragraph 80.5.3.3.3 the vehicle must emit a sound that has a minimum overall sound pressure level according to Table 2 of paragraph 80.4.2.9 column 5.

80.4.2.2.2 If after a vehicle is tested in accordance with paragraph 80.5.3.3.3, for ten consecutive times within a series of measurements without recording a valid measurement because the vehicle's ICE remains active or restarts and interferes with the measurements, the vehicle is exempted from this particular test and 80.4.2.3 test

80.4.2.3 Frequency shift to signify acceleration and deceleration

80.4.2.3.1 The intention of frequency shift is to acoustically inform road users about the change in vehicle speed.

80.4.2.3.2 When tested under the conditions of paragraph 80.5.4, at least one tone within the frequency range as specified in paragraph 80.4.2.8. emitted by the vehicle shall vary proportionally with speed within each individual gear ratio by an average of at least 0.8% per 1 km/h in the speed range from 5 km/h to 20 km/h inclusive when driving in forward direction. In case that more than one frequency is shifted, only one frequency shift needs to fulfil the requirements.

80.4.2.4 Stationary sound

The vehicle may emit a sound when stationary

80.4.2.5 Driver selectable sounds

The vehicle manufacturer may define alternative sounds which can be selected by the driver; each of these sounds shall be in compliance and approved with the provisions in paragraphs 80.4.2.1 to 80.4.2.3.

80.4.2.6 Pause function

Any function for temporary deactivation or turn off the AVAS is prohibited.

80.4.2.7 Specifications on maximum sound level for AVAS

When tested under the conditions of paragraph 80.5.3.3.2, a vehicle which is equipped with an AVAS, shall not emit an overall sound level of more than 75 dB(A), if driving in forward direction.

80.4.2.8 Minimum Sound levels

The sound level measured in accordance with the provisions of paragraph 80.5 to this Regulation, mathematically rounded to the nearest integer value, shall have at least the followings values:

80.4.2.9 Table 2: Minimum Sound Level Requirements in dB(A)

Frequency in Hz		Constant Speed Test paragraph 3.3.2. (10 km/h)	Constant Speed Test paragraph 3.3.2. (20 km/h)	Reversing Test paragraph 3.3.3.
Column 1	Column 2	Column 3	Column 4	Column 5
Overall		50	56	47
1/3rd Octave Bands	160	45	50	-
	200	44	49	
	250	43	48	
	315	44	49	
	400	45	50	
	500	45	50	
	630	46	51	
	800	46	51	
	1,000	46	51	
	1,250	46	51	
	1,600	44	49	
	2,000	42	47	
	2,500	39	44	
	3,150	36	41	
	4,000	34	39	
	5,000	31	36	

80.5 Methods and instruments for measuring the sound made by motor vehicles

80.5.1 Instrumentation

80.5.1.1 Instruments for acoustic measurement

80.5.1.1.1 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 61672-1-2013.

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 60942-2003.

Measurements shall be carried out using the time weighting “F” of the acoustic measurement instrument and the “A” frequency weighting also described in IEC 61672-1-2013. 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 30ms.

When measurements are carried out for one-third octaves, the instrumentation shall meet all requirements of IEC 61260-1-2014, class 1.

When measurements are carried out for frequency shift, the digital sound recording system shall have at least a 16 bit quantization. The sampling rate and the dynamic range shall be appropriate to the signal of interest.

The instruments shall be maintained and calibrated in accordance to the instructions of the instrument manufacturer.

80.5.1.1.2 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 paragraph 80.5.1.1.1. 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.

80.5.1.1.3 Compliance with requirements

Compliance of the sound calibrator with the requirements of IEC 60942-2003 shall be verified once a year. Compliance of the instrumentation system with the requirements of IEC 61672-3-2013 shall be verified at least every 2 years. All compliance testing shall be conducted by a laboratory which is authorized to perform calibrations traceable to the appropriate standards.

80.5.1.2 Instrumentation for speed measurements

The road speed of the vehicle shall be measured with instruments meeting specification limits of at least ± 0,5km/h when using continuous measuring devices.

If testing uses independent measurements of speed, this instrumentation shall meet specification limits of at least ± 0,2 km/h.

80.5.1.3 Meteorological instrumentation

The meteorological instrumentation used to monitor the environmental conditions during the test shall meet the specifications of:

(a)±1C or less for a temperature measuring device;

(b)±1,0m/s for a wind speed-measuring device;

(c)±5hPa for a barometric pressure measuring device;

(d)±5% for a relative humidity measuring device.

80.5.2 Acoustic environment, meteorological conditions, and background noise

80.5.2.1 Test site

80.5.2.1.1 General

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

80.5.2.1.2 Outdoor testing

The test site shall be substantially level. The test track construction and surface shall meet the requirements of ISO 10844:2014.

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 microphones, there shall be no obstacle that could influence the acoustic field and no person shall remain between the microphone and the noise source. The meter observer shall be positioned so as not to influence the meter reading. Microphones shall be located as specified in Figures 1.

80.5.2.1.3 Indoor hemi anechoic or anechoic testing

This paragraph specifies conditions applicable when testing a vehicle, either operating as it would on the road with all systems operational, or operating in a mode where only the AVAS is operational.

The test facility shall meet requirements of ISO 26101:2012 with the following qualification criteria and measurement requirements appropriate to this test method.

Space to be deemed hemi-anechoic shall be defined as shown in Figure 3.

For qualifying the hemi acoustic space, the following evaluation shall be conducted:

(a) Sound source location shall be place on the floor in middle of the space deemed to be anechoic;

(b) Sound source shall provide a broadband input for measurement;

(c) Evaluation shall be conducted in one-third-octave bands;

(d) Microphone locations for evaluation shall be on a line from the source location to each position of microphones used for measurement in this Regulation as shown in Figure 3. This is commonly referred at the microphone transverse;

(e) A minimum of 10 points shall be used for evaluation on the microphone transverse line;

(f) The one-third-octave bands used to establish hemi-anechoic qualification shall be defined to cover the spectral range of interest;

The test facility shall have a cut-off frequency, as defined in ISO 26101.2012, lower than the lowest frequency of interest. The lowest frequency of interest is the frequency below which there is no signal content relevant to the measurement of sound emission for the vehicle under test.

In the vicinity of the microphones, there shall be no obstacle that could influence the acoustic field and no person shall remain between the microphone and the noise source. The meter observer shall be positioned so as not to influence the meter reading. Microphones shall be located as specified in Figures 2.

80.5.2.2 Meteorological conditions

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

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

The meteorological instrumentation shall deliver data representative for the test site and shall be positioned adjacent to the

test area at a height representative of the height of the measuring microphone.

The measurements shall be made when the ambient air temperature is within the range from 5C to 40C.

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

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

80.5.2.3 Background noise

80.5.2.3.1 Measurement criteria for A-weighted sound pressure level

The background, or ambient noise, shall be measured for duration of at least 10seconds. A 10 second sample taken from these measurements shall be used to calculate the reported background noise, ensuring the 10 seconds sample selected is representative of the background noise in absence of any transient disturbance. The measurements shall be made with the same microphones and microphone locations used during the test.

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

The recorded maximum A-weighted sound pressure level from both microphones during the 10 second sample shall be reported as the background noise, L_{bgn}, for both left and right microphones.

For each 10 second sample at each microphone, the maximum to minimum range of the background noise, $\Delta L_{bgn,\ p\text{-}p}$, shall be reported.

The one-third-octave frequency spectrum, corresponding to the reported maximum level of background noise in the microphone with the highest background level, shall be reported.

As an aid for measurement and reporting of background noises see flowchart in Figure 4.

80.5.2.3.2 Vehicle A-weighted sound pressure level measurement correction criteria

Depending on the level and the range of maximum to minimum value of the representative background noise A-weighted sound pressure level over a defined time period, the measured j^{th} test result within a test condition, $L_{test,j}$, shall be corrected according to the table below to obtain the background noise corrected level $L_{testcorr,j}$. Except where noted, $L_{testcorr,j}=L_{test,j} - L_{corr}$.

Background noise corrections to measurements are only valid when the range of the maximum to minimum background noise A-weighted sound pressure levels are 2 dB or less.

In all cases where the range of the maximum to minimum background noise is greater than 2 dB, When the maximum to minimum range of background noise is greater than 2 dB and the level of the background noise is less than 10 dB below the measurement, no valid measurement is possible.

Table 3: Correction for level of background noise when measuring vehicle A-weighted sound pressure level

Correction for background noise		
Range of maximum to minimum value of the representative background noise A-weighted sound pressure level over a defined time period delta $L_{bgn, p\text{-}p}$ in dB(A)	Sound pressure level of j-th test result minus background noise level delta L = $L_{test,j}$ - L_{bgn} in dB(A)	Correction in dB(A) L_{corr}
-	delta $L \geq 10$	no correction needed
≤ 2	$8 \leq$ delta $L <10$	0,5
	$6 \leq$ delta $L <8$	1,0
	$4.5 \leq$ delta $L <6$	1,5
	$3 \leq$ delta $L <4.5$	2,5
	delta $L < 3$	no valid measurement can be reported

If a sound peak obviously out of character with the general sound pressure level is observed, that measurement shall be discarded.

As an aid for measurement correction criteria see flowchart in Figure 4.

80.5.2.3.3 Background noise requirements when analysing in one-third-octave bands

When analysing one-third octaves according to this regulation, the level of background noise in each one-third octave of interest, analysed according to paragraph 80.5.2.3.1, shall be at least 6 dB below the measurement of the vehicle or AVAS under test in each one-third-octave band of interest. The A-weighted sound pressure level of the

background noise shall be at least 10 dB below the measurement of the vehicle or AVAS under test.

Background compensation is not permitted for one-third octave band measurements.

As an aid for background noise requirements when analysing in one-third-octave bands see flowchart in Figure 6.

80.5.3 Test procedures for vehicle sound level

80.5.3.1 Microphone positions

The distance from the microphone positions on the microphone line PP' to the perpendicular reference line CC' as specified in Figure 1 and 2 on the test track or in an indoor test facility shall be 2,0m±0,05m.

The microphones shall be located 1,2m±0,02m above the ground level. The reference direction for free field conditions as specified in IEC 61672-1:2013 shall be horizontal and directed perpendicularly towards the path of the vehicle line CC'.

80.5.3.2 Conditions of the vehicle

80.5.3.2.1 General conditions

The vehicle shall be representative of vehicles to be put on the market as specified by the manufacturer in agreement with the technical service to fulfill the requirements of this Regulation.

Measurements shall be made without any trailer, except in the case of non-separable vehicles.

In the case of HEVs/FCHVs, the test shall be carried out in the most energy efficient mode so to avoid the restart of the ICE, e.g. all audio-, entertainment-, communication- and navigation-systems shall be switched off.

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

80.5.3.2.2 Battery state of charge

If so equipped, propulsion batteries shall have a state-of-charge sufficiently high to enable all key functionalities according to the manufacturer's specifications. Propulsion batteries shall be within their component-temperature

window to enable all key functionalities that could reduce vehicle sound emissions. Any other type of rechargeable energy storage system shall be ready to operate during the test.

80.5.3.2.3 Multi-mode operation

If the vehicle is equipped with multiple driver selectable operating modes, the mode which provides the lowest sound emission during the test conditions of paragraph 80.5.3.3 shall be selected.

When the vehicle provides multiple operating modes that are automatically selected by the vehicle, it is the responsibility of the manufacturer to determine the correct manner of testing to achieve the minimum sound emission.

In cases where it is not possible to determine the vehicle operating mode providing the lowest sound emission, all modes shall be tested and the mode giving the lowest test result shall be used to report the vehicle sound emission in accordance with this regulation.

80.5.3.2.4 Test mass of vehicle

Measurements shall be made on vehicles at mass in running order with an allowable tolerance of 15 percent.

80.5.3.2.5 Tyre selection and condition

The tyres fitted to the vehicle during testing are selected by the vehicle manufacturer, and shall correspond to one of the tyre sizes and -types designated for the vehicle by the vehicle manufacturer.

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

80.5.3.3 Operating conditions

80.5.3.3.1 General

For each operating condition, the vehicle can be tested either indoor or outdoor.

For constant speed and reversing tests the vehicle may be tested either in motion or in simulated operating condition. For simulated vehicle operation, signals shall be applied to the vehicle to simulate actual in-use operation.

If the vehicle is equipped with an internal combustion engine, it shall be turned off.

80.5.3.3.2 Constant speed tests

These tests are conducted with the vehicle in forward motion or with the vehicle speed simulated by an external signal to the AVAS with the vehicle in standstill condition.

80.5.3.3.2.1 Constant speed tests in forward motion

For a vehicle tested in an outdoor facility, the path of the centreline of the vehicle shall follow line CC' as closely as possible with constant speed v_{test} throughout the entire test. The front plane of the vehicle shall pass from the line AA' at the start of the test and the rear plane of the vehicle shall pass from the line BB' at the end of the test, as shown in Figure 1a. Any trailer, which is not readily separable from the towing vehicle, shall be ignored when considering the crossing of the line BB'.

A vehicle tested in an indoor facility, shall be located with the front plane of the vehicle on the PP' line as shown in Figure 2a.. The vehicle shall maintain a constant test speed, v_{test} for at least 5 seconds.

For constant speed test condition of 10 km/h, the test speed v_{test} shall be 10 km/h ± 2 km/h.

For constant speed test condition of 20 km/h, the test speed v_{test} shall be 20 km/h ± 1 km/h.

For automatic transmission vehicle, the gear selector shall be placed as specified by the manufacturer for normal driving.

For manual transmission vehicle, the gear selector shall be placed in the highest gear which can achieve the target vehicle speed with constant engine speed.

80.5.3.3.2.2 Constant speed tests simulated by an external signal to the AVAS with the vehicle in standstill condition

A vehicle tested in an indoor or outdoor facility, shall be located with the front plane of the vehicle on the PP' line as shown in Figure 2b. The vehicle shall maintain a constant simulated test speed, v_{test} for at least 5 seconds.

For constant speed test condition of 10 km/h, the simulated test speed v_{test} shall be 10 km/h ± 0,5 km/h.

For constant speed test condition of 20 km/h, the simulated test speed v_{test} shall be 20 km/h ± 0,5 km/h.

80.5.3.3.3 Reversing tests

These tests may be conducted with the vehicle in rearward motion or with the vehicle speed simulated by an external signal to the AVAS or with the vehicle in standstill condition.

80.5.3.3.3.1 Reversing test in motion

For a vehicle tested in an outdoor facility, the path of the centreline of the vehicle shall follow line CC' as closely as possible with constant speed v_{test} throughout the entire test. The rear plane of the vehicle shall pass from the line AA' at the start of the test and the front plane of the vehicle shall pass from the line BB' at the end of the test, as shown on Figure 1b. Any trailer, which is not readily separable from the towing vehicle, shall be ignored when considering the crossing of the line BB'.

A vehicle tested in an indoor facility, shall be located with the rear plane of the vehicle on the PP' line as shown in Figure 2b. The vehicle shall maintain a constant test speed, v_{test} for at least 5 seconds.

For constant speed test condition of 6 km/h, the test speed v_{test} shall be 6 km/h ± 2 km/h.

For automatic transmission vehicle, the gear selector shall be placed as specified by the manufacturer for normal reverse driving.

For manual transmission vehicle, the gear selector shall be placed in the highest reverse gear which can achieve the target vehicle speed with constant engine speed.

80.5.3.3.3.2 Reversing test simulated by an external signal to the AVAS with the vehicle in standstill condition

A vehicle tested in an indoor or outdoor facility, shall be located with the rear plane of the vehicle on the PP' line as shown in Figure 2b. The vehicle shall maintain a constant simulated test speed, v_{test} during at least 5 seconds.

For constant test condition of 6 km/h, the simulated test speed v_{test} shall be 6 km/h ± 0,5 km/h.

80.5.3.3.3.3 Reversing test in standstill condition

A vehicle tested in an indoor or outdoor facility, shall be located with the rear plane of the vehicle on the PP' line as shown in Figure 2b.

The vehicle's gear selection control shall be in the reverse position and the brake released for test.

80.5.3.4 Measurement readings and reported values

At least four measurements for each test condition shall be made on both sides of the vehicle.

The first four valid consecutive measurement results for each test condition, within 2,0 dB per side, allowing for the deletion of non-valid results, shall be used for the calculation of the intermediate or final result.

If a sound peak obviously out of character with the general sound pressure level is observed, that measurement shall be discarded. For measurement of a vehicle in motion (forward and reversing) outdoor, the maximum A-weighted sound pressure level indicated during each passage of the vehicle between AA' and PP' ($L_{test,j}$) shall be noted for each microphone

position, to the first significant digit after the decimal place (for example XX,X). For measurement of a vehicle in motion indoor and in standstill (forward and reversing), the maximum A-weighted sound pressure level indicated during each period of 5 seconds for each microphone position, $L_{test,j}$, shall be noted, to the first significant digit after the decimal place (for example XX,X).

$L_{test,j}$ shall be corrected according to paragraph 80.5.2.3.2 to obtain $L_{testcorr,j}$.

For each maximum A-weighted sound pressure level, the corresponding one-third-octave spectrum shall be reported for each microphone position. No background correction shall be applied to any measured one-third octave result.

80.5.3.5 Data compilation and reported results

For each test condition described in paragraph 80.5.3.3., the background corrected results, $L_{testcorr,j}$, and the corresponding one third octave spectra of both sides of the vehicle individually shall be arithmetically averaged and rounded to the first decimal place.

The final A-weighted sound pressure level results $L_{crs\ 10}$, $L_{crs\ 20}$ and $L_{reverse}$ to be reported are the lower values of the two averages of both sides, rounded to the nearest integer. The final one third octave spectra to be reported are the spectra corresponding to the same side as the reported A-weighted sound pressure level.

80.5.4 Test procedures for frequency shift

80.5.4.1 General

The provisions on frequency shift outlined in 80.4..2.3 of the main body shall be checked using one of the following test methods to be selected by the manufacturer:

Method (A) Test of the complete vehicle in motion on an outdoor test track

Method (B) Test of the complete vehicle in standstill condition on an outdoor test track with simulation of the vehicle

movement to the AVAS by an external signal generator

Method (C) Test of the complete vehicle in motion in an indoor facility on a chassis dynamometer

Method (D) Test of the complete vehicle in standstill condition in an indoor facility with simulation of the vehicle movement to the AVAS by an external signal generator

Method (E) Test of the AVAS without a vehicle in an indoor facility with simulation of the vehicle movement to the AVAS by an external signal generator

The facility requirements as well as the vehicle and test setup specifications are the same as given in paragraphs 80.5 1, 80.5.2, 80.5.3.1 and 80.5.3.2 of this Annex according to the selected test method unless the following paragraphs below provide different or additional specifications.

No background noise correction shall be applied to any measurement. Special care must be given for outdoor measurements.

Any interference of the background noise shall be avoided. If a sound peak obviously out of character with the general signal is observed, that measurement shall be discarded.

80.5.4.2 Instrumentation and Signal processing

Analyser settings shall be agreed between the manufacturer and the technical service to provide data according to these requirements.

The sound analysis system shall be capable of performing spectral analysis at a sampling rate and over a frequency range containing all frequencies of interest. The frequency resolution shall be sufficiently precise to differentiate between the frequencies of the various test conditions.

80.5.4.3 Test methods

80.5.4.3.1 Method (A) – Outdoor facility and vehicle in motion

The vehicle shall be operated in the same outdoor test facility and according to the same general operating condition as for the vehicle constant speed testing (paragraph 80.5.3.3.2).

The vehicle sound emission shall be measured at target speeds of 5 km/h to 20 km/h in steps of 5 km/h with a tolerance of +/- 2 km/h for the speed of 10 km/h or less and of +/- 1 km/h for any other speeds. The speed of 5 km/h is the lowest target speed. If the vehicle cannot be operated at this speed within the given precision, the lowest possible speed below 10 km/h shall be used instead.

80.5.4.3.2 Method (B) and Method (D) – Outdoor/Indoor facility and vehicle in standstill

The vehicle shall be operated in a test facility where the vehicle can accept an external vehicle speed signal to the AVAS simulating vehicle operation. The microphone locations shall be as for the complete vehicle test conditions as specified in Figure 2a. The front plane of the vehicle shall be placed on line PP'.

The vehicle sound emission shall be measured at simulated speeds of 5 km/h to 20 km/h in steps of 5 km/h with a tolerance of +/- 0.5 km/h for each test speed.

80.5.4.3.3 Method (C) – Indoor facility and vehicle in motion

The vehicle shall be installed in an indoor test facility where the vehicle can operate on a chassis dynamometer in the same manner as outdoors. All microphone locations shall be as for the vehicle test conditions as specified in Figure 2a. The front plane of the vehicle shall be placed on line PP'.

The vehicle sound emission shall be measured at target speeds of 5 km/h to 20 km/h in steps of 5 km/h with a tolerance of +/- 2 km/h for the speed of 10 km/h or less and of +/- 1 km/h for any other speeds. The speed of 5 km/h is the lowest target speed. If the vehicle cannot be operated at this speed within the given precision, the lowest

possible speed below 10 km/h shall be used instead.

80.5.4.3.4 Method (E)

The AVAS shall be mounted rigidly in an indoor facility, by means of the equipment indicated by the manufacturer. The microphone of the measuring instrument shall be placed in 1 m distance from the AVAS in the direction where the subjective sound level is greatest and placed at a height of approximately the same level as the sound radiation of the AVAS.

The sound emission shall be measured at simulated speeds of 5 km/h to 20 km/h in steps of 5 km/h with a tolerance of +/- 0.5 km/h for each test speed.

80.5.4.4 Measurement Readings

80.5.4.4.1 Test Method (A)

At least four measurements shall be made at every speed specified in paragraph 80.5.4.3.1. The emitted sound shall be recorded during each passage of the vehicle between AA' and BB' for each microphone position. From each measurement sample a segment taken from AA until -1 meter before PP' shall be cut out for further analysis.

80.5.4.4.2 Test Methods (B), (C), (D) and (E)

The emitted sound shall be measured at every speed specified in correlated paragraphs above for at least 5 seconds.

80.5.4.5 Signal Processing

For each recorded sample the average auto power spectrum shall be determined, using a Hanning window and at least 66.6% overlap averages. The frequency resolution shall be chosen sufficiently narrow to allow a separation of the frequency shift per target condition. The reported speed per sample segment is the average vehicle speed over the time of the sample

segment rounded to the first decimal place.

In case of test method (A) the frequency that is intended to be changed with the speed shall be determined per sample segment. The reported frequency per target condition f_{speed} shall be the mathematical average of the frequencies determined per measurement sample and rounded to the nearest integer. The reported speed per target condition shall be the mathematical average of the four sample segments.

Table 4: Analysis of the shifted frequency per target condition per side

Target speed	Test run per target condition	Reported speed (average per sample segment)	Determined frequency of interest ($f_{j,\ speed}$)	Reported Speed per target condition (average of the reported speeds)	Reported frequency of interest per target condition (f_{speed})
km/h	No	km/h	Hz	km/h	Hz
5	1				
	2				
	3				
	4				
10	1				
	2				
	3				
	4				
15	1				
	2				
	3				
	4				
20	1				
	2				
	3				
	4				

For all other test methods the frequency spectrum shall directly be used for the further calculation.

80.5.4.5.1 Data compilation and reported results

The frequency intended to be shifted shall be used for the further calculation. The frequency of the lowest reported test speed rounded to the nearest integer is taken as the reference frequency f_{ref}.

For the other vehicle speeds, the corresponding shifted frequencies f_{speed} rounded to the nearest integer shall be taken from the spectra analysis. Calculate del f, the frequency shift of the signal according to equation (1):

$$del\ f=\{[(f_{speed} - f_{ref})/(v_{test} – v_{ref})]/f_{ref}\}\cdot 100 \quad \text{equation (1)}$$

where

f_{speed} is the frequency at a given speed value;

f_{ref} is the frequency at the reference speed of 5 km/h or the lowest reported s_{peed};

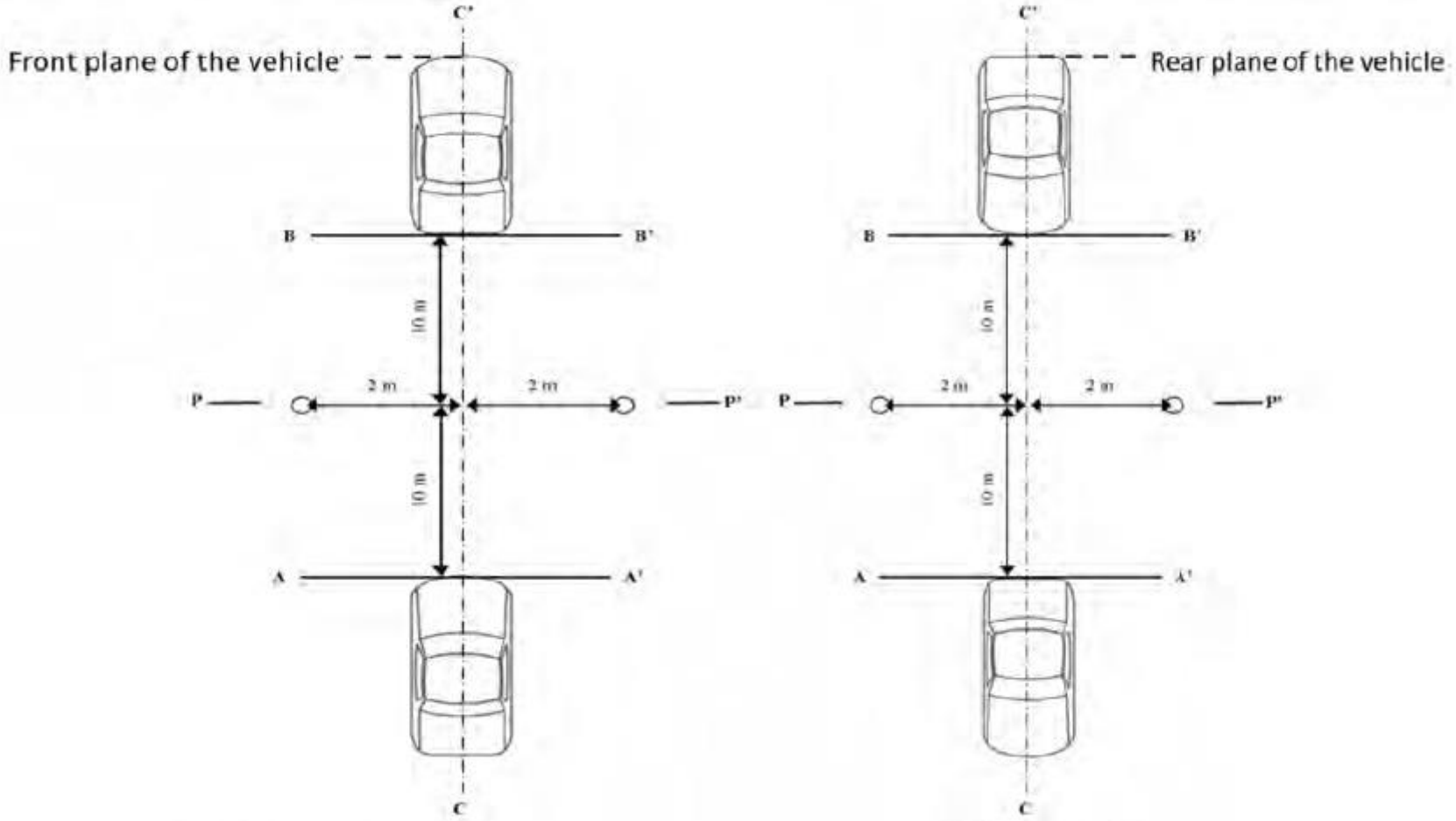
v_{test} is the vehicle speed, actual or simulated, corresponding to the frequency f_{speed};

v_{ref} is the vehicle speed, actual or simulated, corresponding to the frequency f_{ref};

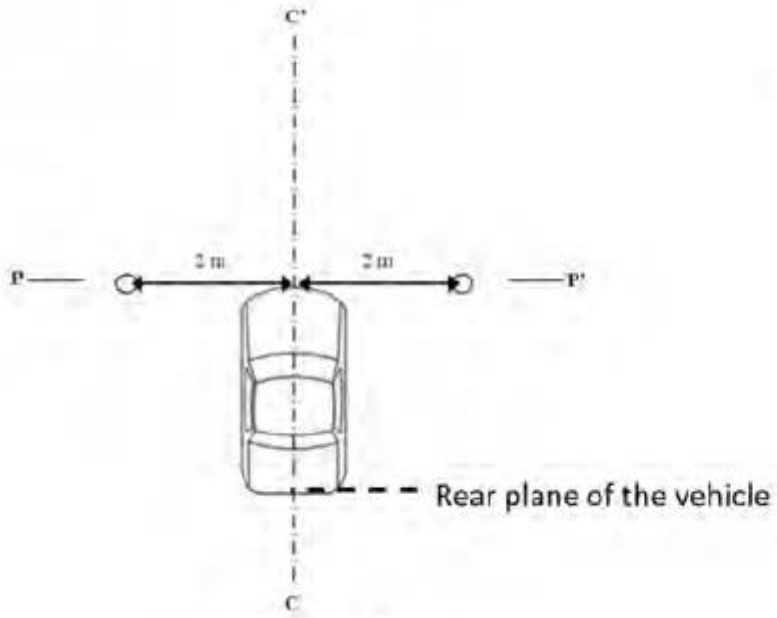
Table 5: Report table, to be completed for each frequency analysed

		Test Results at Target Speeds			
		5 km/h (Reference)	10 km/h	15 km/h	20 km/h
Reported Speed	km/h				
Frequency, f_{speed}, Left Side	Hz				
Frequency, f_{speed}, Right Side	Hz				
Frequency Shift, Left Side	%	n.a.			
Frequency Shift, Right Side	%	n.a.			

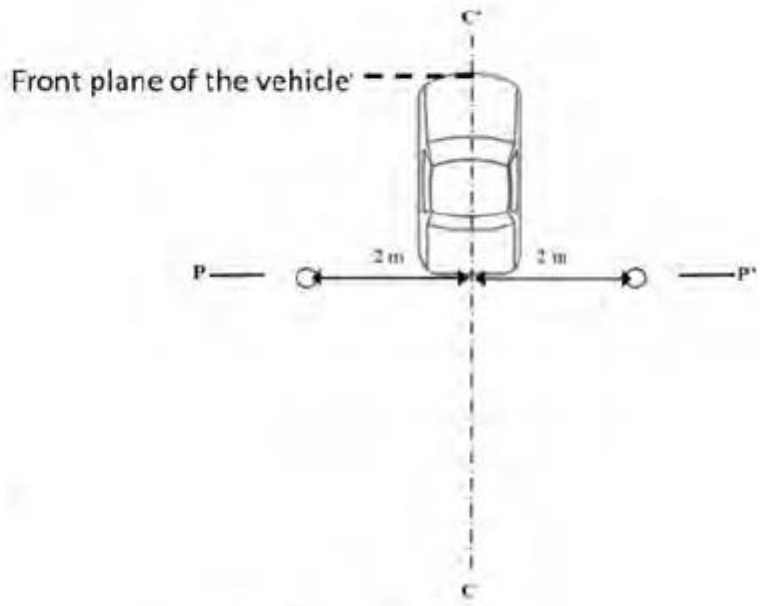
Figures 1a and 1b: Measuring positions for vehicles in motion outdoor



Figures 2a and 2b: Measuring positions for vehicles in motion indoor and in standstill



2a. Forward



2b. Reverse

Figure 3: Minimum space to be qualified as Semi-Anechoic chamber

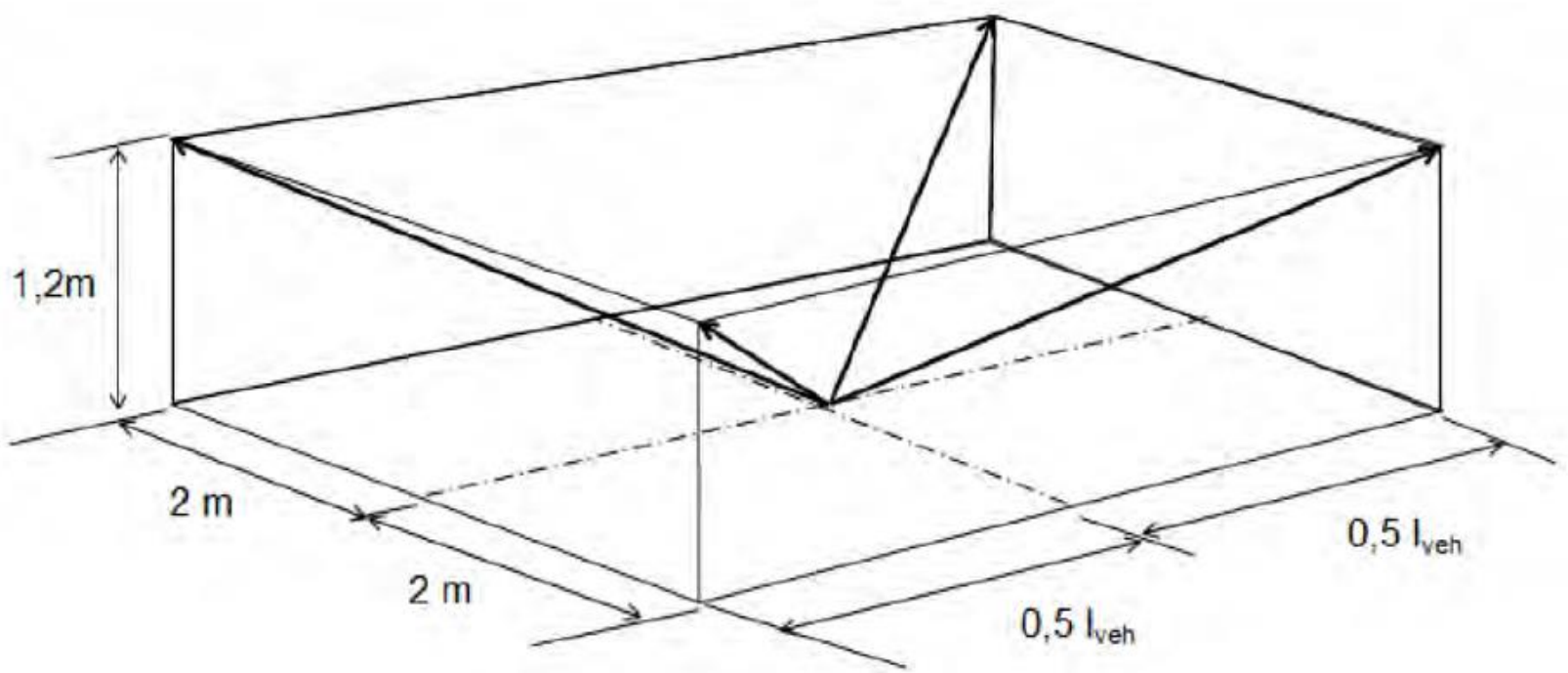


Figure 4: Determination of the range of background noise

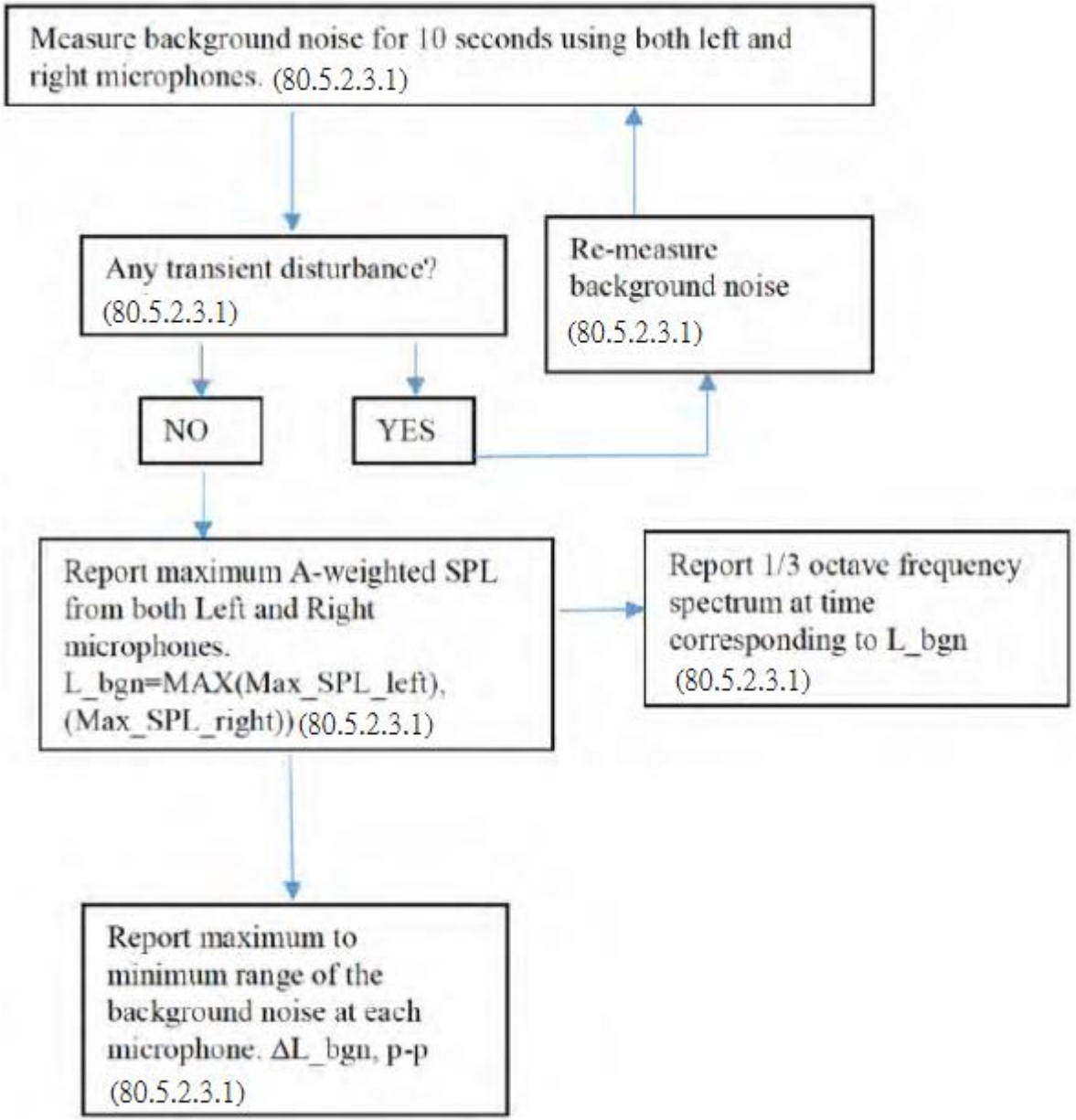


Figure 5: Vehicle A-Weighted sound pressure level measurement correction criteria

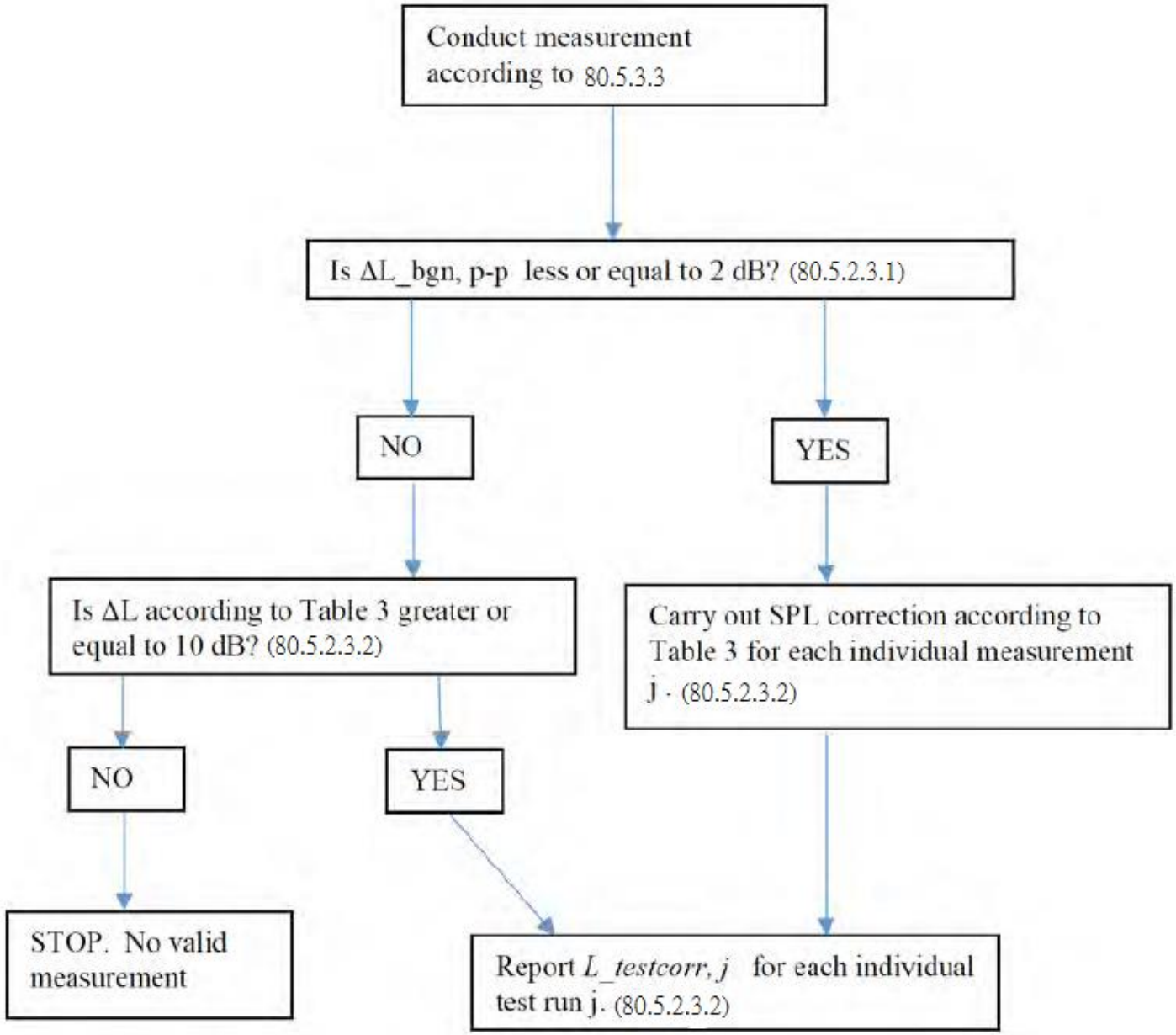


Figure 6: Background noise requirements for analysis in one-third-octave bands

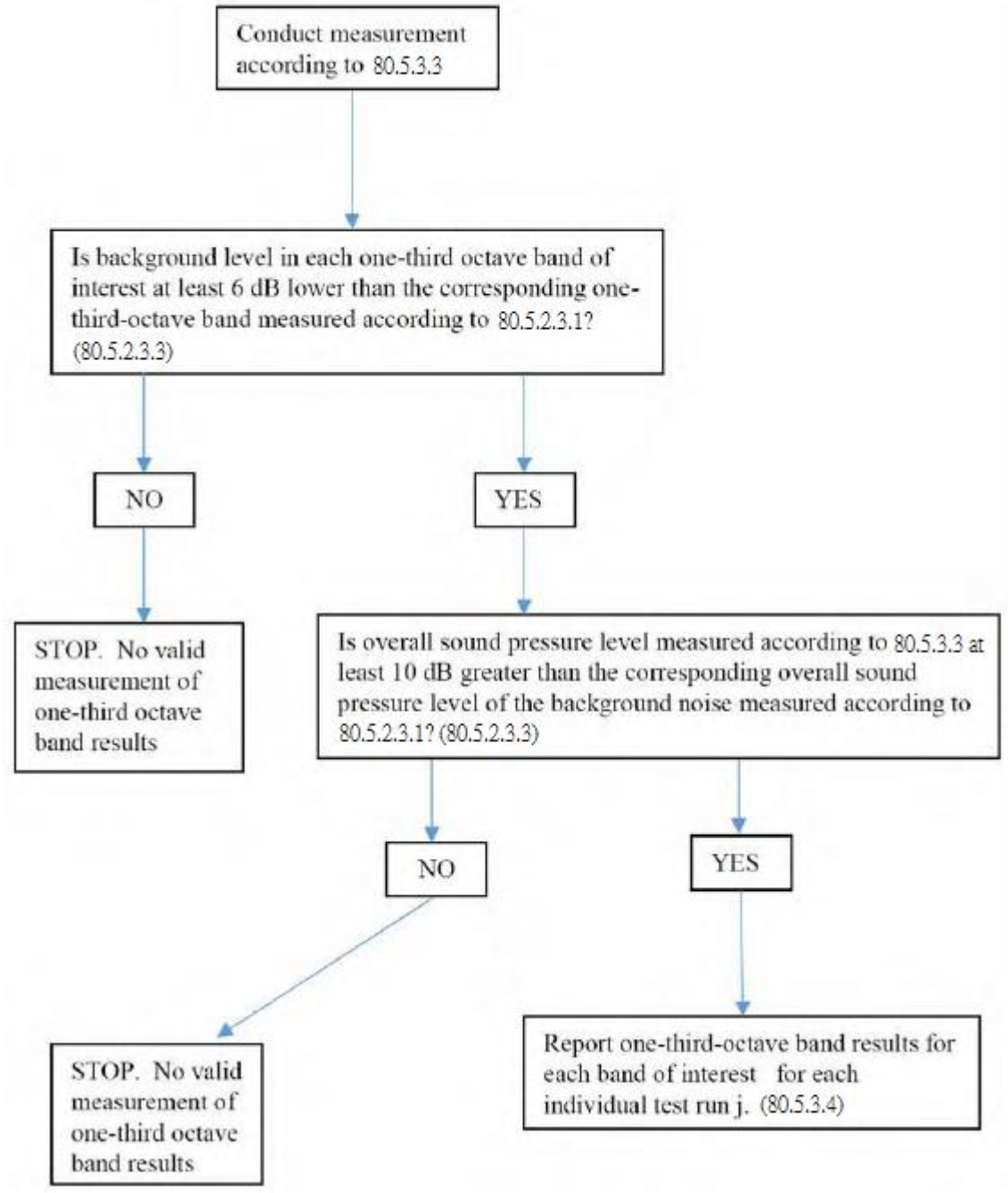


Figure 7a: Test procedures for measurement of frequency shift

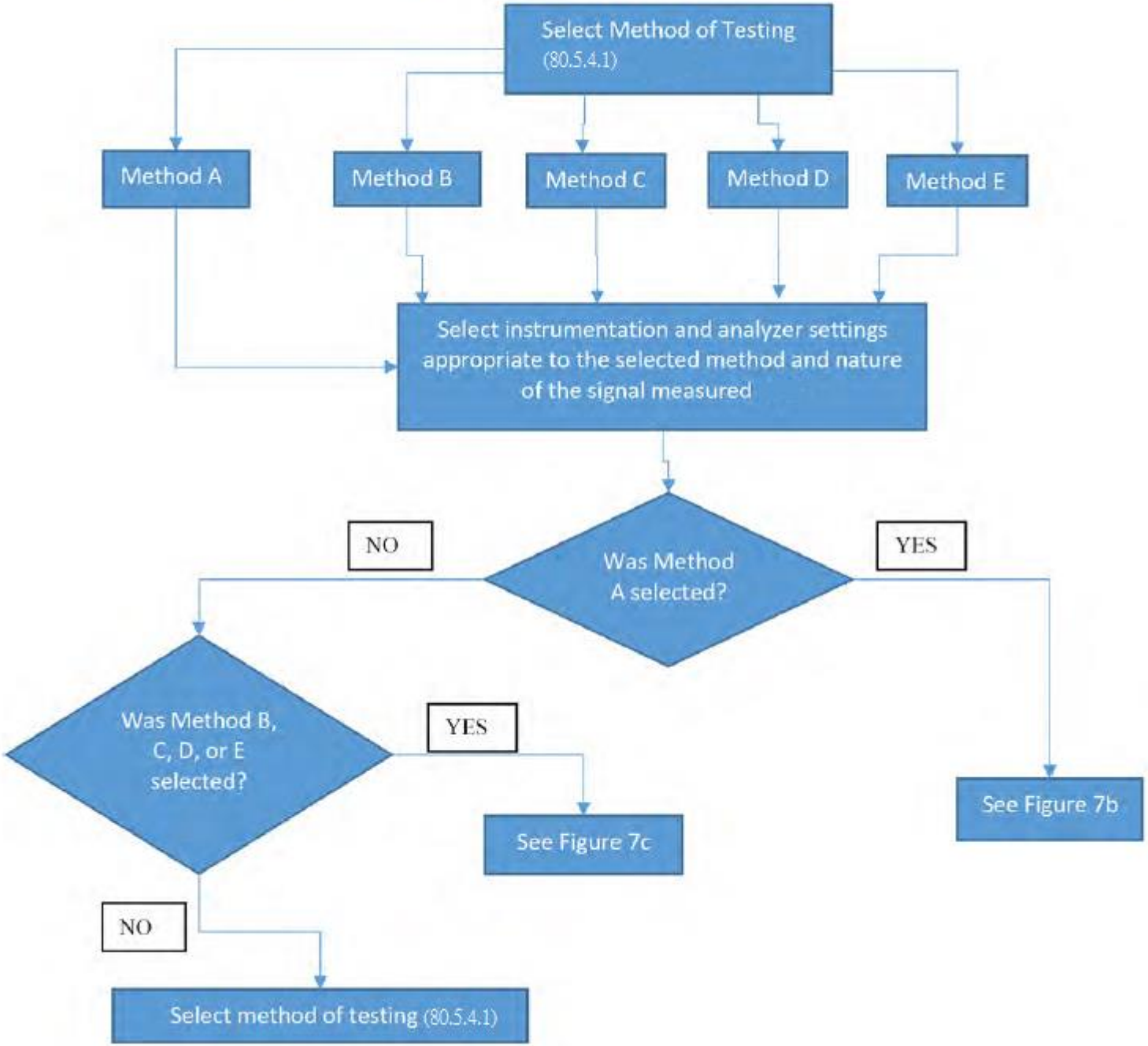
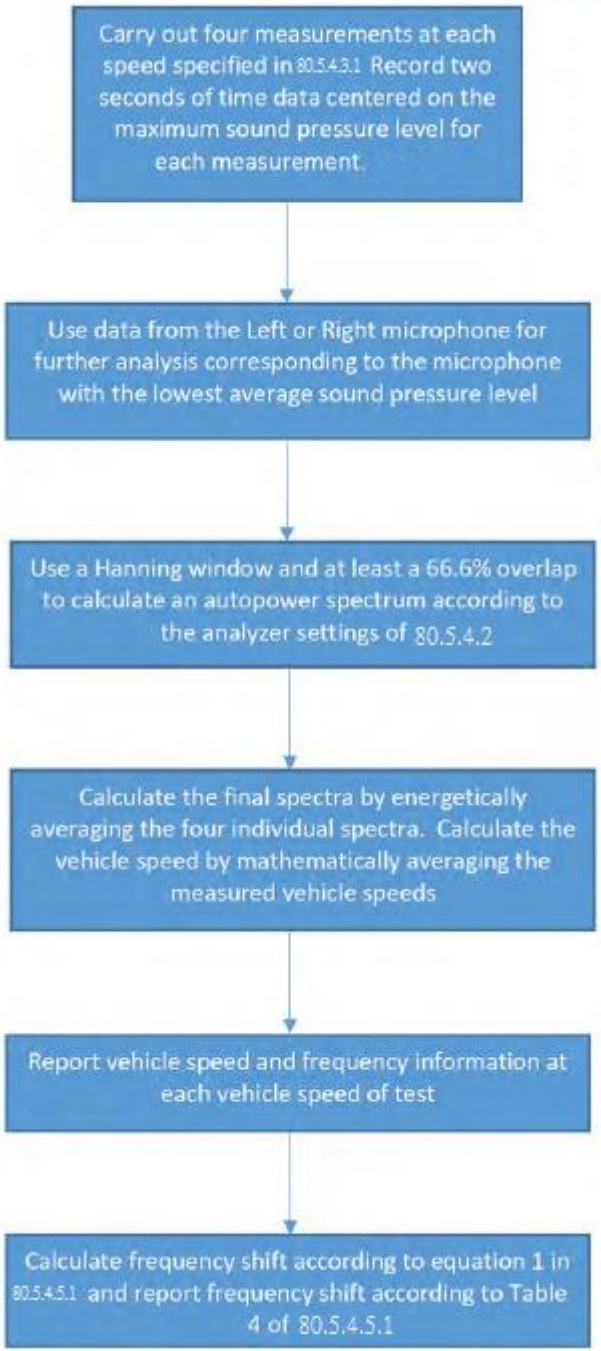


Figure 7b: Test procedures for measurement of frequency shift, Method A



ıce only

Figure 7c: Test procedures for measurement of frequency shift, Methods B, C, D, and E