INTERNATIONAL STANDARD

ISO 11451-2

First edition
1995-12-01

Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Vehicle test methods —

Part 2:
Off-vehicle radiation source

Véhicules routiers — Perturbations électriques par rayonnement d'énergie électromagnétique en bande étroite — Méthodes d'essai du véhicule —

Partie 2: Irradiation par source externe

Reference number
ISO 11451-2:1995(E)

Contents

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland
Printed in Switzerland

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.

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

International Standard ISO 11451-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

ISO 11451 consists of the following parts, under the general title *Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Vehicle test methods*:

— *Part 1: General and definitions*

— *Part 2: Off-vehicle radiation source*

— *Part 3: On-board transmitter simulation*

— *Part 4: Bulk current injection (BCI)*

Annex A forms an integral part of this part of ISO 11451.

This page intentionally left blank

Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Vehicle test methods —

Part 2:
Off-vehicle radiation source

1 Scope

This part of ISO 11451 specifies off-vehicle radiation source test methods and procedures for testing passenger cars and commercial vehicles regardless of the propulsion system (e.g. spark-ignition engine, diesel engine, electric motor). The electromagnetic disturbances considered in this part of ISO 11451 are limited to continuous narrowband electromagnetic fields.

Two methods for calibrating electromagnetic fields are defined in this part of ISO 11451: a substitution method and a closed-loop method. The substitution method is the method most commonly used.

Part 1 of ISO 11451 gives definitions, practical use and basic principles of the test procedure.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 11451. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO 11451 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 11451-1:1995, *Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Vehicle test methods — Part 1: General and definitions.*

3 Test conditions

3.1 Test temperature and supply voltage

Heat is generated in the test chamber when the vehicle is operated during the test. Sufficient cooling shall be provided to ensure that the engine does not overheat (see 4.1).

The ambient temperature in the test chamber shall be recorded if it is outside the range of (23 ± 5) °C.

For tests that require the vehicle engine to be running, the electrical charging system shall be functional. For tests where the vehicle engine is not required to be running, the battery voltage shall be maintained above 12,2 V and 24,4 V for 12 V and 24 V systems respectively.

3.2 Frequency range

The applicable frequency range of this test method is 0,1 MHz to 18 000 MHz. Testing over the full frequency range may require different field generating devices. This does not imply that testing of overlapping frequency ranges is required.

3.3 Modulation

The device under test determines the type and frequency of modulation. If no values are agreed between the users of this part of ISO 11451, the following shall be used:

— no modulation (CW);

— 1 kHz sine-wave amplitude modulation (AM) of 80 %.

3.4 Dwell time

At each frequency, the device under test shall be exposed to the test level for the minimum response time needed to control it. In all cases, this minimum time of exposure shall not be less than 2 s.

3.5 Frequency step sizes

All tests shall be conducted with linear frequency step sizes not greater than those specified in table 1.

Table 1 — Frequency step sizes

Frequency band MHz	**Maximum frequency step size** MHz
>0,1 to ⩽1	0,1
>1 to ⩽10	1
>10 to ⩽200	2
>200 to ⩽1 000	20
>1 000 to ⩽18 000	200

Alternatively, logarithmic frequency steps, with the same minimum number of frequency steps in each frequency band, may be used. The values, as agreed by the users of this part of ISO 11451, shall be documented in the test report.

If it appears that the susceptibility thresholds of the device under test are very near the chosen test level, these frequency step sizes should be reduced in the frequency range concerned in order to find the minimum susceptibility thresholds.

3.6 Test severity levels

Tests shall be conducted in both horizontal and vertical polarizations over the test frequency range. Any exceptions to this practice shall be specified in the test plan.

The user shall specify the test severity level(s) over the frequency range. Suggested test severity levels are given in annex A.

These test severity levels are expressed in terms of the equivalent root-mean-square value of the unmodulated wave.

4 Test instrument description and specification

The test consists of generating radiated electromagnetic fields by using antenna sets with radio frequency (RF) sources capable of producing the desired field strengths over the range of test frequencies. The fields are monitored with small probes to ensure proper test levels. To reduce test error, the vehicle operation under test is usually monitored by optical couplers.

4.1 Absorber-lined chamber

The objective of an absorber-lined chamber is to create an indoor electromagnetic compatibility test facility which simulates open field testing. The chamber is lined with absorbing material on as many surfaces in the chamber as possible to minimize reflections and resonances. The design objective is to reduce the reflectivity in the test area to − 10 dB or less.

The size, shape and construction of an absorber-lined chamber can vary considerably. An example of a rectangular chamber is shown in figure 1. The chamber shape is a function of the types of tests to be performed, the size of vehicle to be tested and the frequency range to be covered. Basically, an absorber-lined chamber consists of a shielded room with absorbing material on its internal reflective surfaces, with the optional exception of the floor. The minimum size of the room is determined by the size of the test region needed, the size of the field generation device and the clearances needed between them and the largest vehicle that is to be tested. To create the test region, the absorber, field generation system and chamber shape are selected to reduce the amount of extraneous energy in the test region below a minimum value which will give the desired measurement accuracy.

A frequency range of 20 MHz to 18 000 MHz has been achieved in some chambers but because of absorber material sizes required for a 20 MHz cut-off, several absorber-lined facilities have been designed with cut-off frequencies of 200 MHz or greater. Testing below cut-off is then accomplished using customized antennas and specialized methods (see 4.2.1).

The vehicle is operated during the performance of this test, generating heat in the enclosed chamber. Sufficient cooling shall be provided through chamber air-conditioning and cooling of the radiator to ensure that the engine does not overheat.

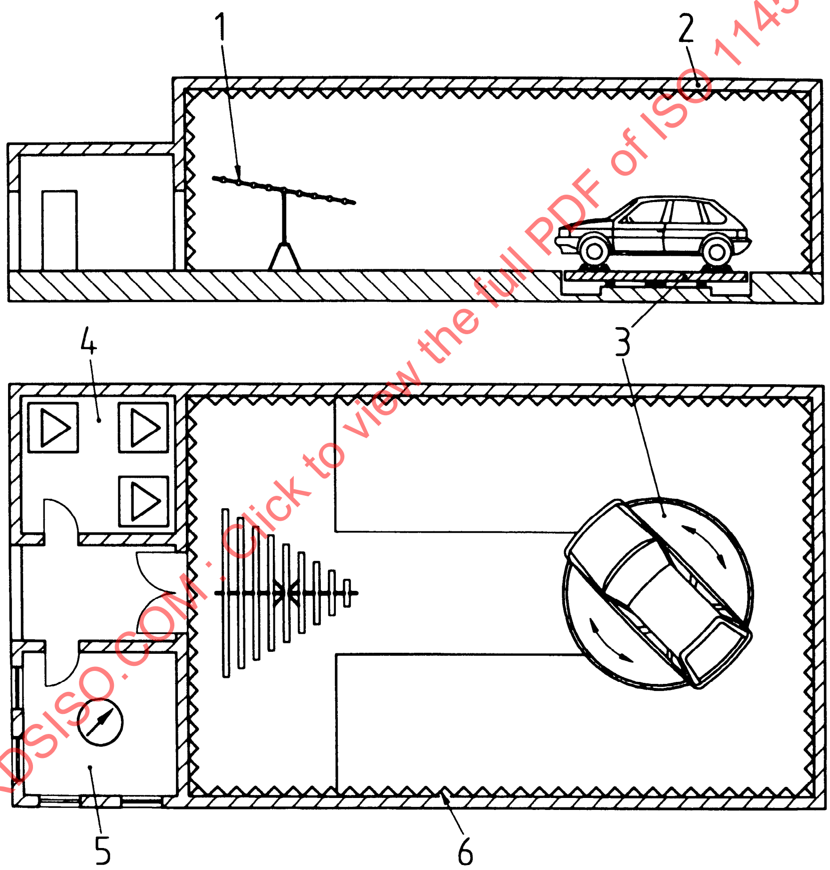
4.2 Instrumentation

4.2.1 Field generating device

The field generating device may be an antenna or a Transmission Line System (TLS).

The construction and orientation of any field generating device shall be such that the generated field can be polarized in the mode specified in the test plan.

The TLS generating device may have to be custom-designed. An example of a parallel plate TLS is shown in figure 2. An example of an equipment block diagram for a field generating device is shown in figure 3.



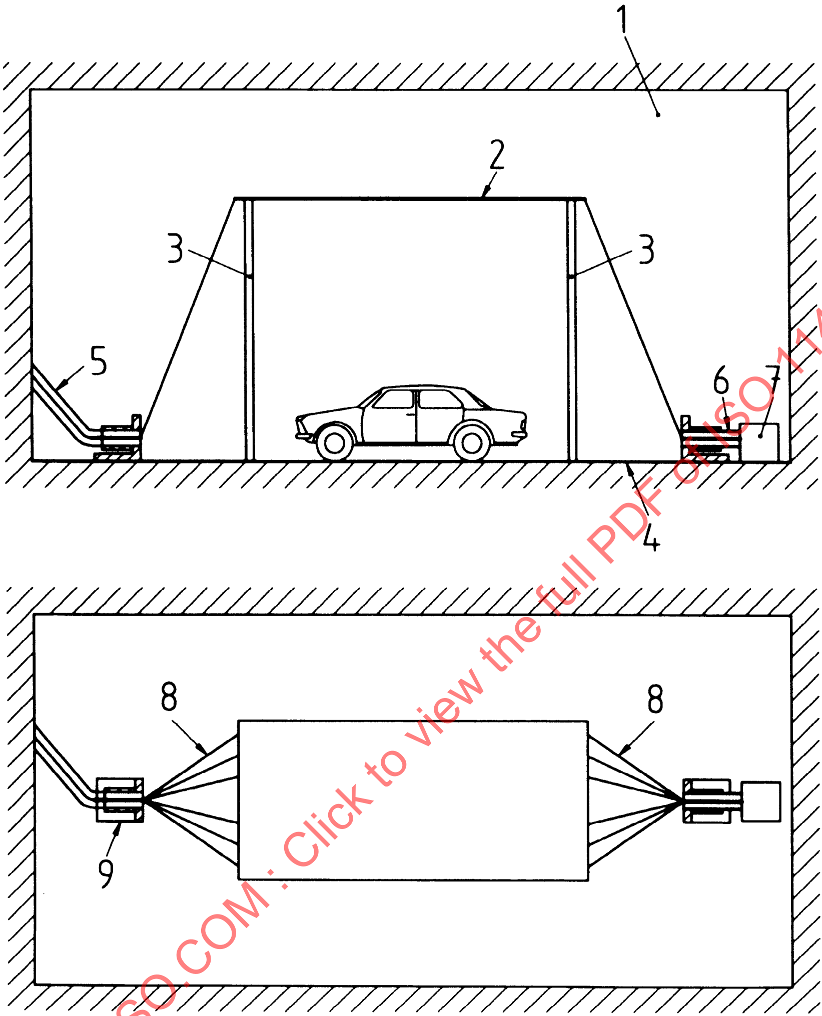
Key

1 Antenna
2 Shielded wall
3 Dynamometer on turntable[1)]
4 Amplifier room
5 Instrumentation room
6 RF absorbers

NOTE — Figure is not to scale.

1) The turntable shown is rotatable through ± 180° with two pairs of variable wheelbase rollers to simulate all vehicle sizes and functions.

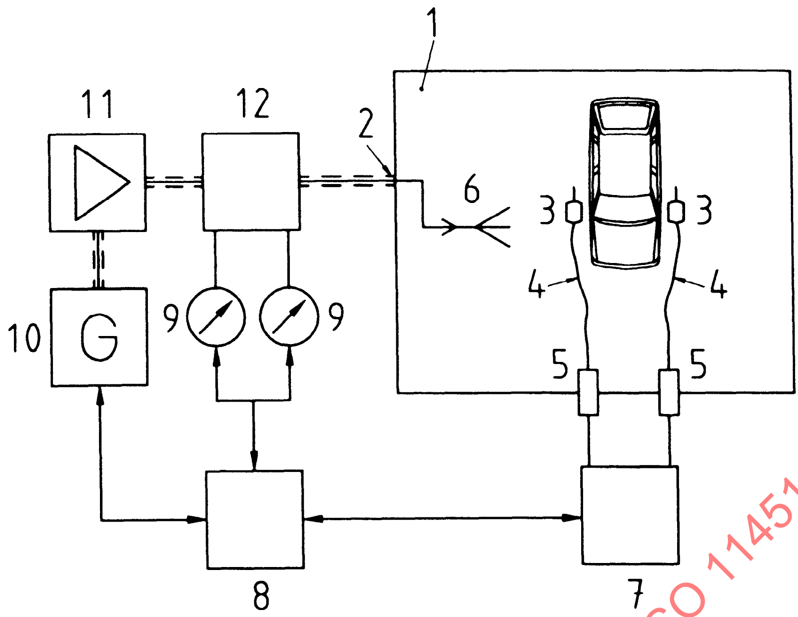
Figure 1 — Example of absorber-lined chamber



Key

1 Shielded room (can be absorber-lined except for floor)
2 Metal plate
3 Non-metallic supports
4 Metal floor
5 Signal source feed line (coaxial)
6 Coaxial
7 Load
8 Metal feed lines
9 Signal source feed connection

Figure 2 — Example of parallel plate TLS



Key
1 Absorber-lined chamber
2 Coaxial penetration
3 Field probe
4 Optical fibre or high resistance leads
5 Waveguide filter
6 Transmitting antenna
7 Field probe output
8 Process controller
9 Power meter
10 RF signal generator(s)
11 Broadband amplifiers
12 Dual directional coupler

Figure 3 — Example of an equipment block diagram for a field generating device

4.2.2 Monitoring of the device under test

Test equipment, appropriate to the test power levels, required to monitor the operation of the device under test shall be coupled to the control centre by fibre-optic links or high resistance leads.

Any electrical connection of a monitoring device to the device under test may cause a malfunction of the device under test. Extreme care shall be taken to avoid such an effect.

4.2.3 Field probes

Field probes should be isotropic. The transmission lines from the probes should be either very high resistance or fibre-optic links.

4.3 Test set-up

4.3.1 Vehicle placement

The vehicle shall be placed in the chamber test area. The test area may contain a dynamometer and/or a turntable (see figure 1).

4.3.2 Field generating device location relative to vehicle and chamber

The position(s) of the vehicle relative to the antenna shall be specified in the test plan.

No part of the radiating antenna shall be closer than 0,5 m to the outer body surface of the vehicle.

No part of a TLS, with the exception of the ground plane, shall be closer than 0,5 m to any part of the vehicle.

Any field generating device which is placed over the vehicle shall extend centrally over at least 75 % of the vehicle length.

No part of any antenna's radiating elements shall be closer than 0,25 m to the floor.

The radiating elements of the field generating devices shall not be closer than 0,5 m to any absorbent material and not closer than 1,5 m to the chamber wall. There shall be no absorbent material between the transmitting antenna and the device under test.

4.3.3 Test actuators and monitors

The device under test shall be operated as required in the test plan by actuators which have a minimum effect on it, e.g. plastics blocks on the accelerator, pneumatic actuators with plastics tubes. Connections to equipment monitoring electromagnetic interference reactions of the device under test may be accomplished by using fibre-optics or high resistance leads. Other types of leads may be used but require extreme care to minimize interactions. The orientation, length and location of leads shall be carefully documented to ensure repeatability of such test results.

5 Test procedures

5.1 Test plan

Prior to performing the tests, a test plan shall be prepared; it shall include interface test points, mode of operation for the device under test, acceptance criteria for the device under test, and any special instructions and changes from the standard test. Every device under test shall be verified under the most significant situations, i.e. at least in stand-by mode and in a mode where all the actuators can be excited. The test plan shall specify whether to use the closed loop method or the substitution method.

5.2 Test methods

CAUTION — Hazardous voltages and fields may exist within the test area. Take care to ensure that the requirements for limiting the exposure of humans to RF energy are met.

A detailed explanation on basic principles of the test methods is given in ISO 11451-1.

Place the vehicle in the test area and operate it according to the test plan.

With the field generating device in the specified polarization, scan each band at the field strength specified in annex A noting any particular events. See 3.3 for recommended modulation modes if not specified in the test plan.

Continue the testing until all modulations, polarizations, frequency bands, vehicle orientations and antenna locations specified in the test plan are completed. The number of vehicle positions and/or antenna locations may have to be increased with frequency to ensure complete coverage, because of the narrow beam width of the high frequency antennas.

If desired, the threshold immunity level and centre frequency can be found. Select the mid-frequency of each response band and slowly increase the transmitted power until a response is seen. Then vary the frequency slightly, maintaining constant power to ensure the lowest response level is monitored.

The vehicle may be tested by one of two methods (see 5.2.1 and 5.2.2) to be agreed between the supplier and customer.

5.2.1 Substitution method

The substitution method is based upon the use of net power as the reference parameter used for calibration and test.

In this method, the specific test level (electric field, current, voltage or power) shall be calibrated prior to the actual testing.

The test with the device under test is then conducted by subjecting it to the test signals based on the calibrated values as predetermined in the test plan.

Measurements using the substitution method can be affected by coupling between the antenna and the device under test as well as by reflected energy. During the test the net power shall be maintained relative to the calibration point up to a limit of 2 dB increase in forward power.

If the forward power has to be increased by 2 dB or more, this shall be indicated in the test report.

If the standing wave ratio (SWR) in the test system can be demonstrated to be less than 1,2:1, then forward power may be used as the reference parameter to establish the test level.

Place the field generation device at its intended location. Place a calibrated isotropic field probe at the reference point (see 5.2.1.1).

An antenna may be substituted for the isotropic field probe. In this case readings shall be taken in three mutually orthogonal directions and the isotropic equivalent field determined.

Measure the field, without the vehicle present, with the field probe or the antenna and record the net power necessary to maintain the field level at the specified test level and antenna polarization.

Place the vehicle in the test area and maintain the measured net power for each frequency and antenna polarization specified in the test plan.

5.2.1.1 Substitution method reference point

The reference point is the point at which the field strength is established.

Normally, the facility reference point is used. Nevertheless, if the test facility is not able to establish the required field in the test area, then the vehicle reference point may be used.

5.2.1.1.1 The facility reference point is defined as follows:

a) at least 2 m horizontally from the closest part of the antenna phase centre or at least 1 m vertically from the radiating elements of a TLS;

b) at the centre of the test area;

c) at a height of (1 ± 0,05) m above the chamber floor for vehicles with roof heights equal to or less than 3 m, or (2 ± 0,05) m for vehicles with roof heights greater than 3 m (other heights may be specified);

d) above 200 MHz the field uniformity over a 1,5 m diameter horizontal plane centred at the reference point should be ± 3 dB for at least 80 % of the test frequency points.

NOTE 1 For existing facilities, this field uniformity requirement may not be met. In those cases, this information should be included in the test report. The user should also ensure good reproducibility of the measurement.

5.2.1.1.2 The vehicle reference point (see figures 4 and 5) is defined as follows:

a) at least 2 m horizontally from the antenna phase centre or at least 1 m vertically from the radiating elements of a TLS;

b) on the vehicle centreline (plane of longitudinal symmetry);

c) at a height of (1 ± 0,05) m above the chamber floor, or (2 ± 0,05) m for vehicles with roof heights greater than 3 m (other heights may be specified);

d) depending on the vehicle geometry, (0,2 ± 0,2) m behind the foremost axle (see figure 4) or (1 ± 0,2) m inside the vehicle, measured from the point of intersection of the vehicle windscreen and bonnet (see figure 5), whichever results in a reference point closer to the antenna;

e) above 200 MHz the field uniformity over a 1,5 m diameter horizontal plane centred at the reference point should be ± 3,0 dB for at least 80 % of the test frequency points.

NOTE 2 For existing facilities, this field uniformity requirement may not be met. In those cases, this information should be included in the test report. The user should also ensure good reproductibility of the measurement.

5.2.2 Closed-loop field levelling method

5.2.2.1 This method is different from the substitution method in that during the actual test, the electric field levels, measured by several field probes (usually two is sufficient) distributed over the vehicle, are used to control the signal generator either to increase or to decrease the field strength until the test level is achieved. The use of more than one probe is necessary to reduce the effects of standing waves.

Placement of the probes for the closed-loop levelling method is critical to reducing measurement errors. If the probes are placed near a discontinuity such as a sharp bend or corner of the vehicle, or near a resonant cable or component, the resulting measurement could be in error by a substantial amount.

Place the specified number of field probes (0,3 ± 0,05) m above the vehicle at the specified locations in the test area. Recommended probe locations are the front, above the centre of the hood slot, and test antenna side, adjacent to the "A" pillar [1] of the vehicle (see also 5.2.2.2). Using the highest level from the probes, adjust the signal generator to give the specified level for each frequency and antenna polarization used in the test.

5.2.2.2 Either one or both of the following closed-loop reference points may be used. The selected reference point(s) shall be recorded in the test report.

a) Passenger cars and light commercial vehicles:

— (0,3 ± 0,05) m above the centre of the bonnet slot, and/or

— (0,3 ± 0,05) m above the vehicle, adjacent to the "A" pillar.

b) Buses and commercial vehicles:

— in the centre, (0,3 ± 0,05) m above the base of the windscreen and 30 mm to 40 mm from the edge of the bonnet, and/or

— near the "A" pillar, (0,3 ± 0,05) m above and at the centre of an arc (0,3 ± 0,05) m away from the intersection of the windscreen and bonnet.

5.3 Test report

When required in the test plan, a test report shall be submitted detailing information regarding the test equipment, test site, systems tested, frequencies, power levels, system interactions and any other relevant information regarding the test.

Dimensions in metres

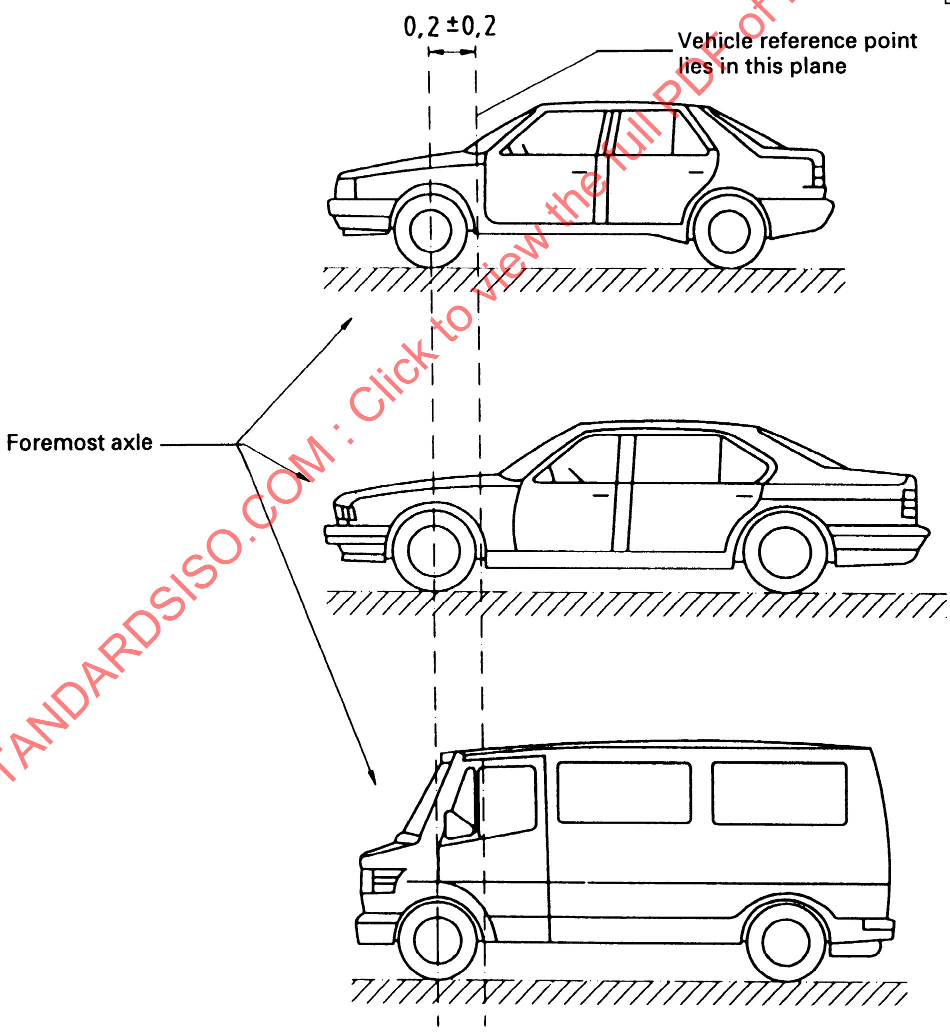


Figure 4 — Example of vehicle reference point for passenger cars and light commercial vehicles

1) The "A" pillar is the vehicle's metal structure on either side of the windscreen.