INTERNATIONAL STANDARD

ISO 11451-1

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

Part 1: General and definitions

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

Partie 1: Généralités et définitions

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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 11451-1 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. Annex B is for information only.

Introduction

During recent years, an increasing number of electronic devices have been introduced into vehicle designs in order to control, monitor and display various functions. It is necessary to consider the electrical and electromagnetic environment in which these devices are required to operate.

Electrical and radio-frequency disturbances occur during normal operation of many items of motor vehicle equipment. They are generated over a wide frequency range with various electrical characteristics and may be distributed to on-board electronic devices and systems by conduction and/or radiation.

Narrowband signals generated from sources on-board or off-board the vehicle can also get into the electrical/electronic system, affecting the normal performance of electronic devices. Sources of narrowband electromagnetic disturbances are mobile radios, broadcast transmitters, etc.

The immunity characteristics of vehicles to radiated disturbances have to be established. It is the intention of the different parts of ISO 11451 to provide various test methods for the analysis of vehicle electromagnetic compatibility (EMC): not all test methods need to be used for a given device under test.

It should also be noted that this part of ISO 11451 is not intended to be a product specification and cannot function as one. Therefore, no specific values for the test severity level are given, since they should be determined for each component by the vehicle manufacturer and supplier(s).

Protection from potential disturbances has to be considered in a total system validation as described in the different parts of ISO 11451.

NOTE 1 The various parts of ISO 11452, *Road vehicles — Electrical disturbances by narrowband radiated electromagnetic energy — Component test methods,* specify test methods for the analysis of component EMC, which is more suited for supplier use.

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

Part 1:
General and definitions

1 Scope

This part of ISO 11451 specifies general test methods, definitions, practical use and basic principles of the test procedures used in other parts of ISO 11451 for electrical disturbances by narrowband radiated electromagnetic energy, providing vehicle test methods regardless of the propulsion system (e.g. spark-ignition engine, diesel engine, electric motor).

Annex A specifies a general method for function performance status classification. Annex B explains the principle of constant peak test level.

Parts 2 to 4 of ISO 11451 specify individual test methods to evaluate the immunity of vehicles to radiated disturbances. The electromagnetic disturbances considered in these parts are limited to continuous narrowband electromagnetic energy. Typical severity levels are included in annexes of these parts of ISO 11451.

The various parts of this International Standard allow a wide frequency range (0,1 MHz to 18 000 MHz) for immunity testing of vehicles.

NOTE 2 Immunity measurements of complete vehicles are generally possible only by the vehicle manufacturer, because, for example, of the high costs of an absorber-lined chamber, preserving the secrecy of prototypes or the large number of different vehicle models.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 11451. At the time of publication, the editions indicated were 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 editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50(161):1990, *International electrotechnical vocabulary — Electromagnetic compatibility.*

IEC 50(726):1982, *International electrotechnical vocabulary — Transmission lines and waveguides.*

3 Definitions

For the purposes of all parts of ISO 11451, the definitions in IEC 50 and the following definitions apply.

3.1 electromagnetic compatibility (EMC): Ability of equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

[Adapted from IEC 50:1990-161-01-07]

3.2 electromagnetic disturbance: Any electromagnetic phenomenon which may degrade the performance of a device, equipment or system, or adversely affect living or inert matter.

[Adapted from IEC 50:1990-161-01-05]

3.3 electromagnetic interference (EMI): Degradation of the performance of equipment, transmission channel or system caused by an electromagnetic disturbance.

[Adapted from IEC 50:1990-161-01-06]

3.4 degradation (of performance): Undesired departure in the operational performance of any device, equipment or system from its intended performance.

[Adapted from IEC 50:1990-161-01-19]

3.5 immunity (to a disturbance): Ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance.

[Adapted from IEC 50:1990-161-01-20]

3.6 (electromagnetic) susceptibility: Inability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance.

[Adapted from IEC 50:1990-161-01-21]

3.7 immunity level: Maximum level of a given electromagnetic disturbance incident on a particular device, equipment or system for which it remains capable of operating at a required degree of performance.

[Adapted from IEC 50:1990-161-03-14]

3.8 narrowband emission: Emission which has a bandwidth less than that of a particular measuring apparatus or receiver.

[Adapted from IEC 50:1990-161-06-13]

3.9 broadband emission: Emission which has a bandwidth greater than that of a particular measuring apparatus or receiver.

[Adapted from IEC 50:1990-161-06-11]

3.10 (electromagnetic) radiation:

(1) Phenomenon by which energy in the form of electromagnetic waves emanates from a source into space.

(2) Energy transferred through space in the form of electromagnetic waves.

[Adapted from IEC 50:1990-161-01-10]

3.11 coupling: Means or device for transferring power between systems.

[Adapted from IEC 50:1982-726-14-01]

3.12 standing wave ratio (SWR); voltage standing wave ratio (VSWR): Ratio, along a transmission line, of a maximum to an adjacent minimum magnitude of a particular field component of a standing wave.

[Adapted from IEC 50:1982-726-07-09]

3.13 polarization (of a wave or field vector): Property of a sinusoidal electromagnetic wave or field vector defined at a fixed point in space by the direction of the electric field strength vector or of any specified field vector; when this direction varies with time the property may be characterized by the locus described by the extremity of the considered field vector.

[Adapted from IEC 50:1982-726-04-01]

3.14 shielded enclosure: Mesh or sheet metallic housing designed expressly for the purpose of separating electromagnetically the internal and external environment.

[Adapted from IEC 50:1990-161-04-37]

3.15 ground (reference) plane: Flat conductive surface whose potential is used as a common reference.

[Adapted from IEC 50:1990-161-04-36]

3.16 current probe: Device for measuring the current in a conductor without interrupting the conductor and without introducing significant impedance into the associated circuits.

[Adapted from IEC 50:1990-161-04-35]

3.17 directional coupler: Four-port device consisting of two transmission lines coupled together in such a manner that a single travelling wave in any one transmission line will induce a single travelling wave in the other, the direction of propagation of the latter wave being dependent upon that of the former.

[Adapted from IEC 50:1982-726-14-02]

3.18 absorber-lined chamber: Shielded room with absorbing material on its internal reflective surfaces.

NOTE 3 The floor may optionally be excepted.

3.19 bulk current: Total amount of common mode current in a harness.

3.20 amplitude modulation (AM): Process by which the amplitude of a carrier wave is varied following a specified law, resulting in an AM signal.

3.21 forward power: Power supplied by the output of an amplifier or generator.

3.22 reflected power: Power reflected by the load due to impedance mismatch between the transmission line and the load.

3.23 net power: Forward power minus reflected power.

3.24 transmission line system (TLS): Stripline or parallel plate or similar device to generate an electromagnetic field in a shielded room.

4 General aim and practical use

The recommended test methods, procedures, test instrumentation and levels presented in all parts of ISO 11451 are intended to facilitate vehicle specification for electrical disturbances by narrowband radiated electromagnetic energy. A basis is provided for mutual agreement between vehicle manufacturers and component suppliers which is intended to assist rather than restrict them.

Certain devices are particularly susceptible to some characteristics of electromagnetic disturbance, such as frequency, severity level, type of coupling or modulation.

Electronic devices are sometimes more susceptible to modulated, as opposed to unmodulated, radio-frequency (RF) signals. The reason is that high-frequency disturbances may be demodulated by semiconductors. In the case of continuous wave (CW) signals this leads to a continuous shift of, for example, a voltage; in the case of AM signals the resulting low-frequency fluctuations may be interpreted as wanted signals (e.g. speed information) and therefore disturb the function of the device under test more severely.

A single standard test may not reveal all the necessary information about the device under test. It is necessary to anticipate the appropriate test conditions, select applicable parts of ISO 11451 and define function performance objectives. The main characteristics of each test method of ISO 11451-2 to ISO 11451-4 are presented in table 1.

5 Test procedures

The common characteristics for all parts of ISO 11451 are described in this clause.

NOTE 4 The use of the same parameters for component test methods as specified in ISO 11452 will achieve better correlation.

5.1 Test conditions

The following test conditions are common to all parts of ISO 11451:

— test temperature and supply voltage;

— modulation;

— dwell time;

— frequency steps.

5.1.1 Test temperature and supply voltage

Heat is generated in the test facility when the vehicle is operated during the performance of the test. Sufficient cooling shall be provided to ensure that the engine does not overheat.

The ambient temperature in the test facility 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.

5.1.2 Modulation

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

— no modulation (CW);

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

Table 1 — Main characteristics of ISO 11451 test methods

	Applicable frequency range MHz	Field coupling mechanism	Test severity parameter and unit	Restrictions
Part 2: Off-vehicle radiation source	0,1 to 18 000	to device under test and wiring harness	Electric field (V/m)	Absorber-lined chamber required
Part 3: On-board transmitter simulation	1,8 to 1 300	to device under test and wiring harness	Power (W)	Absorber-lined chamber recommended
Part 4: Bulk current injection (BCI)	1 to 400	to wiring harness	Current (mA)	Shielded room recommended

5.1.3 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.

5.1.4 Frequency step sizes

All tests in ISO 11451, except those described in ISO 11451-3 (on-board transmitter simulation) shall be conducted with linear frequency step sizes not greater than those given in table 2 (according to the applicable frequency range stated in the relevant part of ISO 11451).

Table 2 — Frequency step sizes

Frequency band MHz	Maximum frequency step size MHz
>0,01 to ⩽0,1	0,01
>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 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 to find the minimum susceptibility thresholds.

5.2 Test methods

5.2.1 Methodologies

Some parts of ISO 11451 present two test methods.

5.2.1.1 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 be calibrated prior to the actual testing.

The test with the device 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.

NOTE 5 If the standing wave ratio (SWR) in the test system is less than 1,2:1, then forward power may be used as the reference parameter to establish the test level.

5.2.1.2 Closed-loop levelling method

During the actual test with the device under test, the test level (electric field, voltage, current or power) is measured by a calibrated device and fed back to the

signal generator either to increase or to decrease the test level until the predetermined value is achieved.

5.2.2 Calibration

Calibration shall be performed in accordance with the requirements of each individual test method. The test level versus frequency data shall be established using a CW signal. The method and results for each calibration shall also be documented in the test report.

5.2.3 Test procedure

The test procedure shall apply the following specifications.

5.2.3.1 At each frequency increase the level, linearly or logarithmically, up to the chosen test level. Control the rate of increase of the test level so that excessive overshoot does not occur. The test level parameter (see annex A regarding test level specification) is

— the net power, P_{net}, related to the test signal severity level, for the substitution method:

$$P_{net} = P_{net,cal} \left(\frac{l_{tss}}{l_{cal}} \right)^k$$

where

$P_{net,cal}$ is the net power by calibration;

l_{tss} is the test signal severity level;

l_{cal} is the calibration level;

k is the factor, equal to 1 for power test levels and equal to 2 for electric field, current or voltage test levels;

— the test signal severity level for the closed-loop levelling method.

Table 3 gives the CW and AM test levels for the substitution and closed-loop levelling methods.

Both of these methods use a constant peak test level for CW and AM tests. The relationship between AM net power and CW calibrated net power results from this principle (see annex B).

5.2.3.2 Maintain the test level for the minimum response time needed to control the device under test (see 5.1.3).

5.2.3.3 Decrease the test level, by at least 20 dB before moving to the next frequency.

The rate of decrease of the level shall be controlled to avoid unreproducible susceptibilities.

NOTE 6 Turning off the signal generator may cause unrepeatable susceptibilities in the device under test.

5.2.3.4 Move to the next test frequency.

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.

5.3 Test severity levels

For both substitution and closed-loop levelling methods, and for CW and AM tests, the test severity levels of ISO 11451 (electric field, current or voltage) are expressed in terms of the equivalent root-mean-square value of the unmodulated wave. For instance, a test severity level of 20 V/m means that the CW and AM tests will be conducted for a 28 V/m peak value.

Table 3 — CW and AM test levels

Method	CW	AM
Substitution method	Net power	$\frac{2 + m^2}{2(1 + m)^2} \times$ Net power (m = modulation index)
Closed-loop levelling method	Test signal severity level	Test signal severity level