INTERNATIONAL STANDARD

# ISO 11452-11

First edition
2010-09-01

# Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy —

## Part 11: Reverberation chamber



*Véhicules routiers — Méthodes d'essai d'un équipement soumis à des perturbations électriques par rayonnement d'énergie électromagnétique en bande étroite —*

*Partie 11: Chambre réverbérante*



Reference number
ISO 11452-11:2010(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

# Contents

Page

# 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 11452-11 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.



ISO 11452 consists of the following parts, under the general title *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy*:



— *Part 1: General principles and terminology*

— *Part 2: Absorber-lined shielded enclosure*

— *Part 3: Transverse electromagnetic mode (TEM) cell*

— *Part 4: Harness excitation methods*

— *Part 5: Stripline*

— *Part 7: Direct radio frequency (RF) power injection*

— *Part 8: Immunity to magnetic fields*

— *Part 9: Portable transmitters*

— *Part 10: Immunity to conducted disturbances in the extended audio frequency range*

— *Part 11: Reverberation chamber*

 

## Introduction

Immunity measurements of complete road vehicles can generally only be carried out by the vehicle manufacturer, owing to, for example, high costs of absorber-lined shielded enclosures, the desire to preserve the secrecy of prototypes or a large number of different vehicle models.

For research, development and quality control, a laboratory measuring method can be used by both vehicle manufacturers and equipment suppliers to test electronic components.

This test method is based on parts of IEC 61000-4-21 and RTCA/DO-160E.



 

# Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy —

# Part 11: Reverberation chamber

## 1 Scope

This part of ISO 11452 specifies a reverberation chamber method for testing the immunity (off-vehicle radiation source) of electronic components for passenger cars and commercial vehicles, regardless of the propulsion system (i.e. spark-ignition engine, diesel engine, electric motor). The device under test (DUT), together with the wiring harness (prototype or standard test harness), is subjected to an electromagnetic disturbance generated inside the reverberation chamber, with peripheral devices either inside or outside the chamber. It is applicable to disturbances from continuous narrowband electromagnetic fields.



The test is performed using the tuned mode method.



## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11452-1, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 1: General principles and terminology*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11452-1 and the following apply.

**3.1**
**antenna characterization factor**
**ACF**
ratio of the average received power to forward power obtained in the antenna characterization

NOTE See Clause B.5.

**3.2**
**chamber characterization factor**
**CCF**
normalized average received power over one tuner rotation with the DUT and supporting equipment present

NOTE See Clause C.3.

**3.3**
**chamber loading factor**
**CLF**
ratio of the antenna characterization factor to the chamber characterization factor

NOTE 1 See Clause C.4.

NOTE 2 It is a measure for the additional loading of the chamber due to the test setup including, for example, the DUT and the support equipment.

**3.4**
**lowest usable frequency**
**LUF**
lowest frequency for which the field uniformity requirements are met

NOTE The LUF is determined during the characterization of the chamber in accordance with Annex B.

**3.5**
**maximum chamber loading factor**
**MLF**
maximum chamber loading factor for which the field uniformity has been demonstrated using the procedure defined in Clause B.7

**3.6**
**reverberation chamber**
high Q shielded room (cavity) whose boundary conditions are changed via one or several stepped rotating tuners



NOTE This results in a statistically uniform electromagnetic field.



**3.7**
**support equipment**
equipment associated with performing an EMC test on a DUT including (but not all inclusive) load simulator, wiring harnesses, power supply (or batteries), DUT monitoring equipment including fibre optic interface modules and TV camera

**3.8**
**test bench**
polystyrene block(s) with a minimum height above the ground floor of $\lambda/4$ at the lowest frequency

NOTE Typically a 1 m high support is used.

**3.9**
**tuner**
large metallic reflector capable of changing the electromagnetic boundary conditions in a reverberation chamber as it rotates or moves

NOTE As the tuner moves, the nulls and maximums in the field change location, ensuring the device under test (DUT) is exposed to a statistically uniform field.

**3.10**
**working volume**
volume within the reverberation chamber that contains the test bench, the DUT, the harness, the support equipment that is located on the test bench, and the receiving antenna

## 4 Test conditions

The applicable frequency range of the test method is from LUF (see Clause B.6) to 18 GHz.

The user of this part of ISO 11452 shall specify the test severity level or levels over the frequency bands. Typical test levels are suggested in Annex A.

Standard test conditions are given in ISO 11452-1 for the following:

- test temperature;
- supply voltage;
- modulation;
- dwell time;
- test signal quality.

## 5 Test location

### 5.1 General

The test shall be performed in a reverberation chamber.



### 5.2 Reverberation chamber

The chamber shall be large enough to test the DUT including the test bench, the support equipment, and the receiving antenna within the chamber's working volume.



NOTE 1 The chamber size will influence the lowest useable frequency (LUF).

This working volume typically has a cuboid shape, but this is not a requirement.

The reverberation chamber shall contain at least one mechanical tuner to stir the electromagnetic fields inside the chamber. The mechanical tuner(s) should be as large as possible with respect to overall chamber size and working volume considerations. In addition each tuner should be shaped such that a non-repetitive field pattern is obtained over one revolution of the tuner.

NOTE 2 The number, size and shape of the tuners will influence the lowest useable frequency (LUF).

After initial construction, the reverberation chamber shall be characterized in accordance with Annex B, and fulfil the field uniformity requirements of Table B.2. The LUF of the reverberation chamber is determined during this initial characterization. Following any major modifications, a new chamber characterization shall be carried out again. Changes to the tuners shall be considered a major modification.

## 6 Test apparatus and instrumentation

### 6.1 Isotropic E-field probe

The field probe shall be capable of measuring electric field strength in three orthogonal axes.

### 6.2 RF signal generator

The RF signal generator shall be capable of covering the specified frequency bands and modulations.

## 6.3 Transmitting and receiving antennas

Linearly polarized antennas capable of satisfying the frequency requirements shall be used for transmitting and receiving, respectively. The antenna efficiency should be at least 75 % (log periodic and horn antennas typically fulfil this requirement). The use of multiple antennas to cover the complete frequency range of the reverberation chamber is allowed.

## 6.4 Power amplifiers

The power amplifiers are used to amplify the RF signal and provide the necessary power to the transmitting antenna to produce the specified field strengths.

## 6.5 Spectrum analyser

The spectrum analyser shall be capable of covering the specified frequency bands. The spectrum analyser is used in conjunction with the receiving antenna during the chamber characterization with and without the DUT.

## 6.6 Directional coupler

The directional coupler shall be capable of covering the specified frequency bands. It shall be capable of handling the RF output of the power amplifier without damage. The directional coupler is used in conjunction with the power meter to measure the forward power delivered to the transmitting antenna.

## 6.7 Power meter



The power meter shall be capable of covering the specified frequency bands. The power meter is used in conjunction with the directional coupler to measure the forward power delivered to the transmitting antenna.

## 6.8 Computer control



Specialized software used in conjunction with a computer and the RF test equipment should be utilized to characterize the chamber performance in accordance with Annex B, prior to any DUT testing. The software should store the characterization information for use during testing. The computer and software will then be used to control the RF test equipment and tuner during DUT testing. The software shall be capable of performing the tests as described in Clause 8.

## 6.9 Stimulation and monitoring of the DUT

The DUT shall be operated as required in the test plan by actuators which have a minimum effect on the electromagnetic characteristics, e.g. plastic blocks on the push-buttons, pneumatic actuators with plastic tubes.

Connections to equipment monitoring electromagnetic interference reactions of the DUT may be accomplished by using fibre-optics, or high resistance leads. Other type of leads may be used but require extreme care to minimize interactions. The orientation, length and location of such leads shall be carefully documented to ensure repeatability of test results.

Any electrical connection of monitoring equipment to the DUT may cause malfunctions of the DUT. Extreme care shall be taken to avoid such an effect.

# 7 Test set-up

## 7.1 General

A general layout of the reverberation chamber is shown in Figure 1.

At the LUF, the working volume shall be at least $\lambda/4$ from any chamber surface, field generating antenna or tuner assembly. The DUT and wiring harness shall be located within the chamber working volume.

The volume of the DUT, test bench and support equipment should not occupy more than 8 % of the total chamber volume.

All unnecessary RF absorbing material shall be removed from the room (e.g. wooden tables, carpeting, extra equipment, etc.).

The equipment placed in the chamber (DUT, wiring harness, support equipment, ground plane) may load the chamber beyond that of the maximum loading verification. Prior to collecting data a check shall be performed to determine if the DUT, or its support equipment, or both the DUT and its support equipment, have adversely loaded the chamber. This check shall be performed as outlined in Annex C.

## 7.2 Ground plane and DUT grounding

If the DUT outer case is not grounded to the vehicle metal structure, the DUT and harness shall be placed either

— directly on the test bench (without ground plane), or

— insulated from a ground plane placed on the test bench.



If the outer case of the DUT is intended to be grounded to the vehicle metal structure, the DUT case should be grounded to a ground plane during testing (either to the ground floor or through a ground plane placed on the test bench). Grounding of the DUT case shall simulate the actual vehicle configuration.

The test bench ground plane (if used) shall be constructed from either copper, brass or galvanized steel. The minimum size of the ground plane depends upon the size of the system under test and shall allow for complete harness and system component placement. The ground plane (excluding the grounding connection) shall be placed within the chamber working volume and at least $\lambda/4$ from any wall and tuner at the lowest frequency of use. The ground plane shall be bonded to the chamber with bonding straps such that the d.c. resistance shall not exceed 2,5 mΩ. In addition, the bond straps shall be placed at a distance no greater than 0,3 m apart edge to edge.

NOTE Using the ground floor as ground plane is an alternative method that is currently being studied.

## 7.3 Power supply and AN

When a d.c. power supply is needed to maintain battery voltage, the d.c. power supply shall be located outside the test chamber. All power lines entering the chamber shall be filtered. The d.c. power leads used for battery maintenance within the chamber may be shielded from the chamber filter to the battery connection point. The d.c. power leads within the chamber should be routed along the wall and chamber floor in order to minimize field coupling to these leads.

If no ground plane is used, then artificial networks shall not be used. The power feeds to the DUT shall be connected directly to the battery terminals.

If a ground plane is used, then each power supply lead shall be connected to the power supply through an AN. Power shall be applied to the DUT via a 5 µH/50 Ω AN (see Annex D for the schematic). The number of ANs required depends upon the intended DUT installation in the vehicle.

 

— For a remotely grounded DUT (vehicle power return line longer than 200 mm), two ANs are required: one for the positive supply line and another for the power return line. The power supply negative terminal shall be connected to the ground plane on the source (input) side of the return line AN.

— For a locally grounded DUT (vehicle power return line 200 mm or shorter), only one AN is required for the positive supply line. The DUT power return line shall be no longer than 200 mm and connected directly to the ground plane. The power supply negative terminal shall be connected to the ground plane near the AN case ground.

The ANs shall be mounted directly on the ground plane. The case or cases of the AN(s) shall be bonded to the ground plane.

The measuring port of each AN shall be terminated with a 50 Ω load.

### 7.4 Location of DUT and wiring harness

A $\left(1700^{+300}_{0}\right)$ mm wiring harness shall be used, unless otherwise specified in the test plan. The wiring harness should be representative of the actual installation (shielded, unshielded, twisted pair, etc.). The length of the wiring harness shall be documented in the test report.

The wiring harness shall be placed in a “U-shaped” configuration to allow a straight harness length of (1 500 ± 75) mm between the DUT and the load simulator. Harness bends shall be $\left(90^{+45}_{0}\right)^{\circ}$.

If a ground plane is used, the DUT and harness shall be elevated (50 ± 5) mm above the ground plane with a non-conductive, low permittivity (dielectric-constant) material (relative permittivity, $\varepsilon_r \leqslant 1{,}4$).



### 7.5 Location of load simulator



Preferably, the load simulator shall be placed directly on the ground plane (if used). If the load simulator has a metallic case, this case shall be bonded to the ground plane.

Alternatively, the load simulator may be located adjacent to the ground plane (with the case of the load simulator bonded to the ground plane) or outside of the test chamber, provided the test harness from the DUT passes through an RF boundary bonded to the ground plane.

When the load simulator is located on the ground plane, the d.c. power supply lines of the load simulator shall be connected through the AN(s).

### 7.6 Location of transmitting antenna

The location of the transmitting (Tx) antenna shall be the same for both characterization and testing. The transmitting antenna shall not directly illuminate the working volume. The transmitting antenna should be directed into a corner of the chamber if possible (see Figure 1 for location of transmitting antenna). Directing the antenna into the tuner is also acceptable. The transmitting antenna should be supported by a non-conductive stand (e.g. non-conductive tripod or polystyrene fixture) and should be placed at a distance not less than $\lambda/4$ (at lowest frequency) from the chamber walls and corners.

NOTE An upward tilt of the antenna is advisable to avoid direct incident wave illumination of the chamber wall resulting in a potentially high VSWR situation.

### 7.7 Location of receiving antenna

The receiving (Rx) antenna may be placed at an arbitrary position within the chamber working volume and should be placed on a polystyrene support. The receiving antenna shall avoid pointing at the transmitting antenna and centre of the working volume.