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Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 2: Absorber-lined shielded enclosure

Véhicules routiers — Méthodes d'essai d'un équipement soumis à des perturbations électriques par rayonnement d'énergie électromagnétique en bande étroite — Partie 2: Chambre anéchoïque

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Foreword

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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.

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ISO 11452-2 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electric 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 transmitter*

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

— *Part 11: Reverberation chamber*

— Annex A, B and C of this part of ISO 11452 are for information only.

Introduction

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

Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 2: Absorber-lined shielded enclosure

1 Scope

This part of ISO 11452 specifies an absorber-lined shielded enclosure method for testing the immunity (off-vehicle radiation source) of electronic components for passenger cars and commercial vehicles regardless of the propulsion system (e.g 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 an absorber-lined shielded enclosure, with peripheral devices either inside or outside the enclosure. It is applicable only to disturbances from continuous narrowband electromagnetic fields. See ISO 11452-1 for general test conditions.

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*[1)]

3 Terms and definitions

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

4 Test conditions

The applicable frequency range of the absorber-lined shielded enclosure test method is 80 MHz to 18 GHz.

The user shall specify the test severity level(s) over the frequency range. Suggested test levels are included in Annex B.

Standard test conditions shall be according to ISO 11452-1 for the following:

- test temperature;
- supply voltage;
- modulation;
- dwell time;

1) Revision 3 of ISO 11452-1:2005

— frequency step sizes;

— definition of test severity levels;

— test signal quality.

5 Test location

The tests shall be performed in an absorber-lined shielded enclosure.

The purpose of such an enclosure is to create an isolated electromagnetic compatibility test facility which simulates open field testing. Basically, an absorber-lined shielded enclosure consists of a shielded room with absorbing material on its internal reflective surfaces. The design objective is to attenuate the reflected energy in the test area by at least 10 dB compared to the direct energy.

6 Test apparatus and instrumentation

6.1 General

Radiated electromagnetic fields are generated using antennas with a radio frequency (RF) energy source capable of producing the desired field strengths. A set of antennas and multiple RF amplifiers could be required to cover the range of test frequencies. The field is monitored electrically with small probes to ensure proper test levels. To reduce test error, the operation of the DUT is usually monitored by fibre-optic couplers.

6.2 Measuring equipment

6.2.1 Field-generating device: any available antenna (including high-power baluns, if appropriate) capable of radiating the specified field strength at the DUT with the available power may be used. 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.

6.2.2 Field probes, which should be electrically small and isotropic. The transmission lines from the probes should be either fibre-optic links or very high resistance.

6.2.3 Artificial network(s) (AN): see 7.2 and ISO 11452-1 Annex B.

6.2.4 HF generator, with internal (or external) modulation capabilities

6.2.5 High-power amplifier

6.2.6 Powermeter (or equivalent measuring instrument), for measuring forward power and reflected power.

6.3 Stimulation and monitoring of DUT

The device under test (DUT) shall be operated as required in the test plan by actuators that 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 types of lead 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 Ground plane

The ground plane shall be made of 0,5 mm thick (minimum) copper, brass or galvanized steel.

The minimum width of the ground plane shall be 1 000 mm. The minimum length of the ground plane shall be 2 000 mm, or the length of the entire underneath of the equipment plus 200 mm, whichever is the larger.

The height of the ground plane (test bench) shall be (900 ± 100) mm above the floor.

The ground plane shall be bonded to the shielded enclosure 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.

7.2 Power supply and AN

Each DUT power supply lead shall be connected to the power supply through an AN.

Power supply is assumed to be negative ground. If the DUT utilizes a positive ground, then the test set-ups shown in the figures need to be adapted accordingly. Power shall be applied to the DUT via a 5 µH/50 Ω AN (see ISO 11452-1 Annex B for the schematic). The number of ANs required depends on 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 (see Annex A).

— For a locally grounded DUT (vehicle power return line 200 mm or shorter), only one AN is required, for the positive supply (see Annex A).

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

The power supply return shall be connected to the ground plane — between the power supply and the AN(s).

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

7.3 Location of DUT

The DUT shall be placed on a non-conductive, low relative permittivity (dielectric-constant) material ($\varepsilon_r \leq 1,4$), at (50 ± 5) mm above the ground plane.

The case of the DUT shall not be grounded to the ground plane unless it is intended to simulate the actual vehicle configuration.

The front of the DUT shall be located at a distance of (200 ± 10) mm from the edge of the ground plane.

7.4 Location of test harness

The part of the test harness parallel to the front edge of the ground plane shall be (1500 ± 75) mm.

The total length of the test harness between the DUT and the load simulator (or the RF boundary) shall not exceed 2 000 mm. The wiring type is defined by the actual system application and requirement.

The test harness shall be placed on a non-conductive, low relative permittivity (dielectric-constant) material ($\varepsilon_r \leq 1,4$), at (50 ± 5) mm above the ground plane.

That part of the test harness parallel to the front edge of the ground plane shall be at a distance of (100 ± 10) mm from the edge of the ground plane.

7.5 Location of load simulator

Preferably, the load simulator shall be placed directly on the ground plane. 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 field generating device (antenna)

The height of the phase centre of the antenna shall be (100 ± 10) mm above the ground plane.

No part of any antenna radiating element shall be closer than 250 mm to the floor. The radiating elements of the antenna shall not be closer than 500 mm to any absorber material.

The distance between the wiring harness and the antenna shall be (1 000 ± 10) mm. This distance is measured from

— the phase centre (mid-point) of the biconical antenna, or

— the nearest part of the log-periodic antenna, or

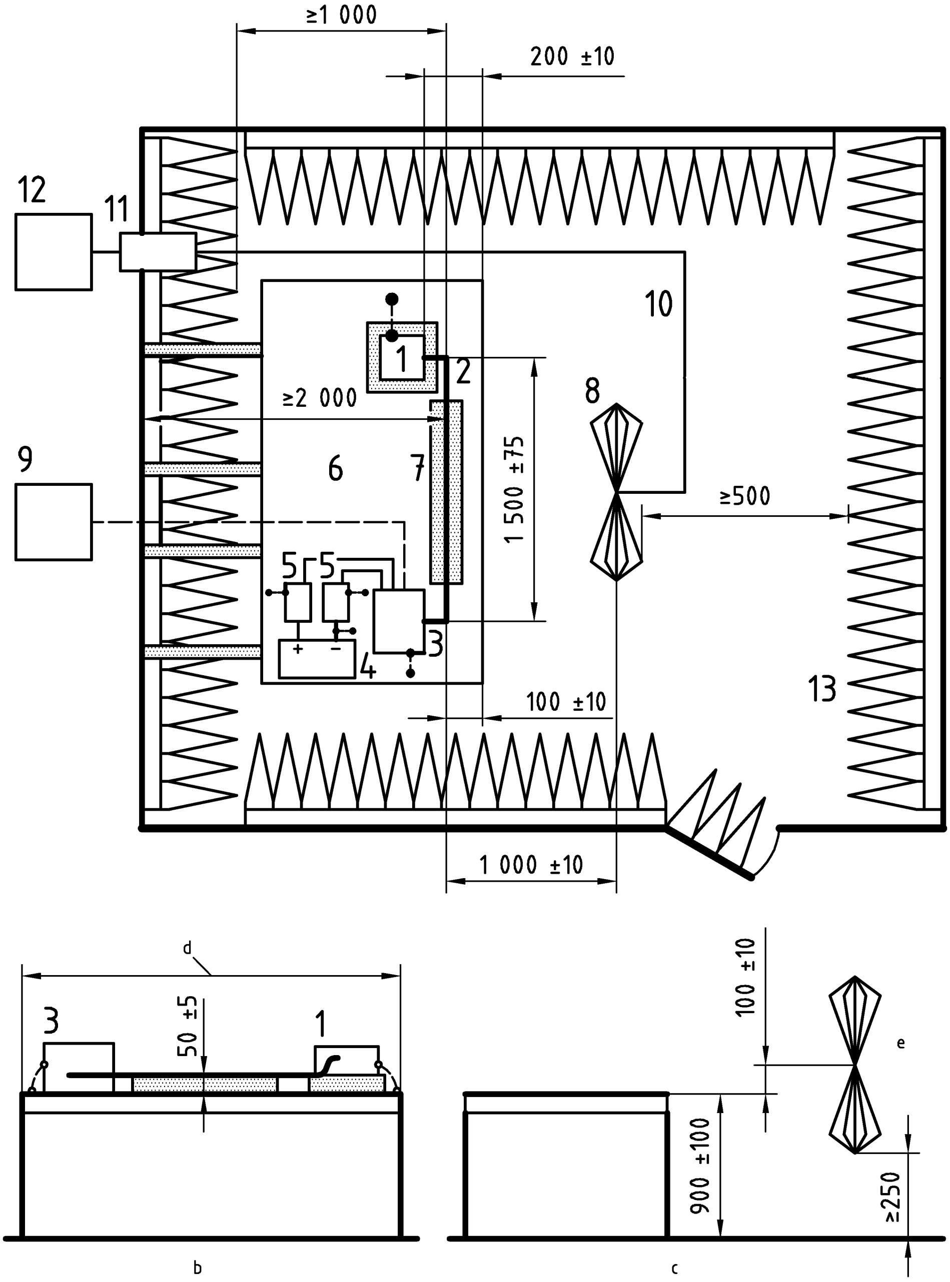
— the nearest part of the horn antenna.

The phase centre of the antenna for frequencies from 80 MHz to 1 000 MHz shall be in line with the centre of the longitudinal part (1 500 mm length) of the wiring harness.

The phase centre of the antenna for frequencies above 1 000 MHz shall be in line with the DUT.

Examples of test set-ups are shown in Figures 1 to 3.

Dimensions in millimetres



Key

1 DUT (grounded locally if required in test plan)

2 test harness

3 load simulator (placement and ground: connection according to 7.5)

4 power supply (location optional)

5 artificial network (AN)

6 ground plane (bonded to shielded enclosure)

7 low relative permittivity support ($\varepsilon_r \leq 1,4$)

8 biconical antenna

9 stimulation and monitoring system

10 high quality double-shielded coaxial cable (50 Ω)

11 bulkhead connector

12 RF signal generator and amplifier

13 RF absorber material

[a] Upper view (horizontal polarisation).

[b] Front view.

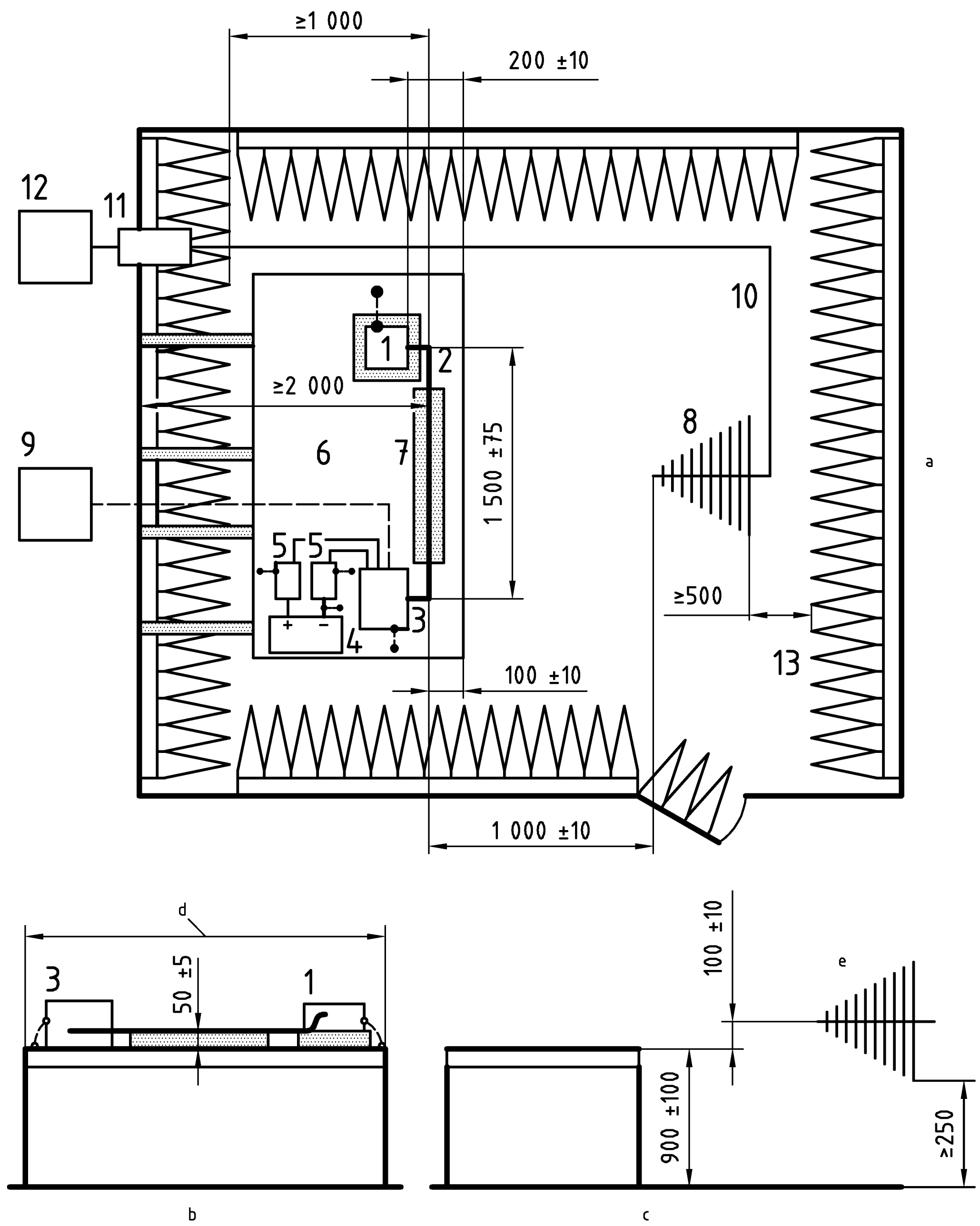
[c] Side view.

[d] See 7.1.

[e] Vertical polarization.

Figure 1 — Example test set-up — Biconical antenna

Dimensions in millimetres



Key

1 DUT (grounded locally if required in test plan)

2 test harness

3 load simulator (placement and ground: connection according to 7.5)

4 power supply (location optional)

5 artificial network (AN)

6 ground plane (bonded to shielded enclosure)

7 low relative permittivity support ($\varepsilon_r \leq 1,4$)

8 log-periodic antenna

9 stimulation and monitoring system

10 high quality double-shielded coaxial cable (50 Ω)

11 bulkhead connector

12 RF signal generator and amplifier

13 RF absorber material

[a] Upper view (horizontal polarisation).

[b] Front view.

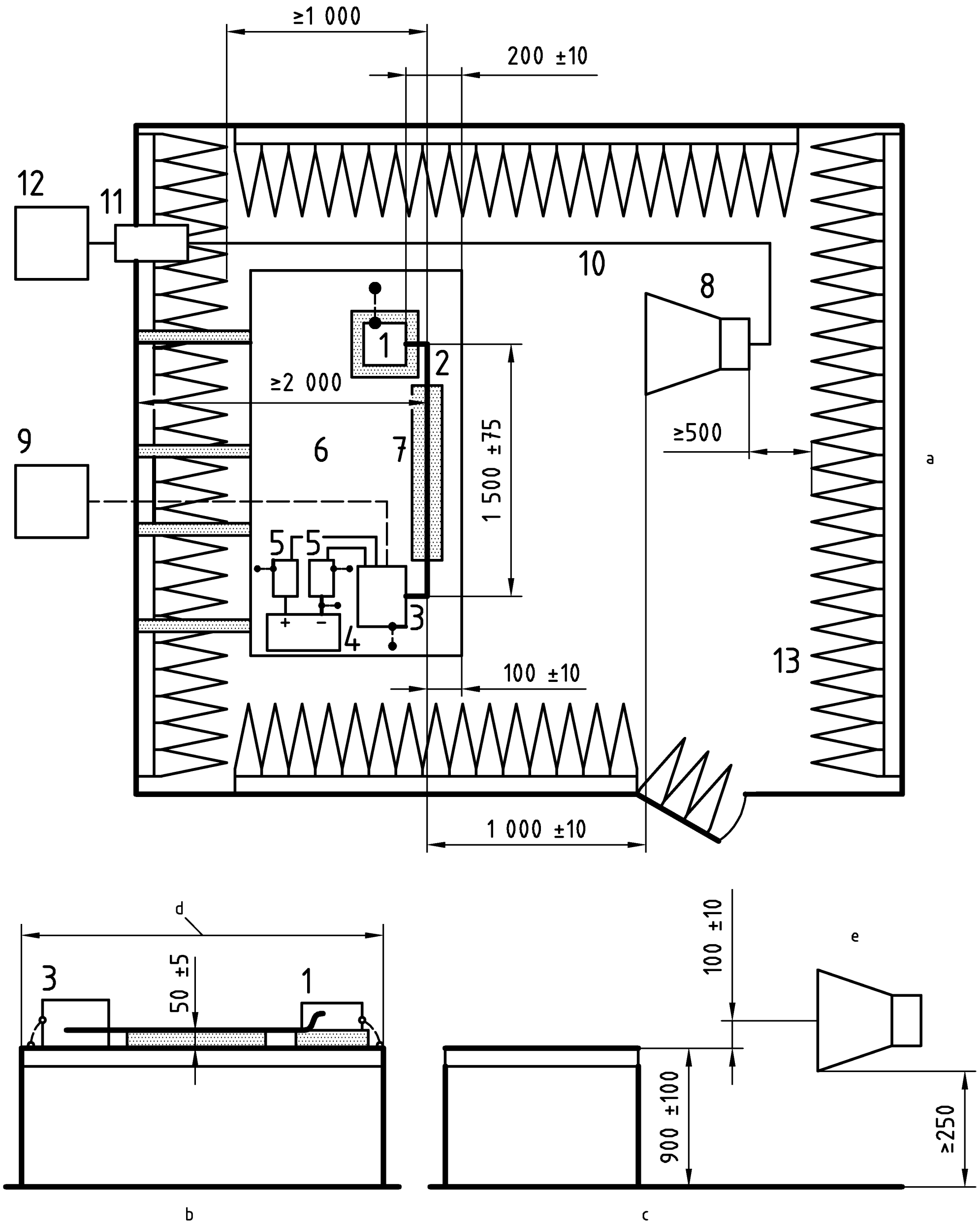
[c] Side view.

[d] See 7.1.

[e] Vertical polarization.

Figure 2 — Example test set-up — Log-periodic-antenna

Dimensions in millimetres



Key

1 DUT (grounded locally if required in test plan)
2 test harness
3 load simulator (placement and ground: connection according to 7.5)
4 power supply (location optional)
5 artificial network (AN)
6 ground plane (bonded to shielded enclosure)
7 low relative permittivity support ($\varepsilon_r \leq 1,4$)
8 horn antenna
9 stimulation and monitoring system
10 high quality double-shielded coaxial cable (50 Ω)
11 bulkhead connector
12 RF signal generator and amplifier
13 RF absorber material

[a] Upper view (horizontal polarisation).
[b] Front view.
[c] Side view.
[d] See 7.1.
[e] Vertical polarization.

Figure 3 — Example test set-up for frequencies above 1 GHz — Horn antenna

7.7 Test setup for DUT with High Voltage (HV) power supply

This clause concerns test for :

- DUT powered by HV d.c.,
- Charger power supply (a.c. or d.c.) for HV battery.

7.7.1 Ground plane arrangement

The ground plane conditions defined in 7.1 apply.

7.7.2 The test set-up

The different setups are shown in Figures 4 to 12. The shielding configuration and any protective ground connection should be representative of the vehicle application and shall be defined in the test plan. The battery charger ground connection shall also be defined in the test plan. DUTs and loads shall be connected to ground using impedance as defined in the test plan. The vehicle HV battery should be used; otherwise the external HV power supply shall be connected via feed-through-filtering.

Unless otherwise specified in the test plan (e.g. use of original vehicle harnesses), the length of harnesses shall be as follows:

- $200\ ^{+200}_{0}$ mm for the LV lines
- $1700\ ^{+300}_{0}$ mm for the HV lines and the length of the HV test harness parallel to the front of the ground plane shall be (1500 ± 75) mm.
- less than 1000 mm for the three phase lines between DUT and electric motor(s)

All of the harnesses shall be placed on a non-conductive, low relative permittivity material ($\varepsilon r \leq 1{,}4$) at (50 ± 5) mm above the ground plane.

HV lines shall be placed at a minimum distance of 100 mm from the edge of the ground plane.

Shielded supply lines for the positive HV d.c. terminal line (HV+), the negative HV d.c. terminal line (HV-) and three phase HV a.c. lines may be separate coaxial cables or in a common shield depending on the connector system used. The original HV harness from the vehicle may be used optionally.

Unless otherwise specified in the test plan the DUT case shall be connected to the ground plane either directly or via defined impedance.

Figures 5, 8 and 11 show a more complex configuration adding an electric motor or load machine emulation to the setup, e.g. in case the DUT is an electric power unit. The electric motor shall be mounted on a non-conductive insulating support and its housing bonded to the ground plane, if applicable. The load machine emulation shall be placed outside the shielded room. In case of using a load machine emulation, the test plan shall define the connection conditions between the DUT and the load machine emulation and also the necessary grounding conditions. The load machine emulation will replace the “electric motor”, the “mechanical connection”, the “filtered mechanical bearing” and the “brake or propulsion motor”. The three phase motor supply lines will be fed through a power line filter.

The electric motor may be placed on a separate ground plane. In this case, the test plan shall define the connection configuration between this separate motor ground plane and the DUT ground plane (representing the vehicle grounding configuration).

The setups in Figures 6, 9 and 12 are examples for further HV- and LV load simulators and supplies attached to the DUT like e.g. for testing an on-board charger and its communication links. Various combinations of the shown setups are possible based on the true application of the HV component under study (DUT).

Note 1 Care shall be taken when using a power line filter (Key 16) on the HV supply line. This filter will increase the common mode capacitance between HV+ and ground reference or HV- and ground reference and may lead to the generation of extra resonances.

Note 2 Depending on the package situation in the vehicle and the material used for the chassis (e. g. metal or alternative material) the impedance of the connection of the shielding to the vehicle chassis may vary drastically.

7.2.3 Location of field generating device (antenna)

The height of the phase centre of the antenna shall be (100 ± 10) mm above the ground plane.

No part of any antenna radiating element shall be closer than 250 mm to the floor. The radiating elements of the antenna shall not be closer than 500 mm to any absorber material, and shall not be closer than 1 500 mm to the walls or ceiling of the shielded enclosure.

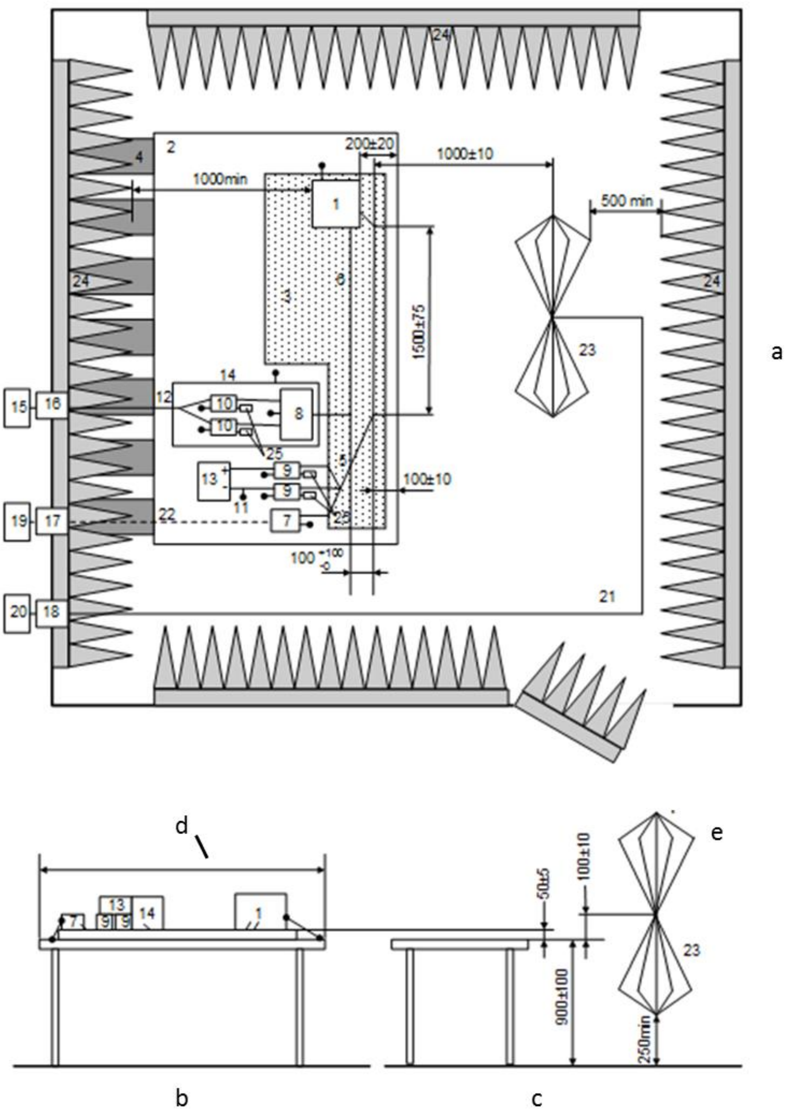
The distance between the wiring harness and the antenna shall be (1 000 ± 10) mm. This distance is measured from

- the phase centre (mid-point) of the biconical antenna, or
- the nearest part of the log-periodic antenna, or
- the nearest part of the horn antenna.

The phase centre of the antenna for frequencies from 80 MHz to 1 000 MHz shall be in line with the centre of the longitudinal part (1 500 mm length) of the wiring harness.

The phase centre of the antenna for frequencies above 1 000 MHz shall be in line with the DUT.

Dimensions in millimetres

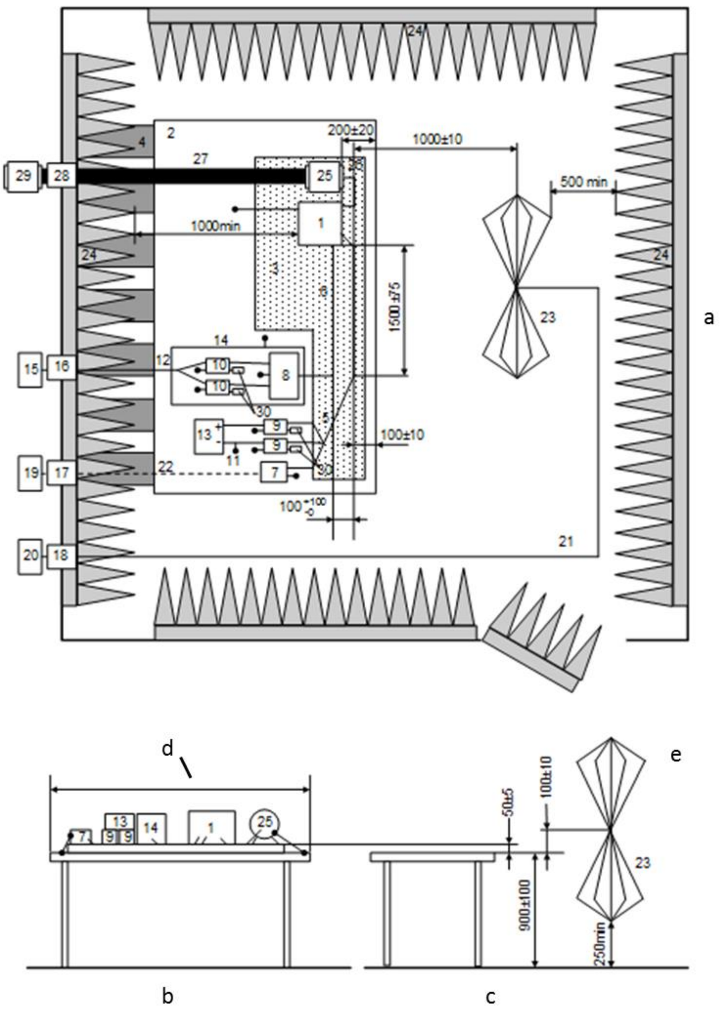


Key

1	DUT	14	additional shielded box
2	ground plane	15	HV power supply (should be shielded if placed inside ALSE)
3	low relative permittivity support ($\varepsilon_r \leq 1,4$); thickness 50 mm	16	power line filter
4	ground straps	17	fiber optic feed through
5	LV harness	18	bulk head connector
6	HV lines (HV+, HV-)	19	stimulating and monitoring system
7	LV load simulator	20	RF signal generator and amplifier
8	impedance matching network (optional)	21	high quality coaxial cable e.g double shielded (50 Ω)
9	LV AN	22	optical fibre
10	HV AN	23	biconical antenna
11	LV supply lines	24	RF absorber material
12	HV supply lines	25	50 Ω load
13	LV power supply 12 V / 24 V / 48 V (should be placed on the bench)		
a	Upper view (horizontal polarisation).	d	See 7.1.
b	Front view.	e	Vertical polarization
c	Side view.		

Figure 4 — Example of test set-up – Biconical antenna for DUTs with shielded power supply systems

Dimensions in millimetres

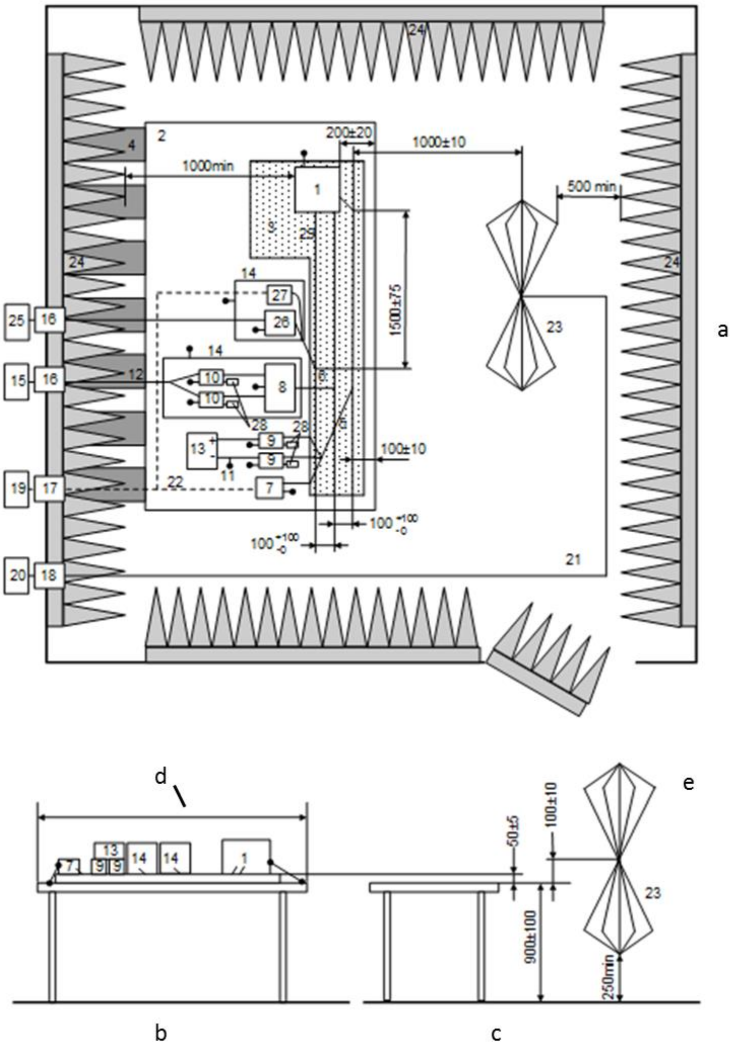


Key

1 DUT
2 ground plane
3 low relative permittivity support ($\varepsilon_r \leq 1,4$); thickness 50 mm (a non-conductive support can be used for the electric motor)
4 ground straps
5 LV harness
6 HV lines (HV+, HV-)
7 LV load simulator
8 impedance matching network (optional)
9 LV AN
10 HV AN
11 LV supply lines
12 HV supply lines
13 LV power supply 12 V / 24 V / 48 V (should be placed on the bench)
14 additional shielded box
15 HV power supply (should be shielded if placed inside ALSE)
16 power line filter
17 fiber optic feed through
18 bulk head connector
19 stimulating and monitoring system
20 RF signal generator and amplifier
21 high quality coaxial cable e.g double shielded (50 Ω)
22 optical fibre
23 biconical antenna
24 RF absorber material
25 electric motor
26 three phase motor supply lines
27 mechanical connection (e.g non-conductive)
28 filtered mechanical bearing
29 brake or propulsion motor
30 50 Ω load
a Upper view (horizontal polarisation).
b Front view.
c Side view.
d See 7.1.
e Vertical polarization

Figure 5 — Example of test set-up – Biconical antenna for DUTs with shielded power supply systems with electric motor attached to the bench

Dimensions in millimetres

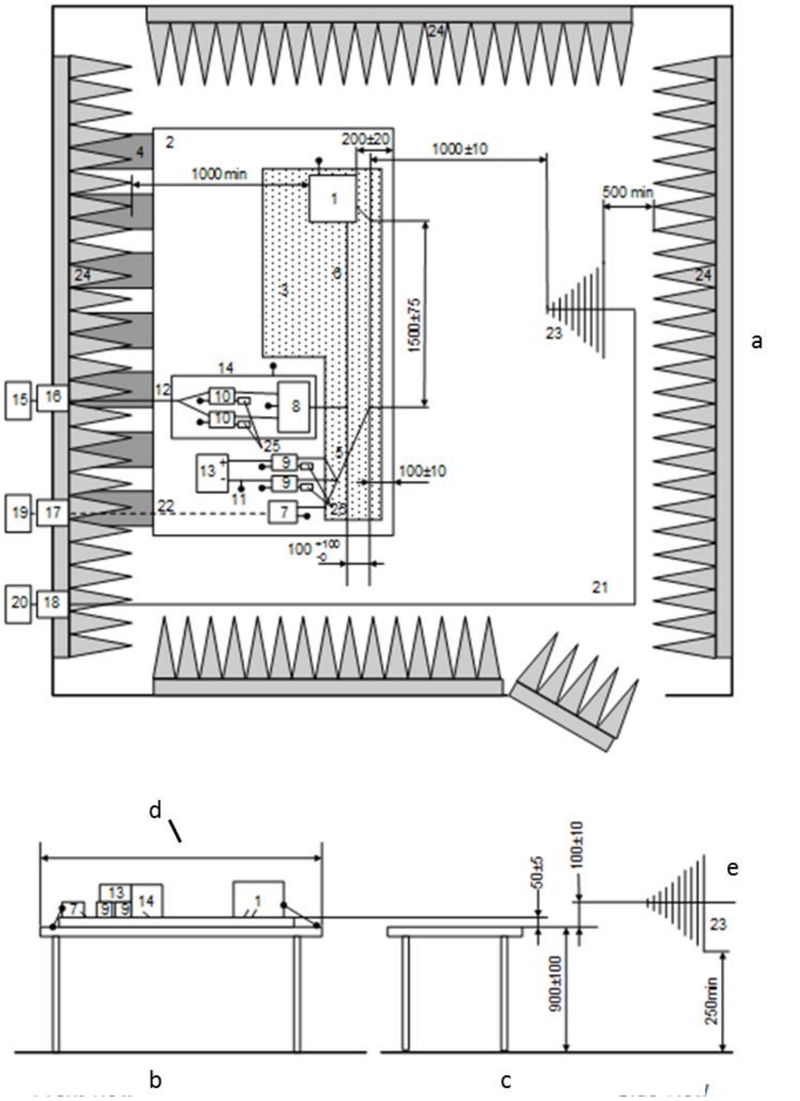


Key

1	DUT
2	ground plane
3	low relative permittivity support ($\varepsilon_r \leq 1,4$); thickness 50 mm
4	ground straps
5	LV harness
6	HV lines (HV+, HV-)
7	LV load simulator
8	impedance matching network (optional)
9	LV AN
10	HV AN
11	LV supply lines
12	HV supply lines
13	LV power supply 12 V / 24 V / 48 V (should be placed on the bench)
14	additional shielded box
15	HV power supply (should be shielded if placed inside ALSE)
16	power line filter
17	fiber optic feed through
18	bulk head connector
19	stimulating and monitoring system
20	RF signal generator and amplifier
21	high quality coaxial cable e.g double shielded (50 Ω)
22	optical fibre
23	biconical antenna
24	RF absorber material
25	a.c. power mains
26	AMN for a.c. power mains
27	a.c. charging load simulator
28	50 Ω load
29	a.c. lines
a	Upper view (horizontal polarisation).
b	Front view.
c	Side view.
d	See 7.1.
e	Vertical polarization

Figure 6 — Example of test set-up – Biconical antenna for DUTs with shielded power supply systems and inverter/charger device

Dimensions in millimetres

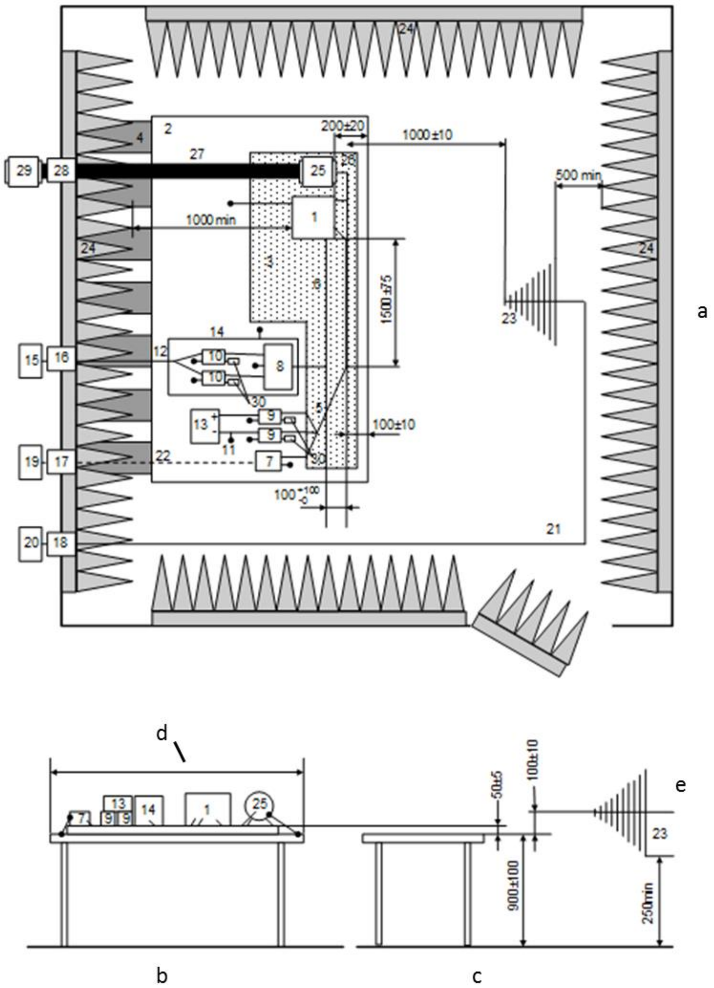


Key

1	DUT	14	additional shielded box
2	ground plane	15	HV power supply (should be shielded if placed inside ALSE)
3	low relative permittivity support ($\varepsilon_r \leq 1,4$); thickness 50 mm	16	power line filter
4	ground straps	17	fiber optic feed through
5	LV harness	18	bulk head connector
6	HV lines (HV+, HV-)	19	stimulating and monitoring system
7	LV load simulator	20	RF signal generator and amplifier
8	impedance matching network (optional)	21	high quality coaxial cable e.g double shielded (50 Ω)
9	LV AN	22	optical fibre
10	HV AN	23	log-periodic antenna
11	LV supply lines	24	RF absorber material
12	HV supply lines	25	50 Ω load
13	LV power supply 12 V / 24 V / 48 V (should be placed on the bench)		
a	Upper view (horizontal polarisation).	d	See 7.1.
b	Front view.	e	Vertical polarization
c	Side view.		

Figure 7 — Example of test set-up – Log-periodic antenna for DUTs with shielded power supply systems

Dimensions in millimetres

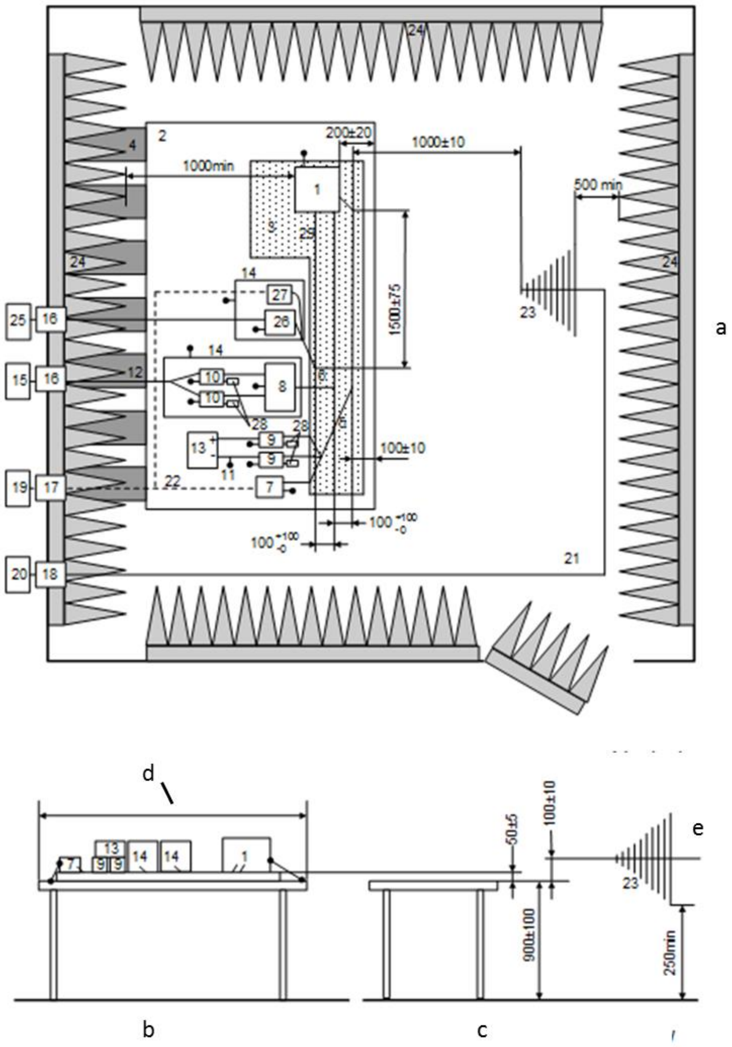


Key

1	DUT	16	power line filter
2	ground plane	17	fiber optic feed through
3	low relative permittivity support ($\varepsilon_r \leq 1,4$); thickness 50 mm (a non-conductive support can be used for the electric motor)	18	bulk head connector
4	ground straps	19	stimulating and monitoring system
5	LV harness	20	RF signal generator and amplifier
6	HV lines (HV+, HV-)	21	high quality coaxial cable e.g double shielded (50 Ω)
7	LV load simulator	22	optical fibre
8	impedance matching network (optional)	23	log-periodic antenna
9	LV AN	24	RF absorber material
10	HV AN	25	electric motor
11	LV supply lines	26	three phase motor supply lines
12	HV supply lines	27	mechanical connection (e.g non-conductive)
13	LV power supply 12 V / 24 V / 48 V (should be placed on the bench)	28	filtered mechanical bearing
14	additional shielded box	29	brake or propulsion motor
15	HV power supply (should be shielded if placed inside ALSE)	30	50 Ω load
a	Upper view (horizontal polarisation).	d	See 7.1.
b	Front view.	e	Vertical polarization
c	Side view.		

Figure 8 — Example of test set-up – Log-periodic antenna for DUTs with shielded power supply systems with electric motor attached to the bench

Dimensions in millimetres

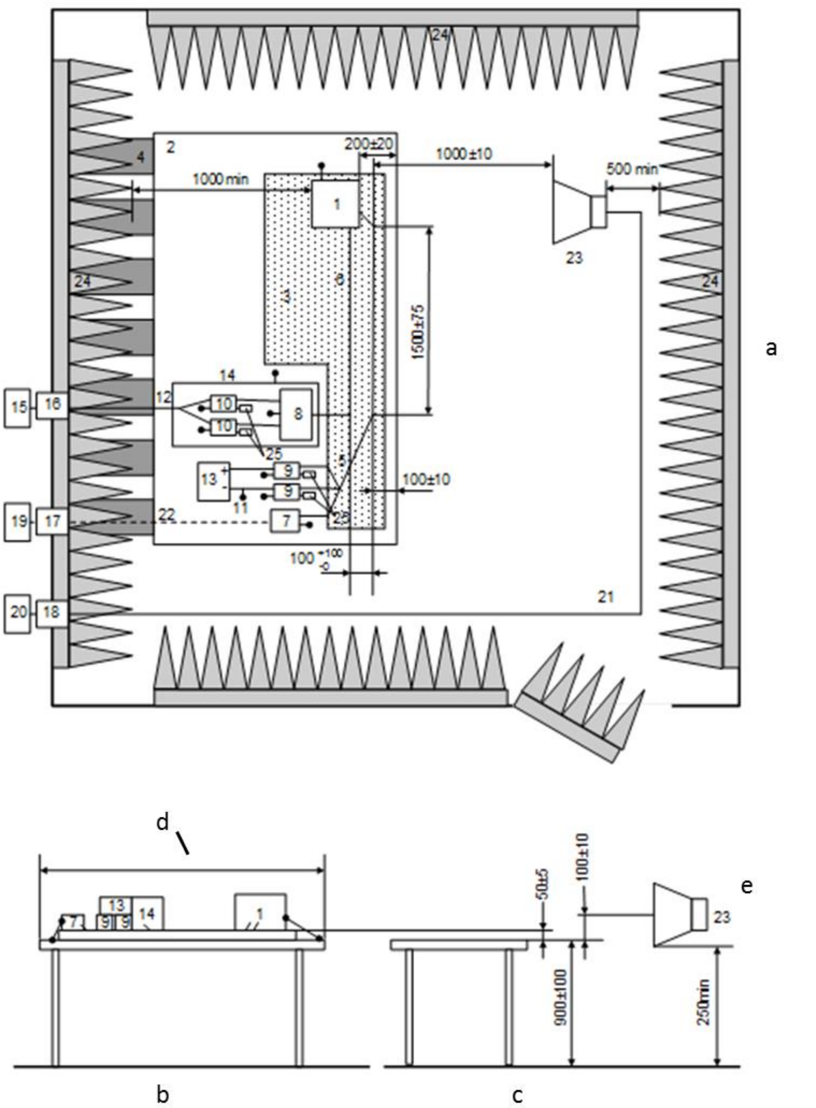


Key

1	DUT	16	power line filter
2	ground plane	17	fiber optic feed through
3	low relative permittivity support (ε_r ≤ 1,4); thickness 50 mm	18	bulk head connector
4	ground straps	19	stimulating and monitoring system
5	LV harness	20	RF signal generator and amplifier
6	HV lines (HV+, HV-)	21	high quality coaxial cable e.g double shielded (50 Ω)
7	LV load simulator	22	optical fibre
8	impedance matching network (optional)	23	log-periodic antenna
9	LV AN	24	RF absorber material
10	HV AN	25	a.c. power mains
11	LV supply lines	26	AMN for a.c. power mains
12	HV supply lines	27	a.c. charging load simulator
13	LV power supply 12 V / 24 V / 48 V (should be placed on the bench)	28	50 Ω load
14	additional shielded box	29	a.c. lines
15	HV power supply (should be shielded if placed inside ALSE)		
a	Upper view (horizontal polarisation).	d	See 7.1.
b	Front view.	e	Vertical polarization
c	Side view.		

Figure 9 — Example of test set-up – Log-periodic antenna for DUTs with shielded power supply systems and inverter/charger device

Dimensions in millimetres



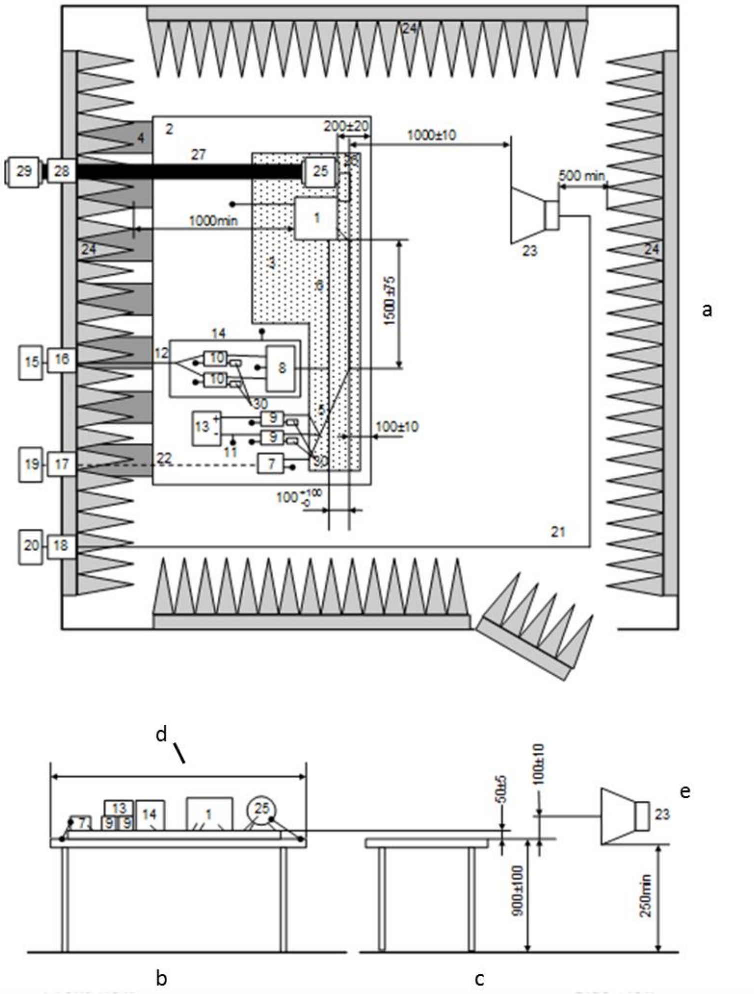
Key

1 DUT
2 ground plane
3 low relative permittivity support ($\varepsilon_r \leq 1,4$); thickness 50 mm
4 ground straps
5 LV harness
6 HV lines (HV+, HV-)
7 LV load simulator
8 impedance matching network (optional)
9 LV AN
10 HV AN
11 LV supply lines
12 HV supply lines
13 LV power supply 12 V / 24 V / 48 V (should be placed on the bench)
14 additional shielded box
15 HV power supply (should be shielded if placed inside ALSE)
16 power line filter
17 fiber optic feed through
18 bulk head connector
19 stimulating and monitoring system
20 RF signal generator and amplifier
21 high quality coaxial cable e.g double shielded (50 Ω)
22 optical fibre
23 horn antenna
24 RF absorber material
25 50 Ω load

a Upper view (horizontal polarisation).
b Front view.
c Side view.
d See 7.1.
e Vertical polarization

Figure 10 — Example of test set-up – Horn antenna for DUTs with shielded power supply systems

Dimensions in millimetres

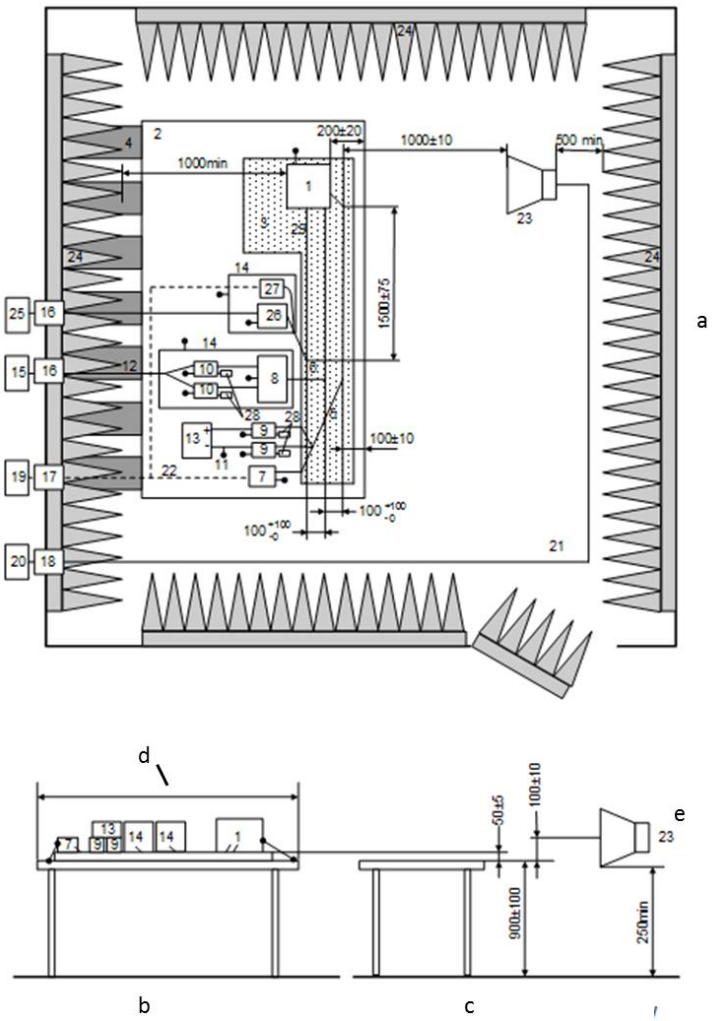


Key

1	DUT	16	power line filter
2	ground plane	17	fiber optic feed through
3	low relative permittivity support ($\varepsilon_r \leq 1,4$); thickness 50 mm (a non-conductive support can be used for the electric motor)	18	bulk head connector
4	ground straps	19	stimulating and monitoring system
5	LV harness	20	RF signal generator and amplifier
6	HV lines (HV+, HV-)	21	high quality coaxial cable e.g double shielded (50 Ω)
7	LV load simulator	22	optical fibre
8	impedance matching network (optional)	23	horn antenna
9	LV AN	24	RF absorber material
10	HV AN	25	electric motor
11	LV supply lines	26	three phase motor supply lines
12	HV supply lines	27	mechanical connection (e.g non-conductive)
13	LV power supply 12 V / 24 V / 48 V (should be placed on the bench)	28	filtered mechanical bearing
14	additional shielded box	29	brake or propulsion motor
15	HV power supply (should be shielded if placed inside ALSE)	30	50 Ω load
a	Upper view (horizontal polarisation).	d	See 7.1.
b	Front view.	e	Vertical polarization
c	Side view.		

Figure 11 — Example of test set-up – Horn antenna for DUTs with shielded power supply systems with electric motor attached to the bench

Dimensions in millimetres



Key

1 DUT
2 ground plane
3 low relative permittivity support ($\varepsilon_r \leq 1,4$); thickness 50 mm
4 ground straps
5 LV harness
6 HV lines (HV+, HV-)
7 LV load simulator
8 impedance matching network (optional)
9 LV AN
10 HV AN
11 LV supply lines
12 HV supply lines
13 LV power supply 12 V / 24 V / 48 V (should be placed on the bench)
14 additional shielded box
15 HV power supply (should be shielded if placed inside ALSE)
16 power line filter
17 fiber optic feed through
18 bulk head connector
19 stimulating and monitoring system
20 RF signal generator and amplifier
21 high quality coaxial cable e.g double shielded (50 Ω)
22 optical fibre
23 log-periodic antenna
24 RF absorber material
25 a.c. power mains
26 AMN for a.c. power mains
27 a.c. charging load simulator
28 50 Ω load
29 a.c. lines

a Upper view (horizontal polarisation).
b Front view.
c Side view.
d See 7.1.
e Vertical polarization

Figure 12 — Example of test set-up – horn antenna for DUTs with shielded power supply systems and inverter/charger device

8 Test method

8.1 General

The general arrangement of the disturbance source and connecting harnesses etc. represents a standardized test condition. Any deviations from the standard test harness length etc. shall be agreed upon prior to testing and recorded in the test report.

The DUT shall be made to operate under typical loading and other conditions as in the vehicle. These operating conditions shall be clearly defined in the test plan to ensure supplier and customer are performing identical tests.

The orientation(s) of the DUT for radiated immunity tests shall be defined in the test plan.

From 400 MHz to 18 GHz, measurements shall be performed in horizontal polarization.

From 80 MHz to 18 GHz, measurements shall be performed in vertical polarization.

8.2 Test plan

Prior to performing the tests, a test plan shall be generated which shall include:

— test set-up,

— frequency range,

— DUT mode of operation,

— DUT acceptance criteria,

— test severity levels,

— DUT monitoring conditions,

— antenna location, and

— test report content,

as well as any special instructions and changes from the standard test.

Every DUT shall be tested under the most significant conditions, i.e. at least in stand-by mode and in a mode where all the actuators can be excited

8.3 Test procedure

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

8.3.1 Substitution method

The test shall be performed with the substitution method, which is based upon the use of forward power as the reference parameter used for field calibration and test.

This method is carried out in two phases:

a) field calibration (without the DUT, wiring harness and peripheral devices present, see 8.3.2);

b) test of the DUT with wiring harness and peripheral devices connected (see 8.3.3).

The RF power required to achieve the required field strength is determined during the field calibration phase.

8.3.2 Field calibration

The specific test level (field) shall be calibrated periodically by recording the forward power required to produce a specific field strength, measured with a field probe, for each test frequency. This calibration shall be performed with an unmodulated sinusoidal wave.

Place the electrical phase centre of the field probe (150 ± 10) mm above the ground plane and at a distance of (100 ± 10) mm from the front edge of the ground plane.

— For frequencies of from 80 MHz to 1 000 MHz, the phase centre of the field probe shall be in line with the centre of the longitudinal part (1 500 mm length) of the wiring harness position.

— For frequencies above 1 000 MHz, the phase centre of the field probe shall be in line with the DUT position.

Place the field-generating device (antenna) at a distance of (1 000 ± 10) mm from the electrical phase centre of the field probe.

Calibrate the field strength for vertical and horizontal polarisations.

When requested, the values of forward and reverse power recorded in the calibration file and a precise description of the associated position of the field probe shall be included in the test report.

8.3.3 DUT test

Install the DUT, harness and associated equipment on the test bench in accordance with Clause 7.

Subject the DUT to the test signal based on the calibrated value as predetermined in the test plan.

To check the actual generated field strength, a field probe may be placed above the wiring harness during the test. Attention should be paid to the location of the probe for avoiding the disturbance of field strength and uniformity

Perform the test for both horizontal and vertical polarisation in the appropriate frequency ranges.

8.4 Test report

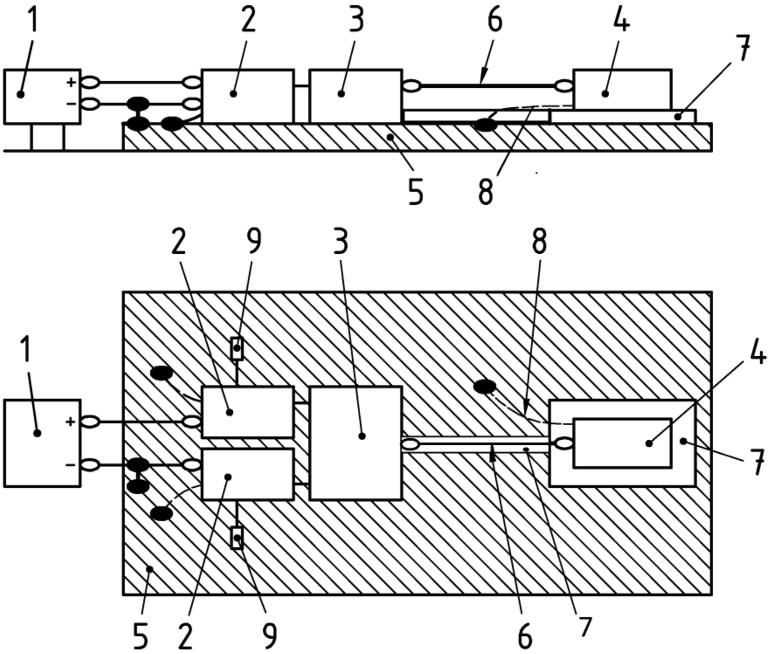
As required in the test plan, a test report shall be submitted detailing information regarding the test equipment, test area, systems tested, frequencies, power levels, system interactions and any other relevant information regarding the test.

Annex A
(informative)

Remote/local grounding

A.1 DUT remotely grounded

The principle for connecting a remotely grounded DUT is shown in Figure A.1.



Key

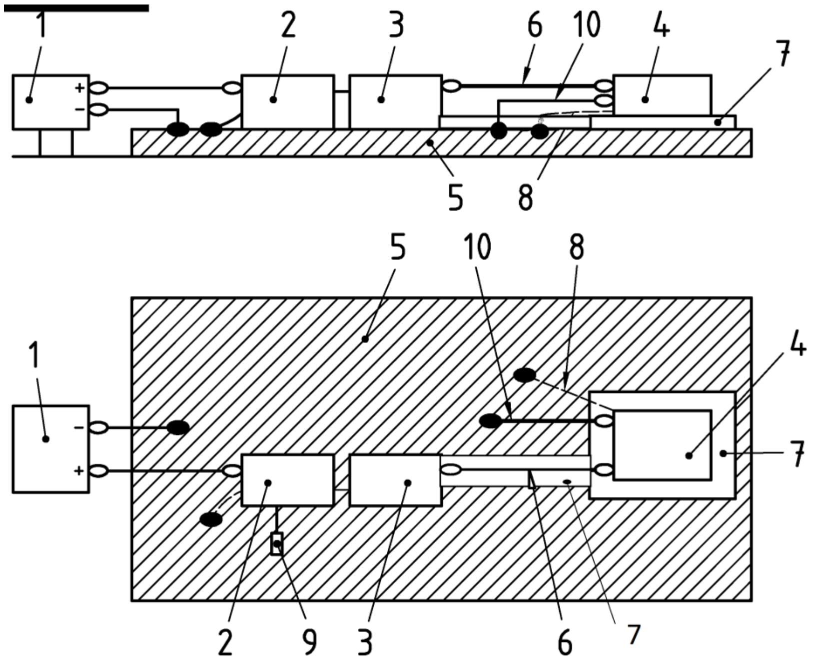
1 power supply
2 AN
3 simulator
4 DUT
5 ground plane
6 wiring harness (containing power supply and return line)
7 insulating support
8 ground connection of the DUT metallic case[a]
9 50 Ω load

[a] Not connected to the ground plane unless specified in the test plan (see 7.3).

Figure A.1 — DUT remotely grounded

A.2 DUT locally grounded

The principle for connecting a locally grounded DUT is shown in Figure A.2.



Key

1 power supply
2 AN
3 simulator
4 DUT
5 ground plane
6 wiring harness (not containing power return line)
7 insulating support
8 ground connection of the DUT metallic case[a]
9 50 Ω load.
10 power return line (maximum length: 200 mm)

[a] Not connected to the ground plane unless specified in the test plan (see 7.3).

Figure A.2 — DUT locally grounded

Annex B
(informative)

Function performance status classification (FPSC)

Suggested test severity levels and the frequency bands are given in Table B.1 and Table B.2, respectively.

NOTE See ISO 11452-1 for a detailed explanation of FPSC.

Table B.1 — Suggested test severity levels

Test severity level	**Value** V/m
I	25
II	50
III	75
IV	100
V	Specific value agreed between the users of this part of ISO 11452, if necessary

Table B.2 — Frequency bands

Frequency band	**Frequency range** MHz
F1	≥ 80 to ≤ 400
F2	> 400 to ≤ 1 000
F3	> 1 000 to ≤ 10 000
F4	> 10 000 to ≤ 18 000