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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

Reference number
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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electric and electronic equipment*.

This third edition cancels and replaces the second edition (ISO 11452-2:2004), which has been technically revised.

The main changes compared to the previous edition are as follows:

a) introduction of reference to additional artificial networks (HV-AN, AMN, AAN) for DUT powered by a shielded power system;

b) precisions for ground plane dimensions;

c) suppression of the minimum distance requirement between rear of horn antenna and absorbers;

d) addition of test set-up descriptions and Figures for DUT powered by a shielded power system;

e) suppression of Annex A relative to artificial networks which are now defined in ISO 11452-1; and

f) update of previous Annex C to be in line with new functional performance status classification (FPSC) format.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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 (ALSE), 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 document 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 documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 11452-1:2015, *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 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

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;

— frequency step sizes;

— definition of test severity levels; and

— test signal quality.

5 Test location

The tests shall be performed in an ALSE.

The purpose of such an enclosure is to create an isolated electromagnetic compatibility test facility which simulates open field testing. Basically, an ALSE consists of a shielded room with absorbing material on its internal reflective surfaces except the floor. However, flat ferrite tiles with a maximum thickness of 25 mm may be optionally applied on the floor.

The same ALSE configuration shall be used for calibration and the DUT test.

The design objective is to attenuate the reflected energy in the test area by at least 10 dB compared to the direct energy.

NOTE In order to achieve this objective, the performance of the absorbing material for the walls and ceiling can be greater than or equal to 6 dB in the frequency range of use. A test method for evaluating absorbing material is described in IEEE STD 1128-1998[1].

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.

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, shall be electrically small in relation to the wavelength, isotropic and with three orthogonal axes. The communication lines from the probe shall be fibre optic links.

6.2.3 Artificial networks (AN), high voltage artificial networks (HV-AN), artificial mains networks (AMN), and asymmetric artificial networks (AAN), see 7.2 and ISO 11452-1: 2015, Annex B.

6.2.4 RF generator, with internal (or external) modulation capabilities.

6.2.5 High-power amplifier.

6.2.6 Power meter and/or **power sensors** (or equivalent measuring instrument) and dual directional coupler, 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 for DUT powered by an unshielded power system

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, or the width of the entire underneath of the test setup (DUT and associated equipment (e.g. harness including supply lines, load simulator located on the test bench and AN(s)), excluding battery and/or power supply) plus 200 mm, whichever is the larger.

The minimum length of the ground plane shall be 2 000 mm, or the length of the entire underneath of the test setup (DUT and associated equipment (e.g. harness including supply lines, load simulator located on the test bench and AN(s)), excluding battery and/or power supply) 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 DC resistance shall not exceed 2,5 mΩ. The distance from the edge of the ground strap to the edge of the next strap shall not be greater than 300 mm. The maximum length to width ratio for the ground straps shall be 7:1.

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 shall be adapted accordingly. Power shall be applied to the DUT via a 5 µH/50 Ω AN (see ISO 11452-1:2015, 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.

The length of the power supply lines between the power supply and the load simulator shall be as short as possible and defined in the test plan. Unless otherwise specified, the power supply lines between the power supply and the load simulator shall be placed directly on the ground plane.

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 unless otherwise specified in the test plan.

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 (1 500 ± 75) mm.

The total length of the test harness between the DUT and the load simulator (or the RF boundary) shall be $(1\,700\,^{+300}_{\ \ 0})$ mm. The wiring type is defined by the actual system application and requirement.

The detailed layout of the harness on DUT side between the ground plane front edge and the DUT connector(s) shall be described in the test plan.

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.

The 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

Unless otherwise specified in the test plan, 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. The layout of the test harness that is connected to the load simulator shall be defined in the test plan and recorded in the test report.

When the load simulator is located on the ground plane, the DC 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, excluding the rear part of the horn 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

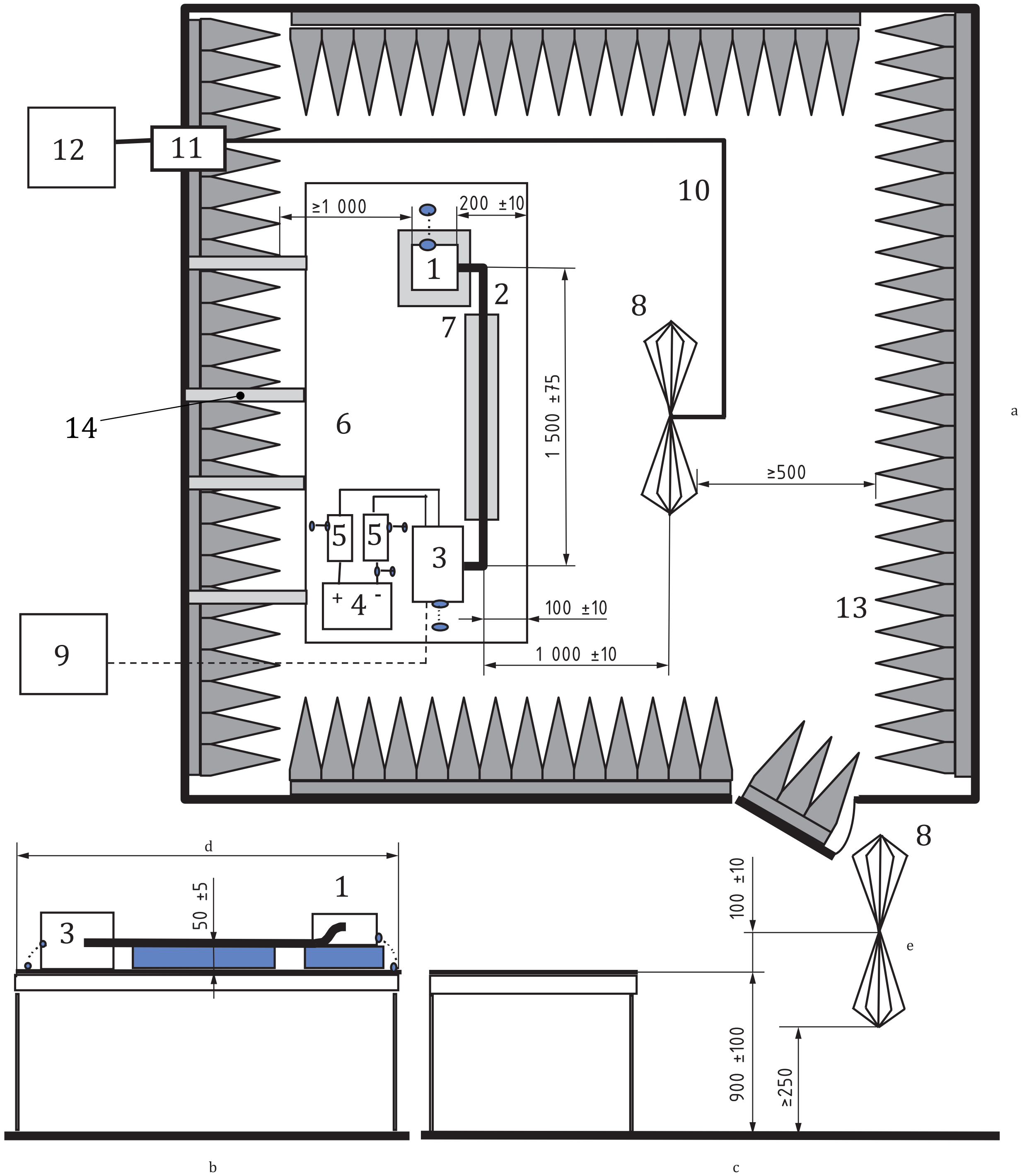
— the nearest part of the horn antenna.

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 ($\varepsilon_r \le 1{,}4$)
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
14 ground straps

a Upper view (horizontal polarisation).
b Front view.

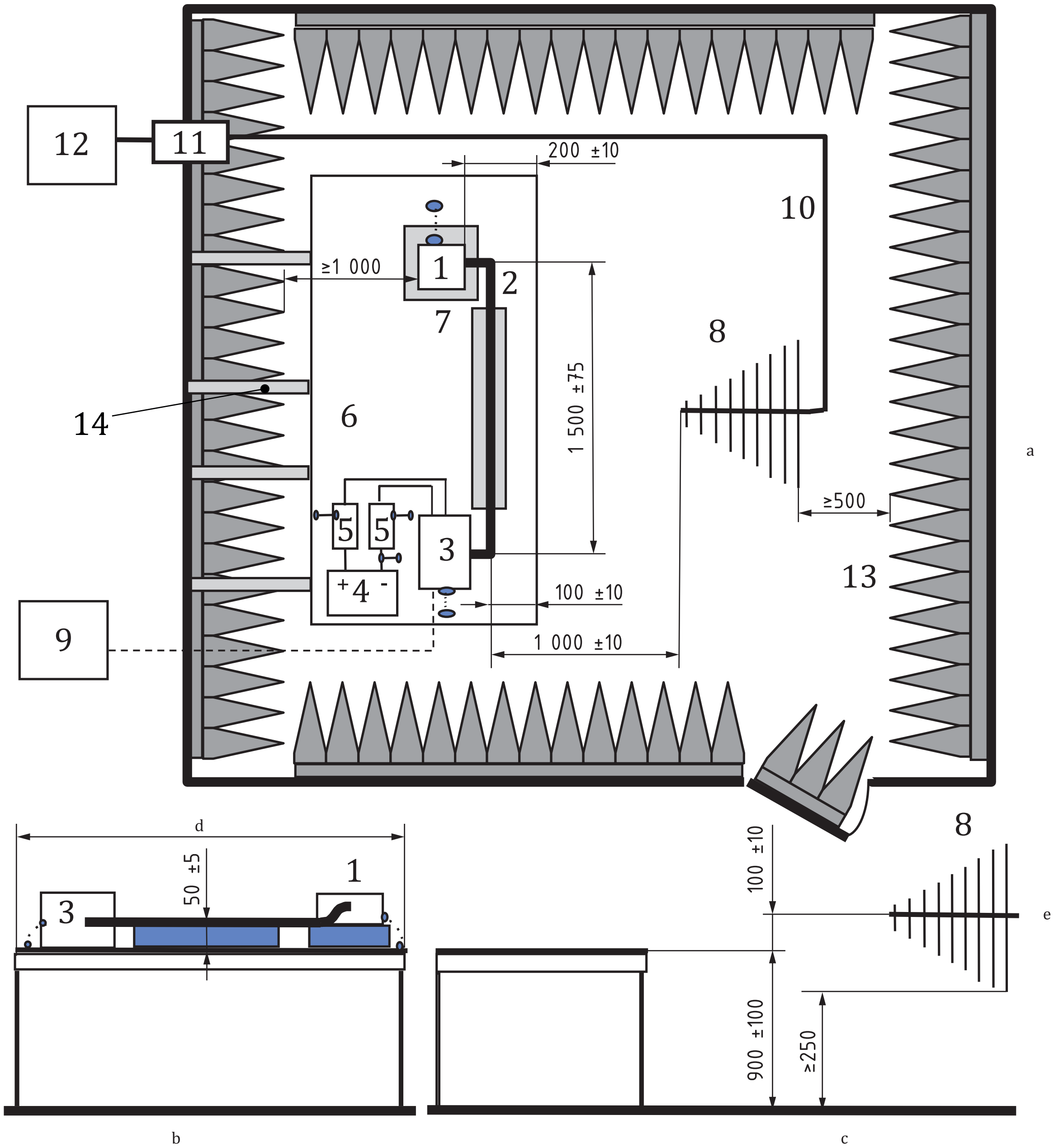
[c] Side view.

[d] See 7.1

[e] Vertical polarisation.

Figure 1 — Example test set-up — Biconical antenna

Dimensions in millimetres



Key

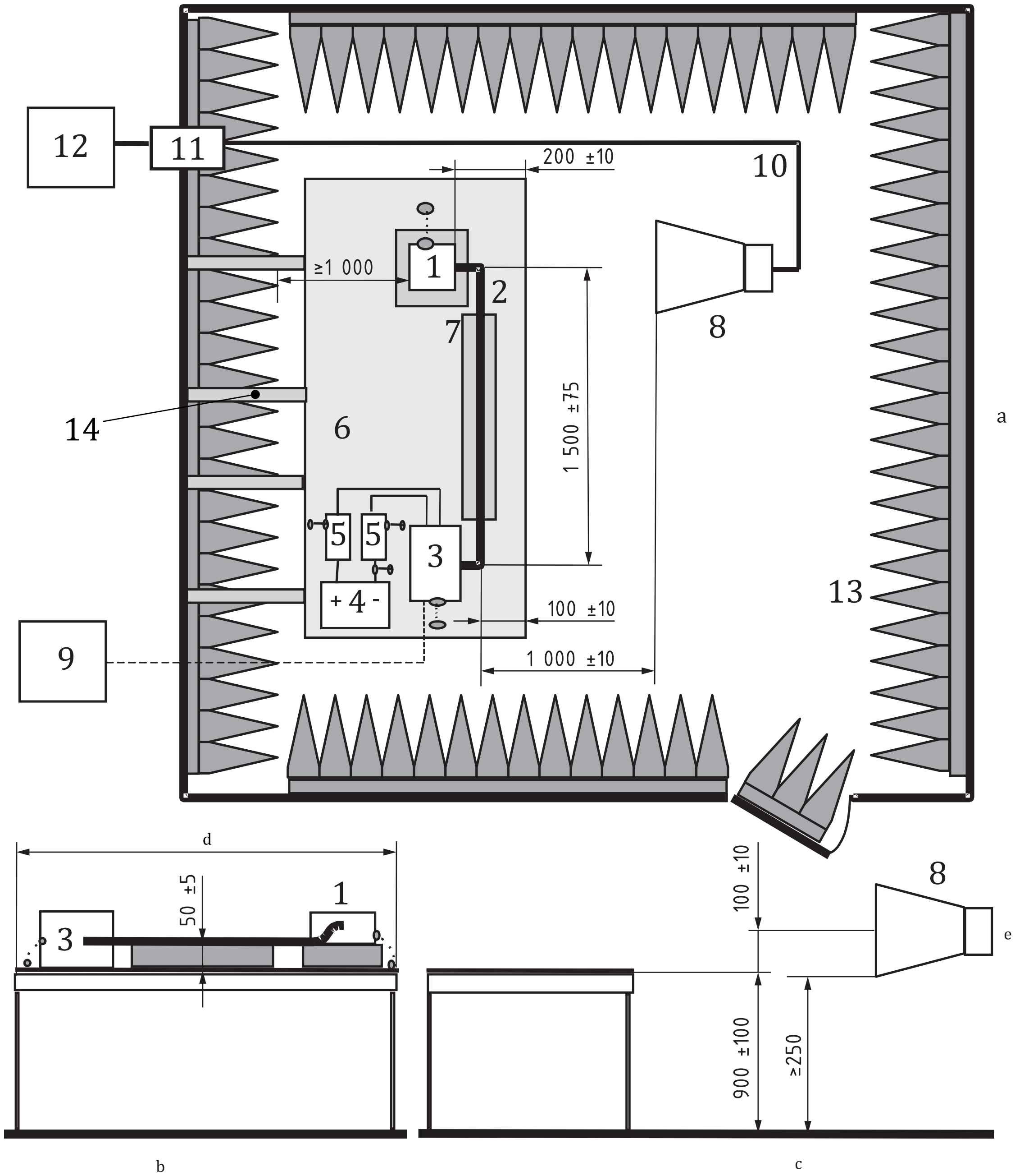
1 DUT (grounded locally if required in test plan)
2 test harness
3 load simulator (placement and ground: connection according to 7.5)
4 power supply (location optional)
5 artificial network (AN)
6 ground plane (bonded to shielded enclosure)
7 low relative permittivity support ($\varepsilon_r \leq 1{,}4$)
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
14 ground straps

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

[e] Vertical polarisation.

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
14 ground straps

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

[e] Vertical polarisation.

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

8 Test setup for DUT powered by a shielded power system

8.1 Ground plane

The ground plane conditions defined in 7.1 apply.

8.2 Power supply and AN

Each DUT power supply lead shall be connected to the power supply through an HV-AN (for DUT with DC HV supply) and/or AMN (for DUT with AC supply).

— DC HV supply shall be applied to the DUT via a 5 µH/50 Ω HV AN (see ISO 11452-1:2015, Annex B for the schematic).

— AC supply shall be applied to the DUT via a 50 µH/50 Ω AMN (see ISO 11452-1:2015, Annex B for the schematic).

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

The measuring port of each HV-AN(s) shall be terminated with a 50 Ω load.

The vehicle HV battery should be used; otherwise the external HV power supply shall be connected via feed-through-filtering.

Shielded supply lines for the positive HV DC terminal line (HV+), the negative HV DC terminal line (HV-) and three phase HV AC lines may be separate coaxial cables or in a common shield depending on the connector system used.

The shielded harnesses used for this test shall be representative of the vehicle application in terms of cable construction and connector termination as defined in the test plan.

Care should 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 could lead to the generation of extra resonances.

For the charger, the AMN(s) shall be mounted on the test facility floor ground plane. The case or cases of the AMN(s) shall be bonded to the test facility floor ground plane. The charger PE (protective earth) line shall be bounded to the test set-up ground plane and to the AMN(s) PE connection.

The measuring port of each HV-AN(s) / AMN(s) shall be terminated with a 50 Ω load.

8.3 Location of DUT

Unless otherwise specified, the DUT shall be placed directly on the ground plane with the DUT case bonded to the ground plane either directly or via defined impedance.

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

In case of a charger, the battery charger case shall be bonded to the ground plane.

8.4 Location of test harness

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

— $(1\,700\,^{+300}_{\;\;0})$ mm for the LV lines;

— $(1\,700\,^{+300}_{\;\;0})$mm for the HV lines and the length of the HV test harness parallel to the front of the ground plane shall be (1 500 ± 75) mm; and

— less than 1 000 mm for the three phase lines between DUT and electric motor(s).

If the HV test harness is over 2 000 mm, the HV test harness length should be defined in the test plan and described in the test report.

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.

The detailed layout of the harness on DUT side between the ground plane front edge and the DUT connector(s) shall be described in the test plan.

The shielded harnesses used for this test shall be representative of the vehicle application in terms of cable construction and connector termination as defined in the test plan.

The long segment of LV lines test harness shall be located parallel to the edge of the reference ground plane facing the antenna at a distance of (100 ± 10) mm from the edge. The long segment of the HV lines test harness shall be located at $(100\,^{+100}_{\;\;0})$ mm from the LV lines test harness (as shown in Figures 4 to 5, Figures 7 to 8 and Figures 10 to 11).

Unless otherwise specified in the test plan, the configuration with the long segment of HV lines test harness at a distance of (100 ± 10) mm from the edge and the LV lines test harness located at $(100\,^{+100}_{\;\;0})$ mm from the HV lines shall also be tested.

For inverter / charger device the setup in Figures 6, 9 and 12 are examples for further HV and LV load simulators and supplies attached to the device under test (DUT), like e.g. for testing an on-board charger and its communication links. The distance between the AC power lines and the closest harness (LV or HV) shall be $(100\,^{+100}_{\;\;0})$ mm. Various combinations of the shown setups are possible based on the true application of the HV component.

Unless otherwise specified in the test plan, for inverter / charger (see Figures 6, 9 and 12) the AC power lines shall be placed the furthest from the antenna (behind LV and HV harness).

8.5 Location of load simulator

Unless otherwise specified in the test plan, 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. The layout of the test harness that is connected to the load simulator shall be defined in the test plan and recorded in the test report.

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

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 may be placed outside the ALSE. 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).

8.6 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, excluding the rear part of the horn 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

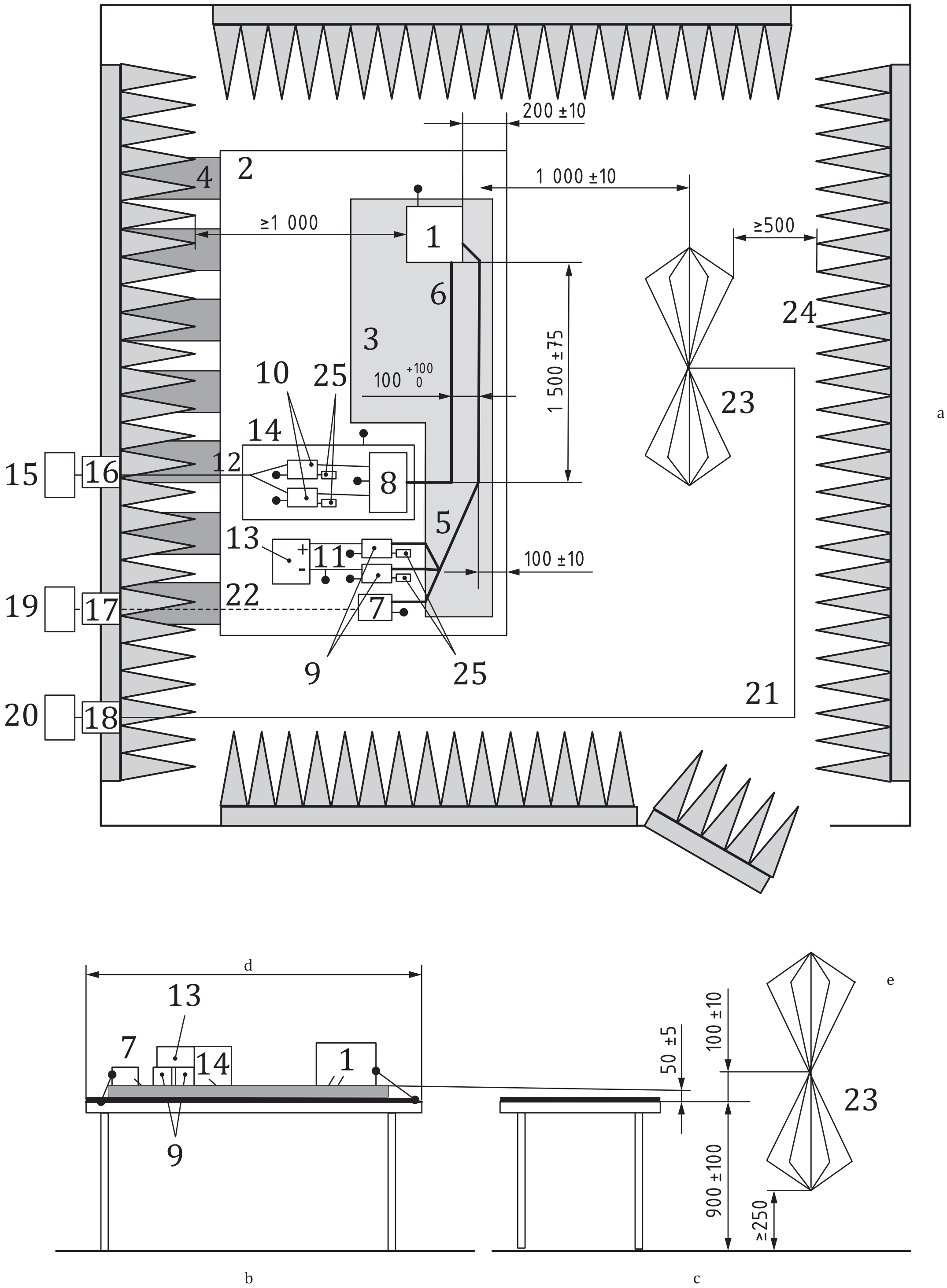
— the nearest part of the horn antenna.

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 4, 5, 7, 8, 10 and 11 (for HV DUT) and Figures 6, 9 and 12 (for chargers).

Dimensions in millimetres



Key

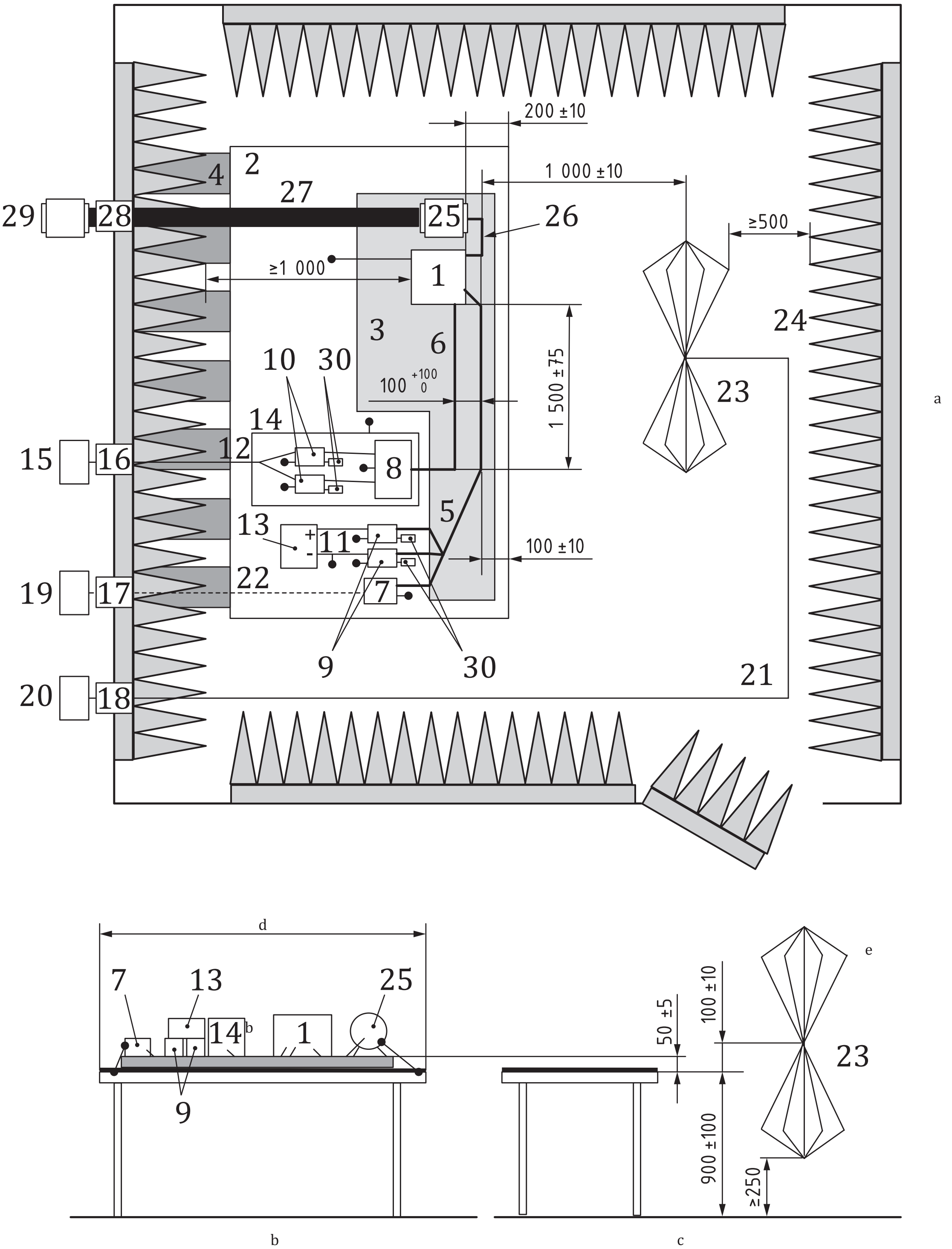
1	DUT	14	additional shielded box
2	ground plane	15	HV power supply (shielded if placed inside ALSE)
3	low relative permittivity support ($\varepsilon_r \leq 1,4$); thickness 50 mm	16	power line filter
4	ground straps	17	fibre optic feed through
5	LV harness	18	bulk head connector
6	HV lines (HV+, HV-)	19	stimulating and monitoring system
7	LV load simulator	20	RF signal generator and amplifier

8 impedance matching network (optional) (see ISO 11452-1)
9 LV AN
10 HV AN
11 LV supply lines
12 HV supply lines
13 LV power supply 12 V / 24 V / 48 V (placed on the bench)
21 high quality coaxial cable e.g. double shielded (50 Ω)
22 optical fibre
23 biconical antenna
24 RF absorber material
25 50 Ω load

a Upper view (horizontal polarisation).
b Front view.
c Side view.
d See 8.1.
e Vertical polarisation.

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

Dimensions in millimetres



Key

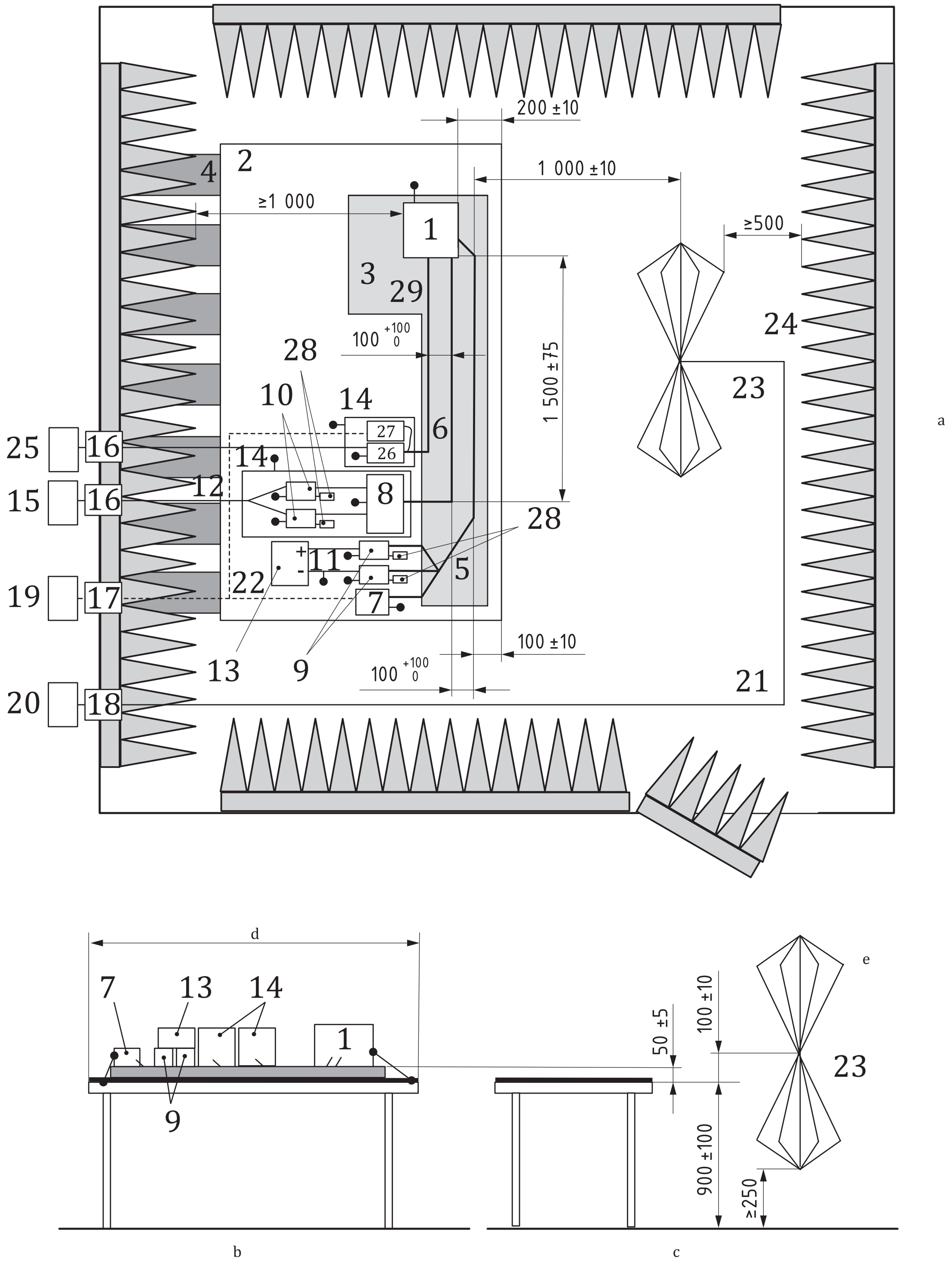
1 DUT
2 ground plane
3 low relative permittivity support ($\varepsilon_r \leq 1,4$); thickness 50 mm (a non-conductive support can be used for the electric motor)
4 ground straps
5 LV harness
6 HV lines (HV+, HV-)
15 HV power supply (shielded if placed inside ALSE)
16 power line filter
17 fibre optic 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

7 LV load simulator
8 impedance matching network (optional) (see ISO 11452-1)
9 LV AN
10 HV AN
11 LV supply lines
12 HV supply lines
13 LV power supply 12 V / 24 V / 48 V (placed on the bench)
14 additional shielded box
a Upper view (horizontal polarisation).
b Front view.
c Side view.
d See 8.1
e Vertical polarisation.

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

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

15 HV power supply (shielded if placed inside ALSE)

16 power line filter

17 fibre optic feed through

18 bulk head connector

19 stimulating and monitoring system

20 RF signal generator and amplifier

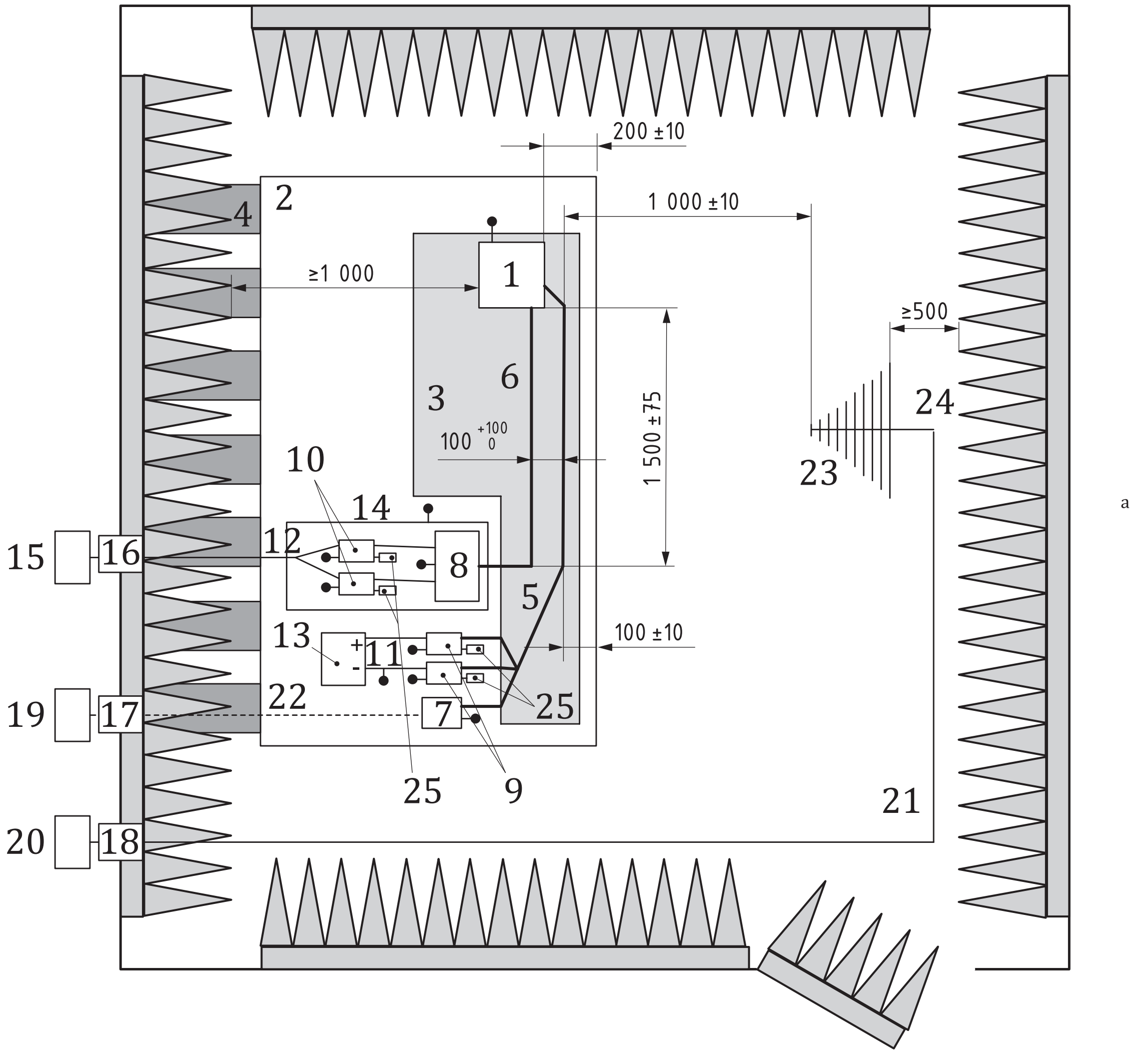
21 high quality coaxial cable e.g. double

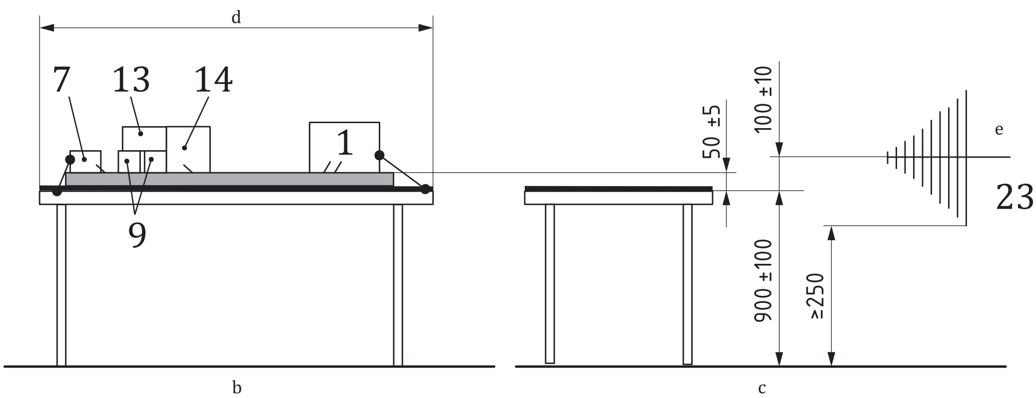
8 impedance matching network (optional) (see ISO 11452-1)
9 LV AN
10 HV AN
11 LV supply lines
12 HV supply lines
13 LV power supply 12 V / 24 V / 48 V (placed on the bench)
14 additional shielded box
a Upper view (horizontal polarisation).
b Front view.
c Side view.
d See 8.1.
e Vertical polarisation.

shielded (50 Ω)
22 optical fibre
23 biconical antenna
24 RF absorber material
25 AC power mains
26 AMN for AC power mains
27 AC charging load simulator
28 50 Ω load
29 AC lines

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

Dimensions in millimetres





Key

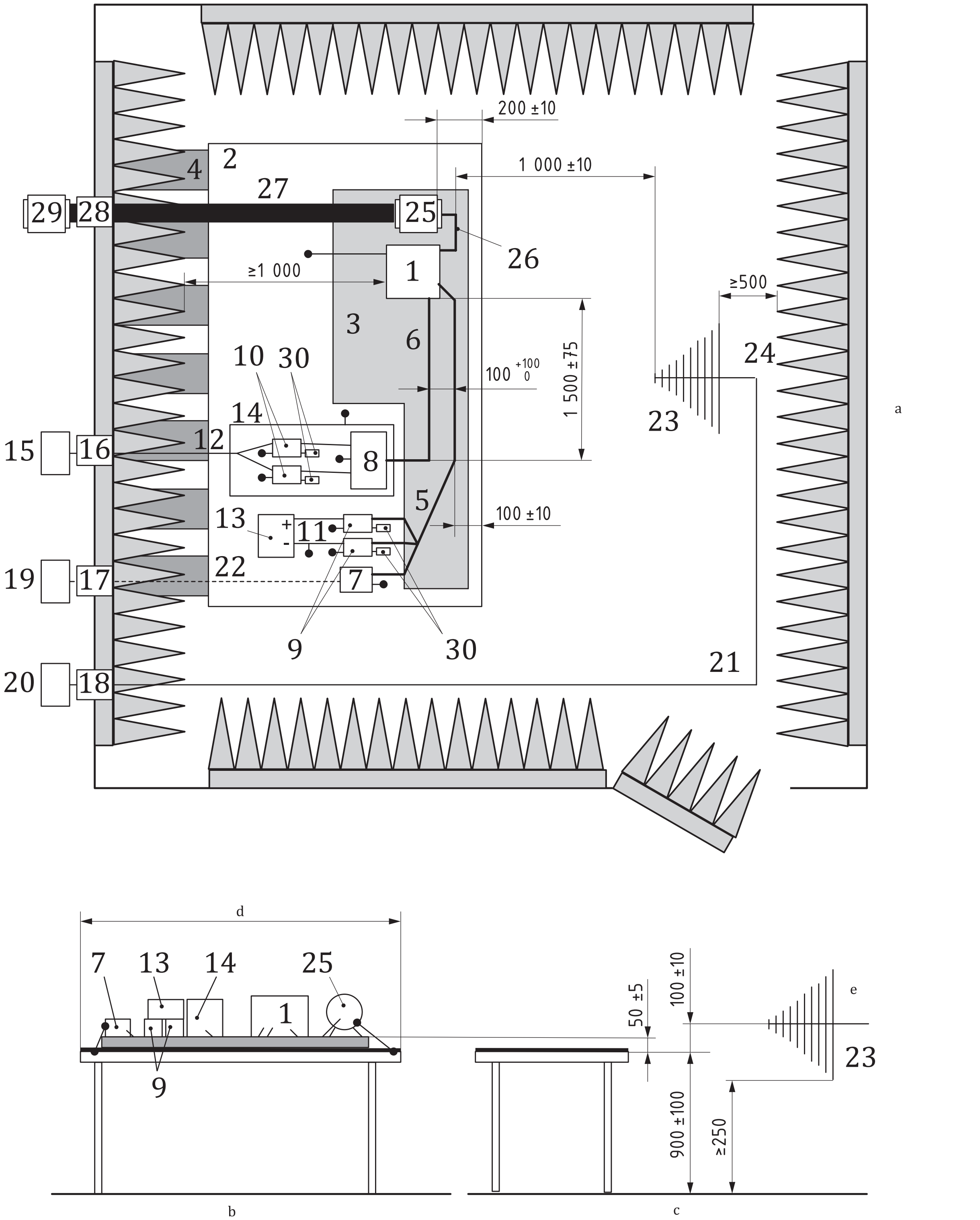
1	DUT	14	additional shielded box
2	ground plane	15	HV power supply (shielded if placed inside ALSE)
3	low relative permittivity support ($\varepsilon_r \leq 1{,}4$); thickness 50 mm	16	power line filter
4	ground straps	17	fibre optic feed through
5	LV harness	18	bulk head connector
6	HV lines (HV+, HV-)	19	stimulating and monitoring system

7 LV load simulator
8 impedance matching network (optional) (see ISO 11452-1)
9 LV AN
10 HV AN
11 LV supply lines
12 HV supply lines
13 LV power supply 12 V / 24 V / 48 V (placed on the bench)
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 50 Ω load

a Upper view (horizontal polarisation).
b Front view.
c Side view.
d See 8.1.
e Vertical polarisation.

Figure 7 — Example of test set-up — Log-periodic 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

15 HV power supply (shielded if placed inside ALSE)

16 power line filter

17 fibre optic feed through

18 bulk head connector

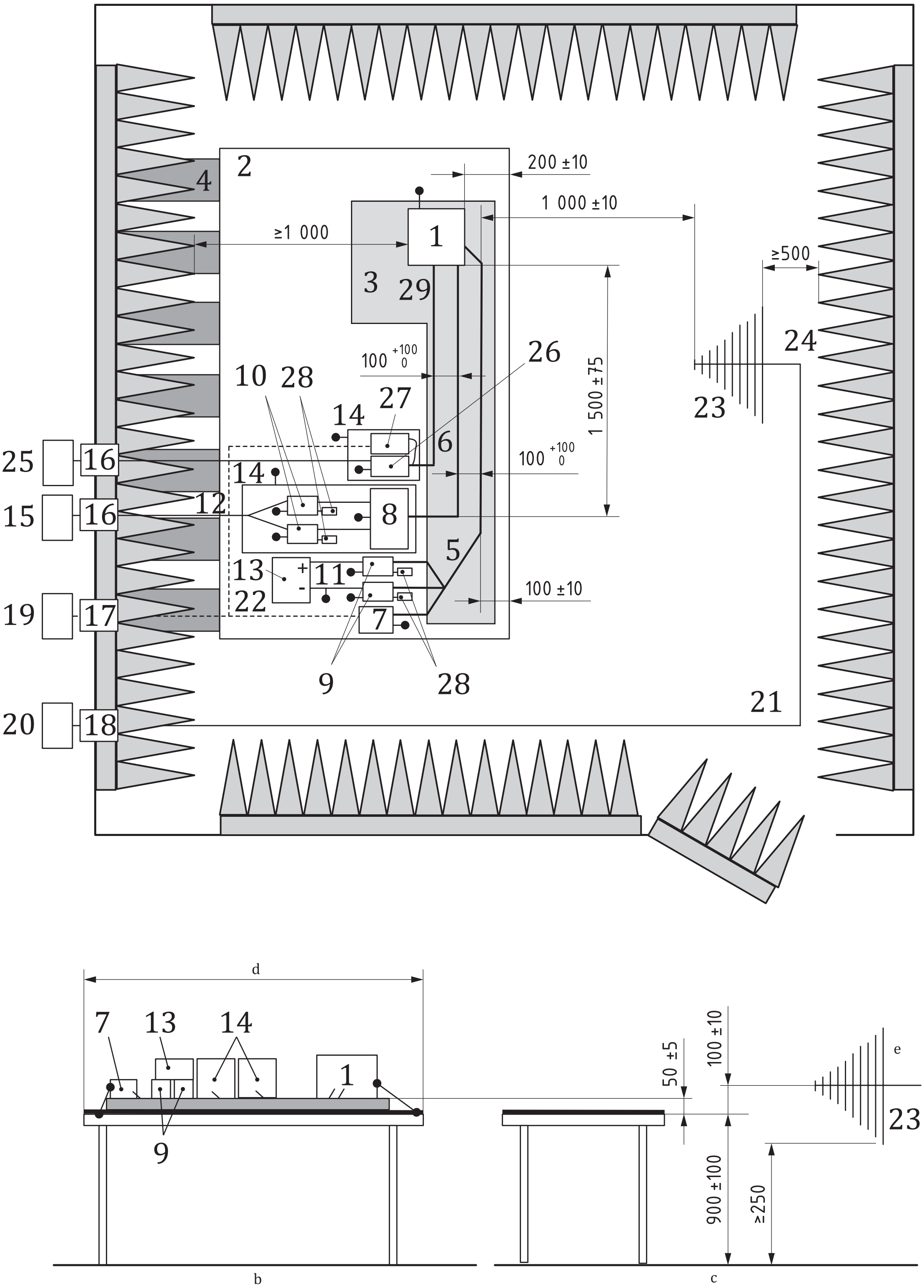
19 stimulating and monitoring system

5 LV harness
6 HV lines (HV+, HV-)
7 LV load simulator
8 impedance matching network (optional) (see ISO 11452-1)
9 LV AN
10 HV AN
11 LV supply lines
12 HV supply lines
13 LV power supply 12 V / 24 V / 48 V (placed on the bench)
14 additional shielded box
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 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 8.1.
e Vertical polarisation.

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

2 ground plane

3 low relative permittivity support ($\varepsilon_r \leq 1,4$); thickness 50 mm

4 ground straps

5 LV harness

15 HV power supply (shielded if placed inside ALSE)

16 power line filter

17 fibre optic feed through

18 bulk head connector

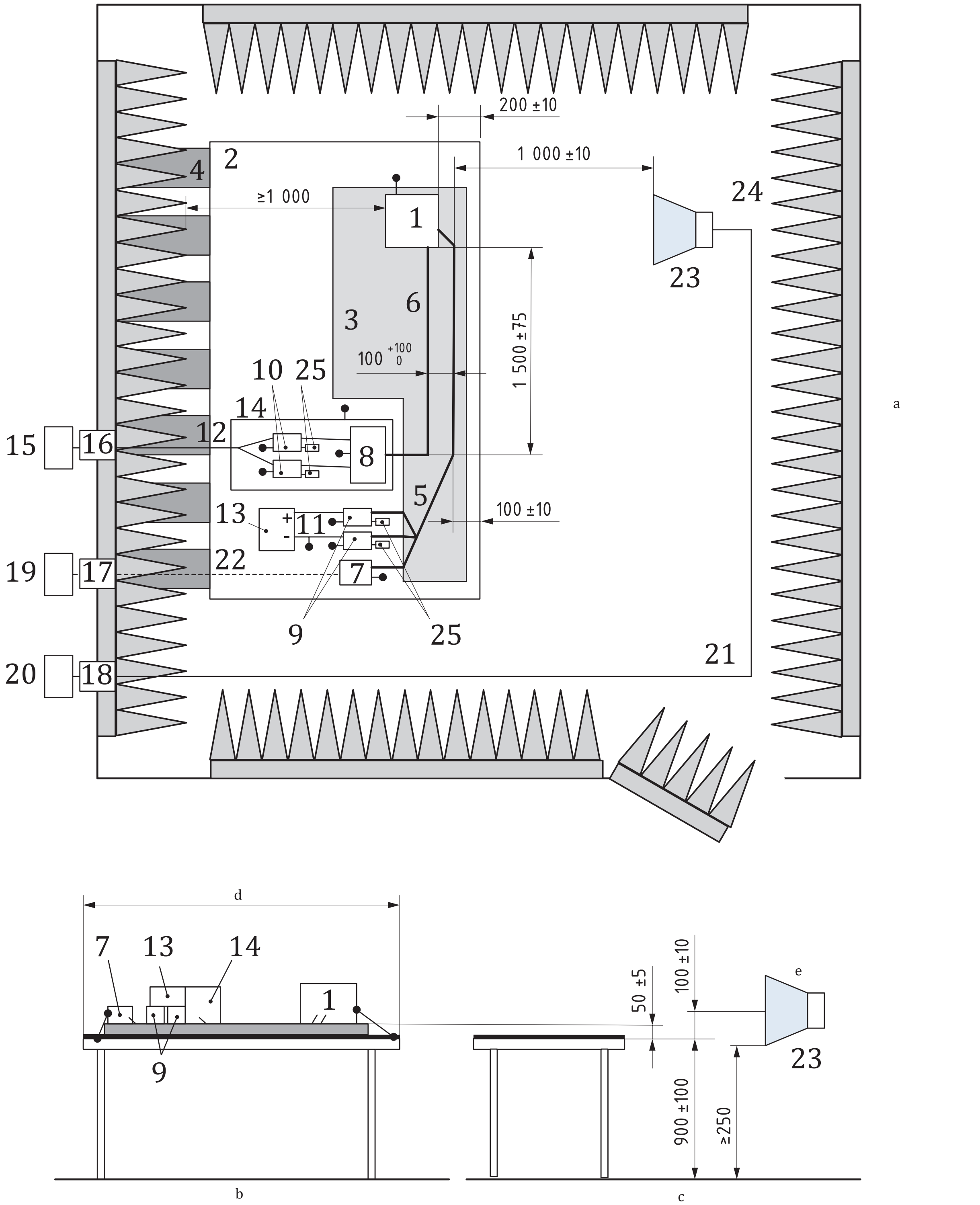
19 stimulating and monitoring system

6 HV lines (HV+, HV-)
7 LV load simulator
8 impedance matching network (optional) (see ISO 11452-1)
9 LV AN
10 HV AN
11 LV supply lines
12 HV supply lines
13 LV power supply 12 V / 24 V / 48 V (placed on the bench)
14 additional shielded box (optional)
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 AC power mains
26 AMN for AC power mains
27 AC charging load simulator
28 50 Ω load
29 AC lines

a Upper view (horizontal polarisation).
b Front view.
c Side view.
d See 8.1.
e Vertical polarisation.

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-)

14 additional shielded box

15 HV power supply (shielded if placed inside ALSE)

16 power line filter

17 fibre optic feed through

18 bulk head connector

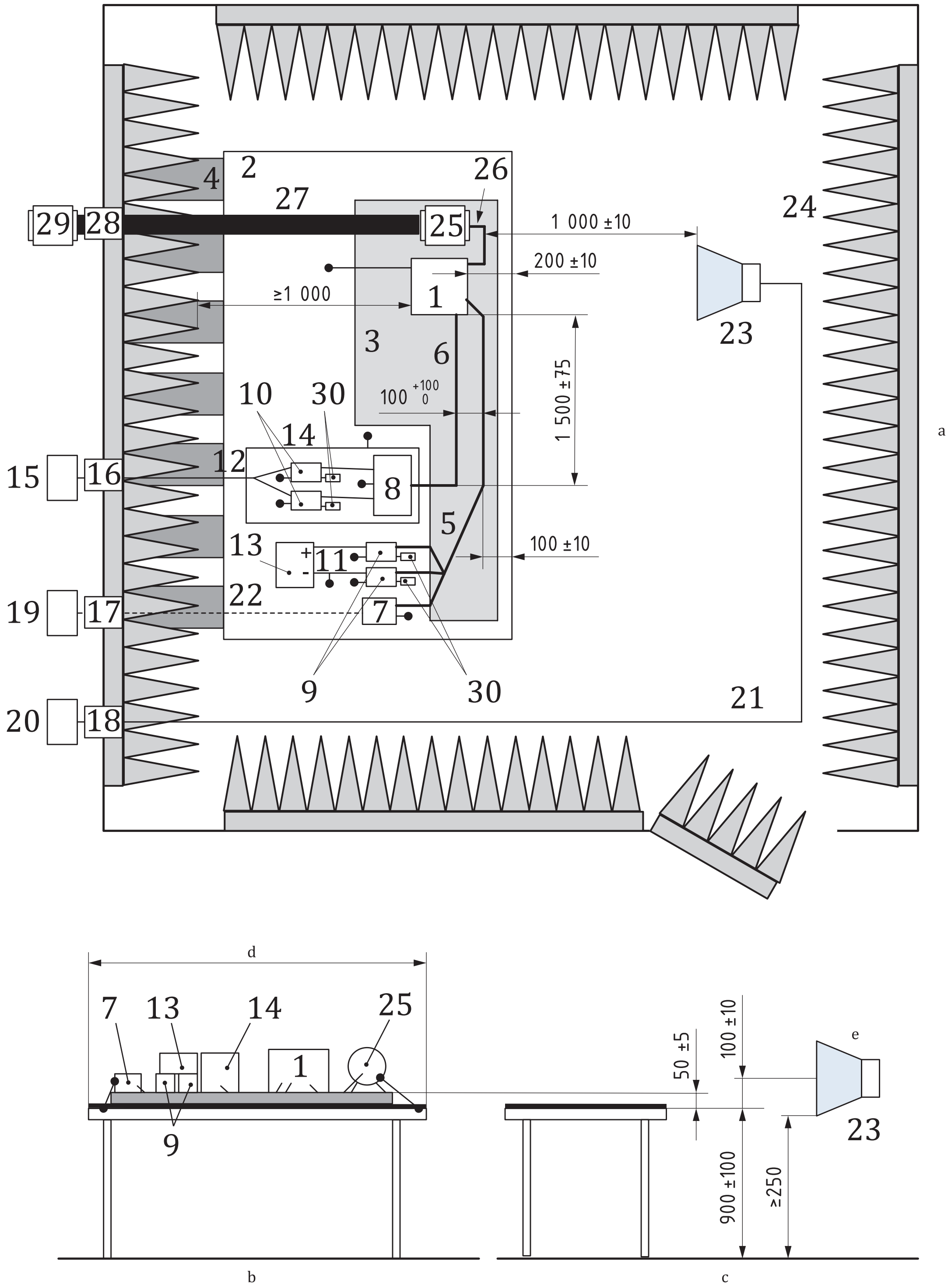
19 stimulating and monitoring system

7 LV load simulator
8 impedance matching network (optional) (see ISO 11452-1)
9 LV AN
10 HV AN
11 LV supply lines
12 HV supply lines
13 LV power supply 12 V / 24 V / 48 V (placed on the bench)
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 8.1.
e Vertical polarisation.

Figure 10 — Example of test set-up — Horn 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-)

15 HV power supply (shielded if placed inside ALSE)

16 power line filter

17 fibre optic feed through

18 bulk head connector

19 stimulating and monitoring system

20 RF signal generator and amplifier

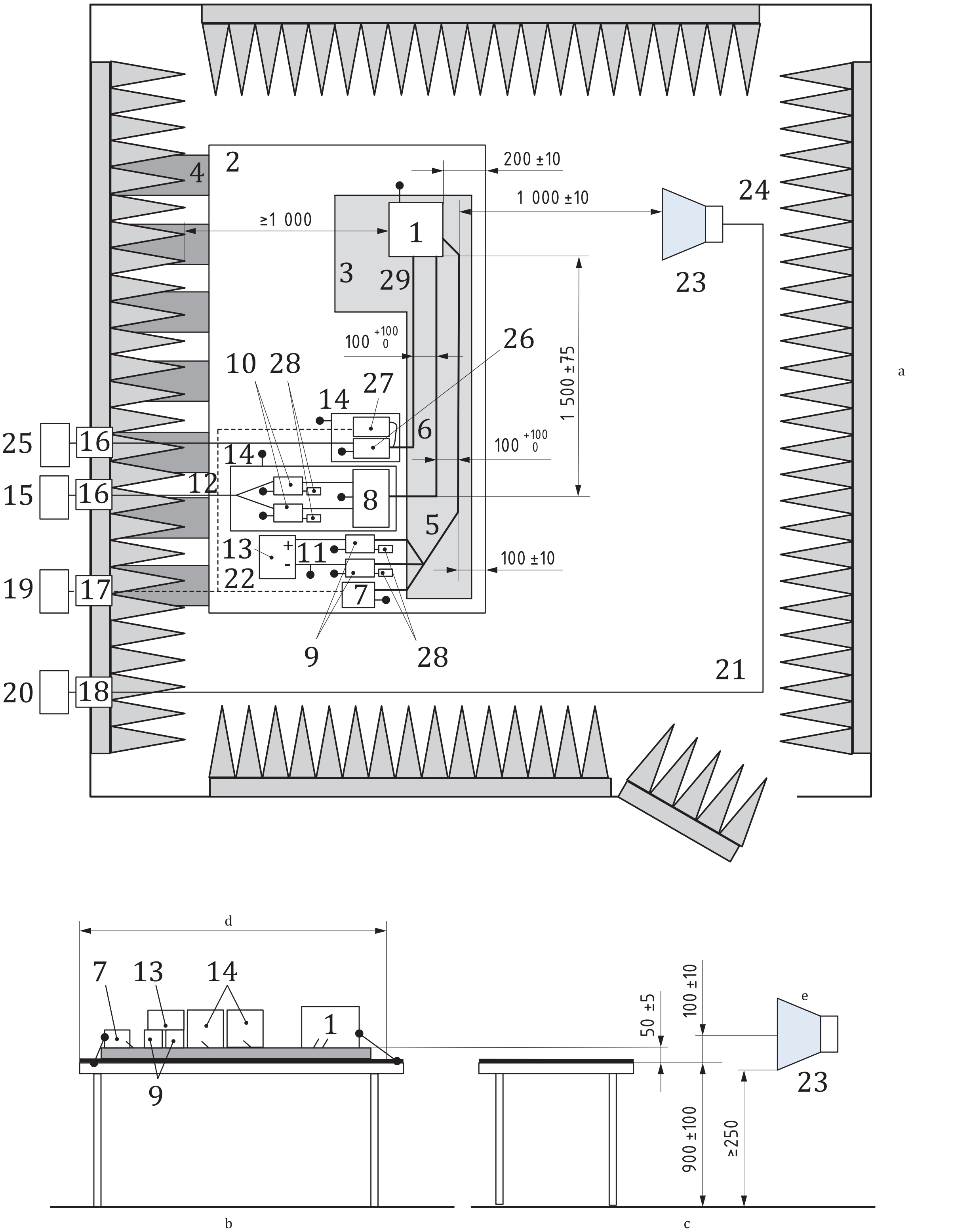
21 high quality coaxial cable e.g. double

7 LV load simulator
8 impedance matching network (optional) (see ISO 11452-1)
9 LV AN
10 HV AN
11 LV supply lines
12 HV supply lines
13 LV power supply 12 V / 24 V / 48 V (placed on the bench)
14 additional shielded box
a Upper view (horizontal polarisation).
b Front view.
c Side view.
d See 8.1.
e Vertical polarisation

shielded (50 Ω)
22 optical fibre
23 horn 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

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

15 HV power supply (shielded if placed inside ALSE)

16 power line filter

17 fibre optic feed through

18 bulk head connector

19 stimulating and monitoring system

6 HV lines (HV+, HV-)
7 LV load simulator
8 impedance matching network (optional) (see ISO 11452-1)
9 LV AN
10 HV AN
11 LV supply lines
12 HV supply lines
13 LV power supply 12 V / 24 V / 48 V (placed on the bench)
14 additional shielded box
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 AC power mains
26 AMN for AC power mains
27 AC charging load simulator
28 50 Ω load
29 AC lines
a Upper view (horizontal polarisation).
b Front view.
c Side view.
d See 8.1.
e Vertical polarisation.

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

9 Test method

9.1 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.

Horizontal polarization measurements shall be performed from 400 MHz to 18 GHz.

Vertical polarization measurements shall be performed from 80 MHz to 18 GHz.

9.2 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;

— details on load simulator;

— detailed layout of test harness nearby DUT;

— antenna location; and

— test report content.

In addition, any special instructions and changes from the standard test.

Every DUT shall be tested in the modes identified from the process detailed in 9.1. These shall be detailed in the test plan.

9.3 Test procedure

9.3.1 General

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.

9.3.2 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 all peripheral devices (load simulator, AN(s), power supply, battery, ...) present, see 9.3.2); and

b) test of the DUT with wiring harness and all peripheral devices (load simulator, AN(s), power supply, battery, ...) connected (see 9.3.3).

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

9.3.3 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, at frequency steps not greater than the maximum frequency step sizes defined in ISO 11452-1. This calibration shall be performed with an unmodulated sinusoidal wave.

The specific field strength from the field probe shall be the RMS value of the 3 axes resultant.

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 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.

Preferably one of the field probe axes should be parallel to field polarisation.

Place the field-generating device (antenna) in accordance with 7.6 and place the electrical phase centre of the field probe at a distance of (1 000 ± 10) mm from the antenna.

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.

9.3.4 DUT test

Install the DUT, harness and all peripheral devices (e.g. load simulator, AN(s), power supply, battery, …) on the test bench in accordance with Clause 7 (for DUT powered by an unshielded power system) or Clause 8 (for DUT powered by a shielded power system).

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

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

9.4 Test report

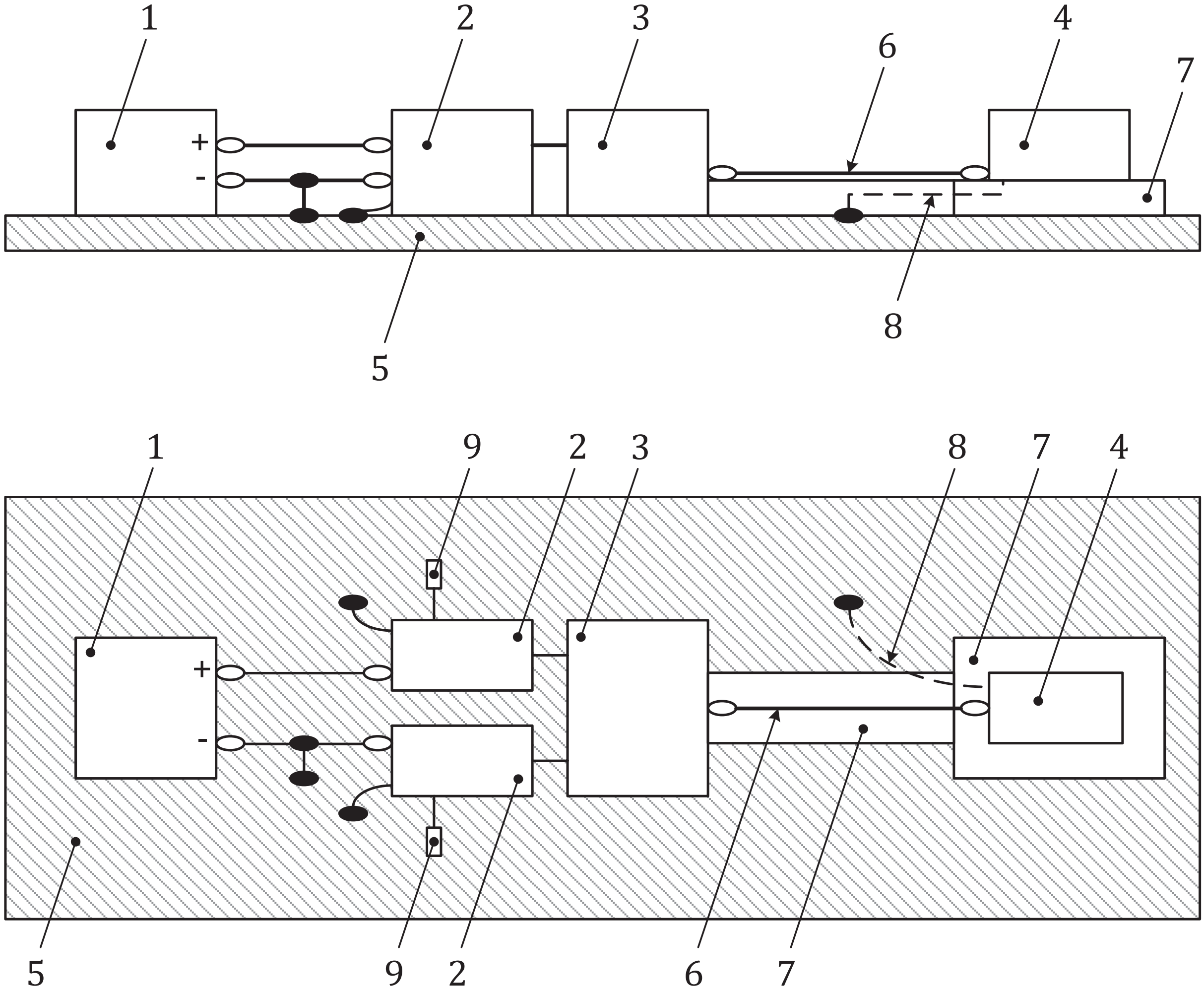
As required in the test plan, a test report shall be submitted detailing information regarding the test equipment, test area, systems tested, frequencies, power levels, system interactions and any other relevant information regarding the test.

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

Key

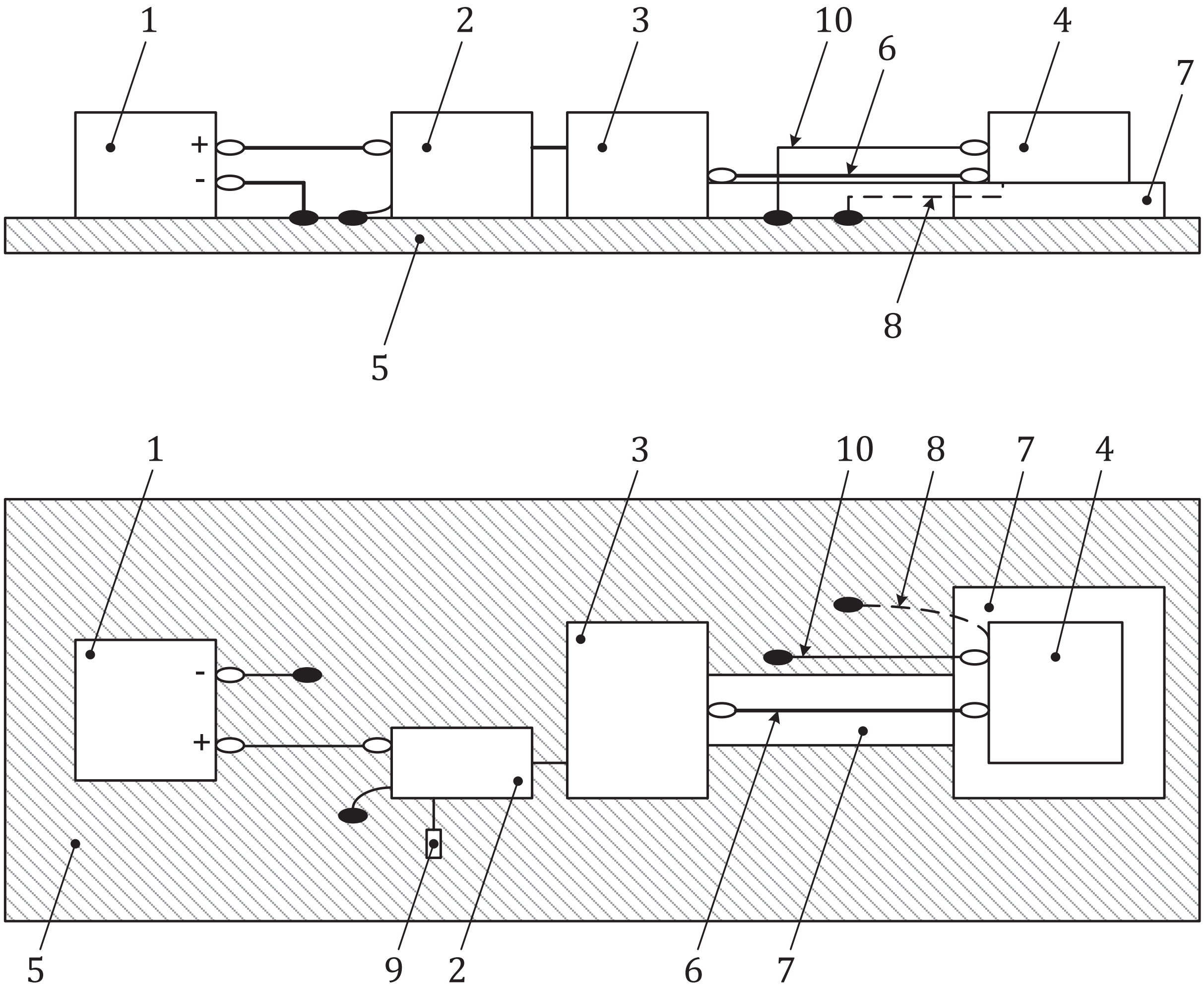
1 power supply
2 AN
3 simulator
4 DUT
5 ground plane
6 wiring harness (containing power supply and return line)
7 insulating support
8 ground connection of the DUT metallic case[a]
9 50 Ω load

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

Key

1	power supply	7	insulating support
2	AN	8	ground connection of the DUT metallic case[a]
3	simulator	9	50 Ω load
4	DUT	10	power return line (maximum length: 200 mm)
5	ground plane	a	Not connected to the ground plane unless specified in the test plan (see 7.3).
6	wiring harness (not containing power return line)		

Figure A.2 — DUT locally grounded

Annex B
(informative)

Function performance status classification (FPSC)

B.1 General

This annex gives examples of test severity levels which should be used in line with the principle of functional performance status classification (FPSC) described in ISO 11452-1.

B.2 Classification of test severity level

Examples of test severity levels for ALSE are given in Table B.1.

Table B.1 — Example of test severity levels (ALSE)

<table>
<tr><th>Frequency band (MHz)</th><th>Test Level I (V/m)</th><th>Test Level II (V/m)</th><th>Test Level III (V/m)</th><th>Test Level IV (V/m)</th><th>Test Level V (V/m)</th></tr>
<tr><td>80 to 200</td><td>25</td><td>50</td><td>75</td><td>100</td><td rowspan="4">Specific values agreed between the users of this document</td></tr>
<tr><td>200 to 1 000</td><td>25</td><td>50</td><td>75</td><td>100</td></tr>
<tr><td>1 000 to 8 000</td><td>25</td><td>50</td><td>75</td><td>100</td></tr>
<tr><td>8 000 to 18 000</td><td>25</td><td>50</td><td>75</td><td>100</td></tr>
<tr><td colspan="6">Frequency bands and test levels values given in this table are examples and may change for frequency bands.</td></tr>
</table>

B.3 Example of FPSC application using test severity levels

An example of severity levels is given in Table B.2.

Table B.2 — Example of test severity levels (ALSE)

Test Severity Level	Function Category 1	Function Category 2	Function Category 3	Function Category 4
L4i	Level IV	—	—	—
L3i	Level III	Level IV	—	—
L2i	Level II	Level III	Level IV	—
L1i	Level I	Level II	Level III	Level IV

Bibliography

[1] IEEE STD 1128-1998, *IEEE Recommended Practice for Radio Frequency (RF) Absorber — Evaluation in the Range of 30 MHz to 5 GHz*

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