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Road vehicles — Test methods for electrical disturbances from electrostatic discharge

Véhicules routiers — Méthodes d'essai des perturbations électriques provenant de décharges électrostatiques

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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.

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 10605 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

This second edition cancels and replaces the first edition (ISO 10605:2001), which has been technically revised.

Introduction

The familiar electrostatic discharge, due to former charge build-ups generated, for example, when moving about inside a vehicle or getting out of it, has assumed greater significance with the increase of vehicle electronic modules. Tests simulating the electrostatic discharge of humans, in common use by various industries, were examined and it was determined that they were not fully applicable to the automotive environment. As a consequence, tests tailored to the automotive environment were developed.

Tests that simulate an electrostatic discharge (ESD) into a vehicle electrical system are based on the human ESD model. Sensitive electrical devices can be adversely affected by energy either coupled or radiated from electrostatic discharges. This International Standard describes ESD tests that are applicable to both automotive electronic modules and vehicles.

Road vehicles — Test methods for electrical disturbances from electrostatic discharge

1 Scope

This International Standard specifies the electrostatic discharge (ESD) test methods necessary to evaluate electronic modules intended for vehicle use. It applies to discharges in the following cases:

— ESD in assembly;

— ESD caused by service staff;

— ESD caused by occupants.

ESD applied to the device under test (DUT) can directly influence the DUT. ESD applied to neighbouring parts can couple into supply and signal lines of the DUT in the vehicle and/or directly into the DUT.

This International Standard describes test procedures for evaluating both electronic modules on the bench and complete vehicles. This International Standard applies to all types of road vehicles regardless of the propulsion system (e.g. spark-ignition engine, diesel engine, electric motor).

This International Standard is based in part on IEC 61000-4-2 and describes vehicle-specific requirements.

This International Standard does not apply to pyrotechnic modules.

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 7637-1, *Road vehicles — Electrical disturbances from conduction and coupling — Part 1: Definitions and general considerations*

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 7637-1 and ISO 11452-1 and the following apply.

3.1
air discharge
test method characterized by bringing the test generator electrode close to the device under test (DUT); the discharge is by arcing on the DUT

3.2
contact discharge
test method characterized by contact of the test generator electrode with the DUT, where discharge is initiated by the generator discharge switch

3.3
device under test
DUT
single component or combination of components as defined to be tested

3.4
direct discharge
discharge directly on the DUT

3.5
electrostatic discharge
ESD
transfer of electrostatic charge between bodies at different potentials occurring prior to contact or induced by an electrostatic field

3.6
ESD generator
instrument that simulates the human ESD model

3.7
ground reference plane
GRP
flat conductive surface whose potential is used as a common reference

NOTE Where applicable, it is advisable that the test voltage of the DUT and the operator ground also be referenced to the ground plane.

3.8
holding time
interval of time within which the decrease of the test voltage due to leakage, prior to the discharge, is 10 %

3.9
horizontal coupling plane
HCP
metal plane oriented in horizontal direction, to which discharges are applied to simulate electrostatic discharge to objects adjacent to the DUT

3.10
human ESD model
network of passive elements and voltage that characterizes a charged person as a source of an electrostatic discharge for automotive conditions

3.11
indirect discharge
discharge on a coupling plane near the DUT

NOTE Discharge current produces a transient field that might affect the DUT. Indirect discharge simulates discharge by a human being on items near the DUT.

3.12
surface
uninterrupted housing area, gap or opening

EXAMPLE Switches, tip switches, points of contact, air vents, speaker openings.

4 Test conditions

The user shall specify the test severity level(s) for the component and vehicle tests. Suggested test levels are included in Annex C.

Standard test conditions shall be as follows:

— ambient temperature: (25 ± 10) °C;

— relative humidity between 20 % and 60 % (20 °C and 30 % relative humidity preferred).

If other values are agreed to by the users, these values shall be documented in the test report.

5 Test location

Special locations, such as shielded enclosures or even absorber-lined shielded enclosures, are allowed but not required.

NOTE ESD testing creates transient fields, which can interfere with sensitive electronic devices or receivers, even at a distance of a few meters. It is advisable that this be considered when choosing a test location.

6 Test apparatus and instrumentation

6.1 ESD generator

The ESD generator characteristics shall be as specified in Table 1.

Table 1 — General ESD generator parameters

Parameter	Characteristic
Output voltage range contact discharge mode	2 kV to 15 kV, or as required in the test plan [a]
Output voltage range air discharge mode	2 kV to 25 kV, or as required in the test plan [a]
Output voltage accuracy	⩽ 5 %
Output polarity	Positive and negative
Rise time of short circuit current in contact discharge mode (10 % to 90 %)	0,7 ns to 1,0 ns
Holding time	⩾ 5 s
Storage capacitances	150 pF, 330 pF
Discharge resistances	330 Ω, 2 000 Ω
[a] See examples in Annex C.	

NOTE When an ESD generator is supplied from an external supply source (a.c. or d.c.) or controlled by a separate unit and this/these cable(s) is/are not combined (bundled) with the ESD generator discharge return cable, unintended current can flow through this/these cable(s).

The ESD generator should be able to generate a repetition rate of at least 10 discharges per second down to manual control without any degradation of the discharge current waveform.

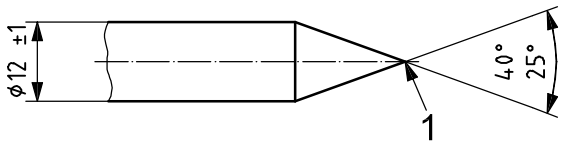
In cases where a 2 m length of the discharge return cable is insufficient (e.g. for tall DUTs), a length not exceeding 3 m may be used and compliance with the waveform specifications shall be guaranteed (e.g. by the manufacturer or from calibration).

6.2 Discharge tips

6.2.1 Contact discharge tip

The discharge electrode for contact mode ESD is shown in Figure 1. The tip is typically made of stainless steel.

Dimensions in millimetres



Key

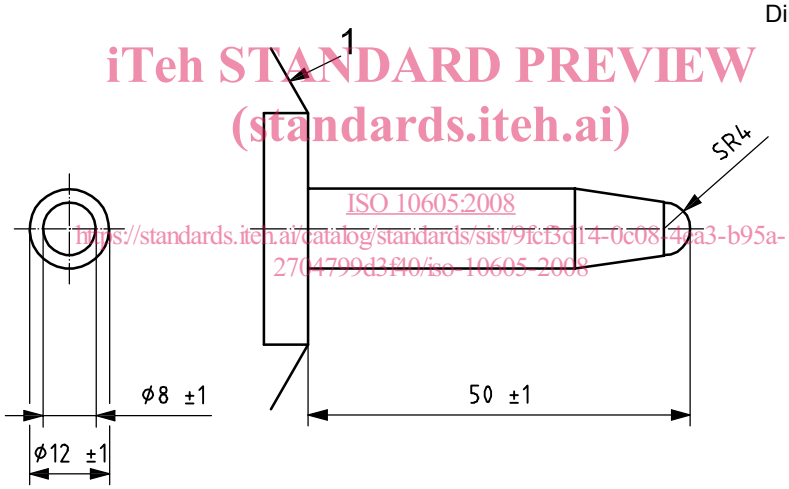
1 sharp point

Figure 1 — Contact discharge mode electrode of the ESD generator

6.2.2 Air discharge tip

The discharge electrode for air discharge mode ESD is shown in Figure 2.

Dimensions in millimetres



Key

1 body of simulator

NOTE For air discharge at test voltages higher than 15 kV, larger electrode tip (e.g. 20 mm to 30 mm diameter) can be used to avoid pre-discharge.

Figure 2 — Air discharge mode electrode of the ESD generator

6.3 Discharge current specifications

6.3.1 Contact discharge mode current specifications

The contact discharge mode currents shall be verified according to Annex A. The contact discharge mode waveform parameters for each discharge network shall be within the value ranges specified in Table 2.

Table 2 — Contact discharge mode current specifications

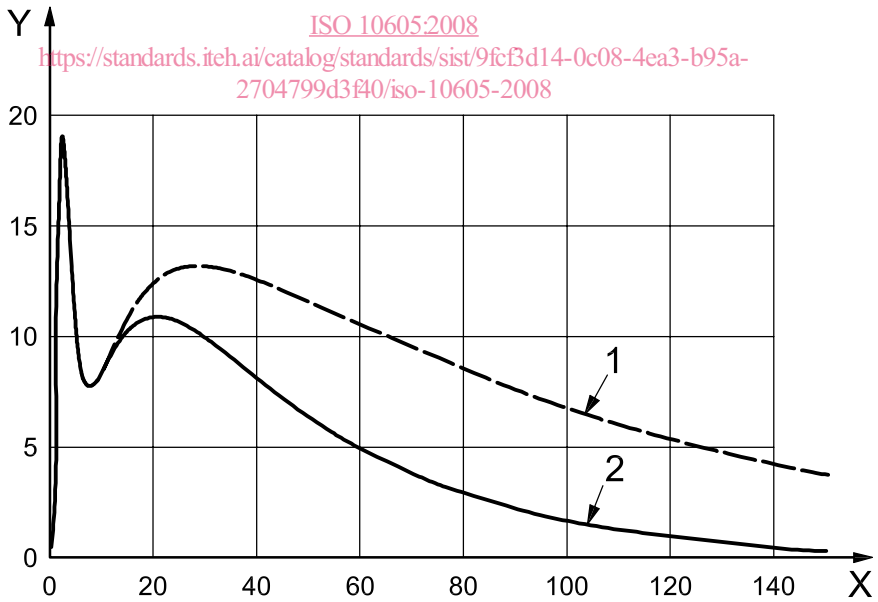
Typical capacitance/ resistance values	Peak current/ charge voltage A/kV	Tolerance %	Current at t_1/ charge voltage A/kV	Tolerance %	Current at t_2/ charge voltage A/kV	Tolerance %
150 pF / 330 Ω	3,75	± 10	2 (at t_1 = 30 ns)	± 30	1 (at t_2 = 60 ns)	± 30
330 pF / 330 Ω	3,75	± 10	2 (at t_1 = 65 ns)	± 30	1 (at t_2 = 130 ns)	± 30
150 pF / 2 000 Ω	3,75	+30 0	0,275 (at t_1 = 180 ns)	± 30	0,15 (at t_2 = 360 ns)	± 50
330 pF / 2 000 Ω	3,75	+30 0	0,275 (at t_1 = 400 ns)	± 30	0,15 (at t_2 = 800 ns)	± 50

NOTE 1 The peak current level is taken from the measurement system without any data interpolation.

NOTE 2 The target used with this measurement system fulfils the requirements of Clauses A.1 and A.2. An example is defined in Annex B.

NOTE 3 The measurement times (30 ns, 60 ns, 65 ns, 130 ns, 180 ns, 360 ns, 400 ns and 800 ns) are derived from the resistance-capacitive (RC) time constant – 40 % (current t_1) and + 20 % (current t_2), to define two values on the falling slope of the current pulse in accordance with IEC 61000-4-2.

Examples of calculated contact discharge waveforms in accordance with the specifications in Table 2 are given in Figures 3 a) and 3 b).

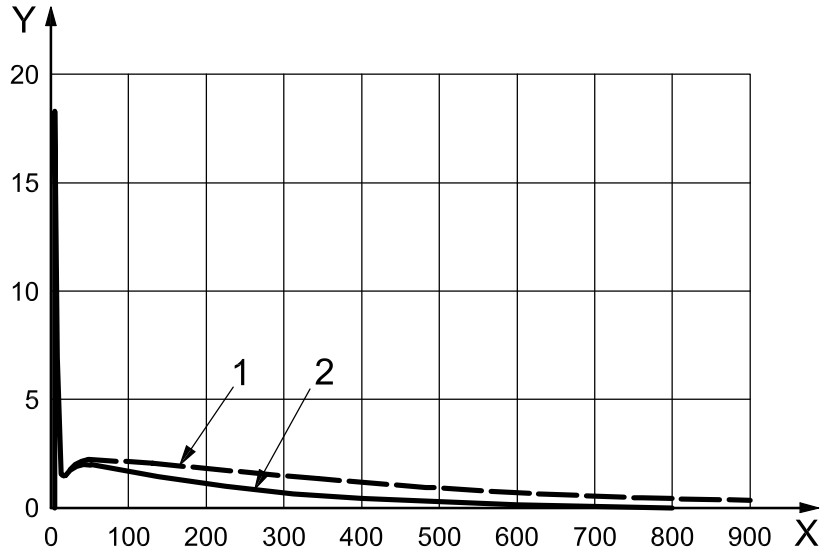


Key

X time, ns
Y current, A
1 330 pF/330 Ω
2 150 pF/330 Ω

a) For 150 pF/330 pF, 330 Ω and 5 kV

Figure 3 *(continued)*



Key

X time, ns
Y current, A
1 330 pF/2 000 Ω
2 150 pF/2 000 Ω

b) For 150 pF/330 pF, 2 kΩ and 5 kV

Figure 3 — Examples of calculated contact discharge waveform of ESD generator

6.3.2 Air discharge mode current specifications

ESD generator verification is only required in contact mode.

NOTE Annex E provides information on possible air discharge generator verification procedures.

6.4 Coupling and ground reference planes

The horizontal coupling plane (HCP) and ground reference plane (GRP), which is placed under the non-conductive table, shall be metallic sheets (e.g. copper, brass or aluminium) and a minimum thickness of 0,25 mm.

NOTE If aluminium is used, care is taken that oxidation does not prevent a good ground connection.

The HCP shall extend the projected geometry of the DUT (the projected geometry of the DUT comprises the cables connected to the DUT) by at least 0,1 m on all sides. The size should be at least 1,6 m × 0,8 m. The height of the HCP above the GRP shall be between 0,7 m and 1,0 m. The GRP on the floor should have at least the dimensions of the HCP.

6.5 Insulation block

Insulation blocks, if used, shall be constructed of clean non-hygroscopic material. The relative permittivity should range between 1 and 5 (e.g. polyethylene). The blocks shall be (50 ± 5) mm in height and extend beyond the test set-up by at least 20 mm on all sides.

6.6 Insulation support

Insulation support, if used, shall be constructed of clean non-hygroscopic material with a relative permittivity between 1 and 5 (e.g. polyethylene). The support shall be between 2 mm and 3 mm in height and project beyond the test set-up by at least 20 mm on all sides. Care shall be taken that support prevents dielectric breakdown up to 25 kV.

7 Discharge modes

7.1 General

Discharges can be applied by two discharge modes: contact and air. See Annex D for guidance on air versus contact discharge modes.

7.2 Contact discharge mode

In contact discharge mode, the tip of the ESD generator's discharge electrode is brought in contact with the DUT before the discharge switch is actuated to apply the discharge.

7.3 Air discharge mode

In air discharge mode, the discharge electrode is charged to the test voltage and then brought with the demanded speed of approach to the DUT, applying the discharge through an arc that happens when the tip approaches close enough to the DUT to break down the dielectric material between the tip and test point.

The speed of approach of the discharge electrode is a critical factor in the rise time and amplitude of the injected current during an air discharge. The speed of approach should be between 0,1 m/s and 0,5 m/s for any test. Because the approach speed is not trivial to measure, in practice the ESD generator should approach the DUT as quickly as possible until the discharge occurs or the discharge tip touches the discharge point without causing damage to the DUT or generator.

8 Component immunity test method (powered-up test)

8.1 General

These tests consist of direct and indirect types of application of discharges to the DUT, as follows:

— direct type discharges (contact or air discharge mode) are applied directly to the DUT and to the remote parts that are accessible by the vehicle users, e.g. switches and buttons (see 8.3);

— indirect type discharges (contact discharge mode) simulate discharges that occur to other conductive objects in the vicinity of the DUT and are applied through an intervening metal, such as an HCP (see 8.4).

NOTE An optional field coupling test with direct discharge test method is described in Annex F.

For the test of electronic modules, the ESD generator shall be configured with the 330 pF or 150 pF capacitor, depending on the DUT location in the vehicle (see 10.1), and the 330 Ω resistor. If the DUT location is not specified, the 330 pF capacitor shall be used.

Conductive surfaces shall be tested using contact mode discharges. For contact discharge, use the contact discharge tip (see Figure 1). Air discharge may also be applied to conductive surfaces, if required in the test plan.

Non-conductive surfaces shall be tested using air mode discharges. For air discharge, use the air discharge tip (see Figure 2).

Before applying any discharges to the DUT, verify that the ESD generator discharge verification procedure, as specified in Annex A, has been performed within the time period established by the laboratory or the customer.

8.2 Test plan

Prior to performing the test, generate a test plan, including the following:

— the detailed test set-up;

— test points;

— electronic module mode of operation;

— any special instructions and changes from the standard test.

8.3 Test procedure for direct discharges

8.3.1 General

Discharges shall be applied to all specified test points with the equipment operating in normal modes. Product response may be affected by the polarity of the discharge. Both polarities of discharge shall be used during testing to determine their effect on the DUT.

NOTE An optional field coupling test with direct discharge test method is described in Annex F.

8.3.2 Test set-up

Place the DUT on the HCP (see Figure 4). Place and connect chassis-mounted electronic modules directly to the HCP. Test electronic modules, which will be isolated from the ground in normal installation with an insulator between the electronic module and the HCP using insulation support (see 6.6).

For testing, the DUT shall be connected to all peripheral units necessary for functional testing. The line lengths used should be between 1,50 m and 2,50 m.

If vehicle intent peripheral units are not available for testing, substitute peripheral units and test discharge points shall be addressed in the test plan.

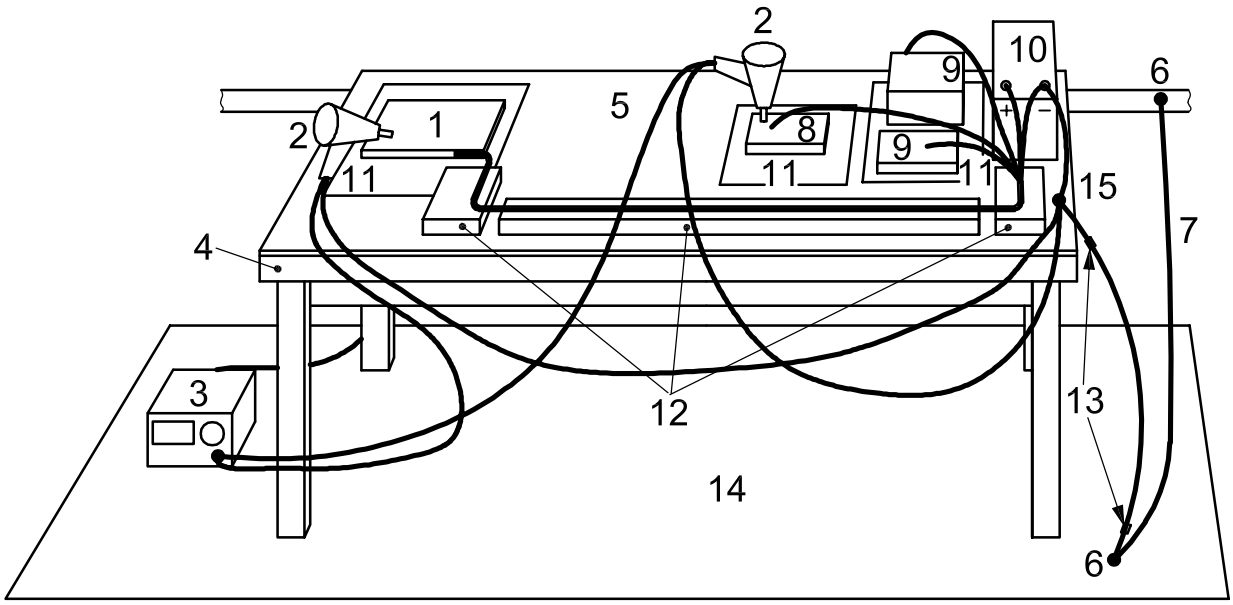
All components on the test table shall be a minimum distance of 0,2 m from each other. The lines shall be laid in such a way that they run parallel to the HCP edges and the plane and, like all components, they shall be a distance of 0,1 m away from the HCP edges. The lines should be bundled and shall be secured on an insulating block, in accordance with 6.5. The wiring type is defined by the actual system application and requirement.

The supply battery shall be on the test table, with the negative terminal of the battery directly connected to the HCP. The explosion hazard of the battery shall be taken into account and appropriate protective measures taken.

For direct discharge, the discharge return cable of the ESD generator shall be connected to the HCP, as shown in Figure 4.

The ESD test bench (test surface) shall be a minimum of 0,1 m from other conductive structures, such as the surfaces of a shielded room.

The same generator discharge return cable to the HCP shall be used for verification and testing. While the discharge is being applied, the discharge return cable of the generator shall be kept at least 0,2 m away from the DUT and all cables connected to the DUT (to reduce coupling from this cable which might affect the test results).



Key

1	DUT	9	periphery
2	ESD generator	10	battery
3	ESD generator main unit	11	isolating support, if required
4	non-conductive table	12	insulating blocks
5	HCP	13	470 kΩ resistors
6	ground point	14	GRP optional
7	ground connection	15	HCP ground connection
8	remotely accessible parts of the DUT		

Figure 4 — Test set-up example for testing powered DUT immunity to direct ESD

8.3.3 Electrode connections for direct discharge method

8.3.3.1 Contact discharge mode

In the case of contact discharges, the tip of the discharge electrode (see Figure 1) shall touch a conducting point on the DUT before the discharge switch is actuated.

Where painted surfaces cover a conducting substrate, the following procedure is used. If the coating is not declared to be an insulating coating by the equipment manufacturer, then the pointed tip of the generator penetrates the coating so as to make contact with the conducting substrate.

8.3.3.2 Air discharge mode

In the case of air discharges, the tip of the discharge electrode (see Figure 2) shall be brought sufficiently close to the DUT as quickly as possible after the discharge switch is actuated (see 7.3).

Where painted surfaces cover a conducting substrate or dielectric surfaces are used as boxes, the following procedure is used. If the coating is declared to be an insulating coating for the dielectric surfaces, then the surface is tested as an insulating surface using the air discharge mode.