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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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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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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).

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For an explanation of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

This third edition cancels and replaces the second edition (ISO 10605:2008), which has been technically revised. It also incorporates the Amendment ISO 10605:2008/Amd 1 2014 and the Technical Corrigendum ISO 10605:2008/Cor 1:2010.

The main changes are as follows:

— introduction of alternative test set-up with field coupling plane for direct and indirect discharges on component (powered-up test);

— minimum number of discharges changed from 50 to 10 for indirect discharge on component (powered-up test);

— interval between successive single discharges changed from 50 ms to 1 s for indirect discharge on component (powered-up test);

— addition of a ground connection for discharges on DUT pins for component packaging and handling test method (unpowered test);

— optional test set-up and procedure for electronic modules (powered-up test) moved from Annex to main body;

— addition of new Annex G.

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

The 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 document 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 document 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.

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

The test for electronic modules on the bench described in this document applies to any DUT (powered by an unshielded power system, DUT powered by a shielded power system, self-powered DUT, etc.).

This document does not apply to pyrotechnic modules.

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

3 Terms and definitions

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

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

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

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

3.1
air discharge
test method characterized by bringing the test generator discharge tip close to the *device under test (DUT)* (3.3); the discharge is by arcing on the DUT

3.2
contact discharge
test method characterized by contact of the test generator discharge tip with the *device under test (DUT)* (3.3), where discharge is initiated by the generator discharge switch

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

3.4
direct discharge
discharge directly on the *device under test (DUT)* (3.3)

3.5
ESD
electrostatic discharge
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* (3.9)

3.7
GP
ground plane
flat conductive *surface* (3.11) whose potential is used as a common reference

Note 1 to entry: The test voltage should 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
human ESD model
network of passive elements and voltage that characterizes a charged person as a source of an *electrostatic discharge* (3.5) for automotive conditions

3.10
indirect discharge
discharge to a coupling plane near the *device under test (DUT)* (3.3)

Note 1 to entry: Discharge current produces a transient field that might affect the DUT. Indirect discharge simulates discharge by a human being on items near the DUT.

3.11
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 %.

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

5 Test location

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[b]	150 pF, 330 pF
Discharge resistances[b]	330 Ω, 2 000 Ω

[a] See examples in Annex C.

[b] Storage capacitance and discharge resistance are nominal values, ESD generator shall meet discharge current specifications in 6.3.

NOTE When an ESD generator is supplied from an external supply source, AC or DC, 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 20 discharges per second down to manual control without any degradation of the discharge current waveform.

The tip voltage should be checked continuously by the generator internal tip voltage supervision.

For contact discharge a grounded discharge resistor with 1 MΩ ±20 % resistance from tip to ground is recommended and prevents pre-pulse-voltage occurrence which can lead to non-reproducible test results; proper fixing of resistor shall not change the current shape.

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).

The ESD generator protective earth terminal shall be terminated to the facility protective earth.

Guidance on automatic operated ESD testing can be found in Annex G.

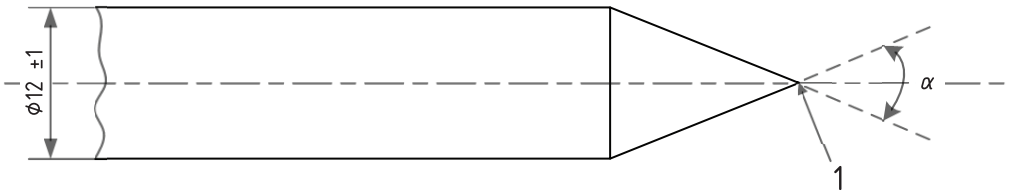
6.2 Discharge tips

6.2.1 Contact discharge tip

The discharge tip for contact mode ESD is shown in Figure 1. The tip is typically made of stainless steel. For contact discharge to pins the discharge tip shape can be varied. The diameter of the tip shall be 12 ± 1 mm. Springs for safe contact and a bending of not more than 90° are possible. The current shape

with modified tip shall comply with the given specification. The angle “alpha” shall be between 25° and 40°.

Dimensions in millimetres



Key

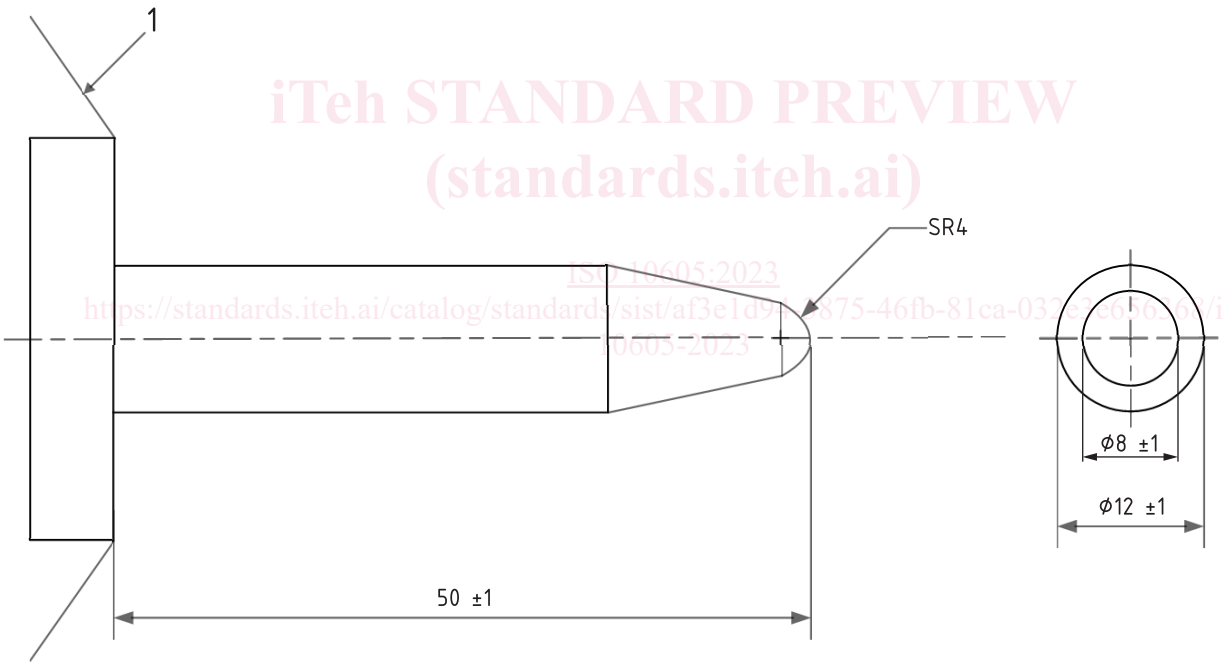
1 sharp point

Figure 1 — Contact discharge tip of the ESD generator

6.2.2 Air discharge tip

The discharge tip 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, a larger tip (e.g. 20 mm to 30 mm diameter) can be used to avoid pre-discharge.

Figure 2 — Air discharge tip 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

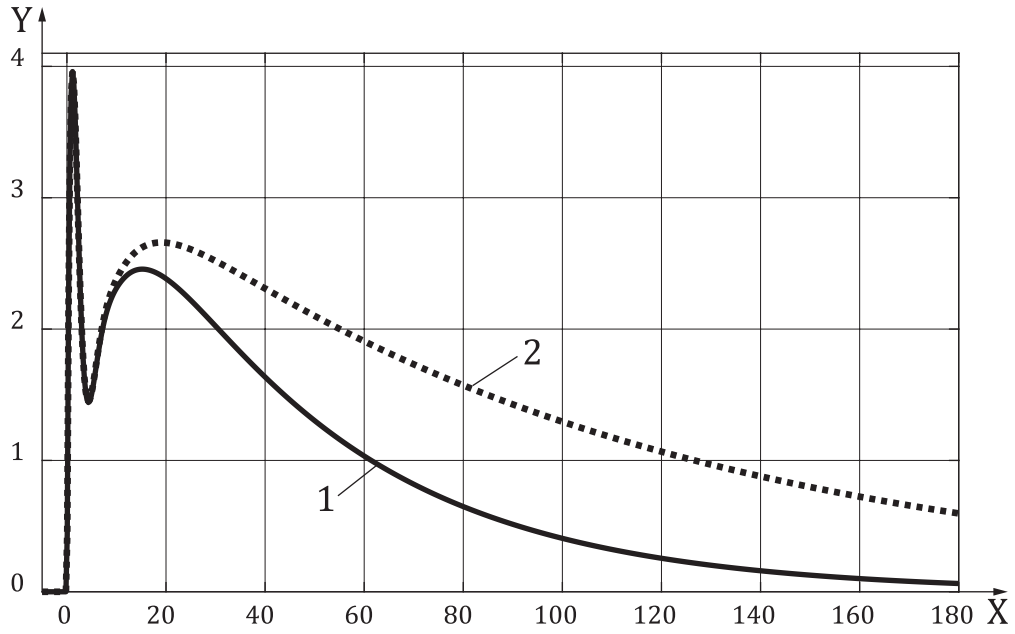
Nominal capacitance/ resistance values	Peak current/ test voltage A/kV	Tolerance %	Current at t_1/ test voltage A/kV	Tolerance %	Current at t_2/ test voltage A/kV	Tolerance %
150 pF / 330 Ω	3,75	±10	2 (at t_1 = 30 ns)	±30	1 (at t_2 = 60 ns)	±30
330 pF / 330 Ω	3,75	±10	2 (at t_1 = 65 ns)	±30	1 (at t_2 = 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.

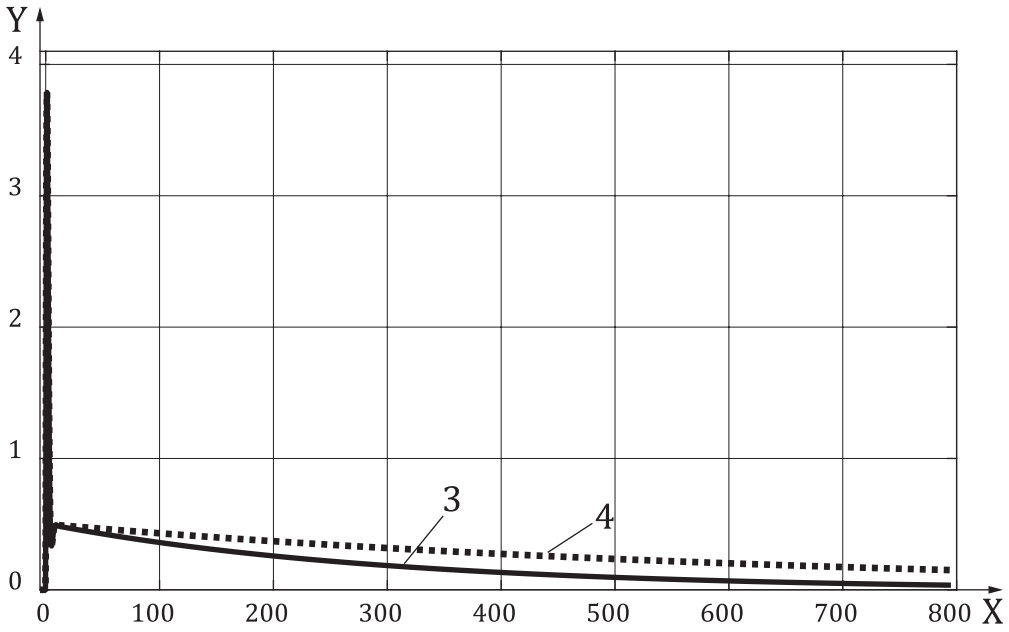
NOTE 2 The target used with this measurement system fulfils the requirements of Clauses A.1 and A.2. An example is defined in Annex B.

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).



a) Calculated contact discharge waveform of ESD generator (for 150 pF / 330 pF, 330 Ω and 1 kV)



Key

X time [ns]

Y current [A]

1 150 pF, 330 Ω

2 330 pF, 330 Ω

3 150 pF, 2 kΩ

4 330 pF, 2 kΩ

b) Calculated contact discharge waveform of ESD generator (for 150 pF/330 pF, 2 kΩ and 1 kV)

Figure 3 — Calculated contact discharge waveform of ESD generator

6.3.2 Air discharge mode current specifications

Information on possible air discharge generator verification procedures is given in Annex E.

6.4 Ground plane

The ground plane (GP) shall be metallic sheets (e.g. copper, brass or aluminium) and have 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 minimum width of the GP shall be 800 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 GP shall be 1 600 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.

In case of very large DUT, the above GP dimensions/shape can be adapted by using a GP extension.

Connection between an already existing GP and a GP extension should have a DC resistance lower or equal to 2,5 mΩ.

6.5 Field coupling plane

Details of the construction of the field coupling plane can be found in Annex F.

6.6 Insulating block

Insulating 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 setup by at least 20 mm on all sides.

6.7 Dissipative mat

Dissipative support from a material which has a surface resistivity between 10^7 Ω per square and 10^9 Ω per square with a height between 2 mm and 3 mm.

6.8 Uncertainty (informative)

Refer to IEC 61000-4-2:2008, Annex E.

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 the case of contact discharges, the discharge tip (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.

7.3 Air discharge mode

In air discharge mode, the discharge tip 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 tip is a critical factor in the rise time and amplitude of the injected current during an air discharge. Because the approach speed is not trivial to measure, in practice the ESD generator should approach the DUT as quickly as possible (e.g. between 0,1 m/s and 0,5 m/s) until the discharge occurs or the discharge tip touches the discharge point without causing mechanical damage to the DUT or generator.

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.

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. surfaces of switches, diagnostic connectors, 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 to GP (see 8.4).

For direct and indirect discharge testing 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 discharge mode. 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 discharge mode. 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.

8.3.2 Test set-up

Two alternative test setups can be used:

— test setup with GP only;

— test setup with GP and field coupling plane.

The test set-up to be used shall be defined in the test plan.

8.3.2.1 Test set-up with GP only

Place the DUT on the GP (see Figure 4). Chassis-mounted DUTs shall be placed on and directly connected to the GP. DUTs that are not chassis-mounted shall be placed with an insulating block between the DUT and the GP (see 6.5).

For testing, the DUT shall be connected to all peripheral devices (e.g. load simulator, AN(s), power supply, battery) necessary for functional testing. The test harness shall be $1\,700\binom{+300}{0}$ mm long (or as agreed upon the test plan).

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

All components on the test table shall be a minimum distance of 200 mm from each other. The lines shall be laid in such a way that they run parallel to the GP edges and the plane and, like all components, they shall be a distance of 100 mm ± 10 mm away from the GP 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.

Unless otherwise specified, the load simulator and remotely accessible part of DUT shall be placed on an insulating block.

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

The ESD test bench (test surface) shall be a minimum of 100 mm from other conductive structures, such as the surfaces of a shielded room.

The same generator discharge return cable to the GP 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 200 mm away from the DUT and all cables connected to the DUT (to reduce coupling from this cable which might affect the test results).