COSINUS MESSTECHNIK GMBH

A Practical Guide for erection and operation of electrical test equipment According to EN 50191

Introduction

Testing of the electrical devices during the production process is one of the fields in the more general electrical equipment testing. It requires special attention to the operator's safety. Test procedures require application of very high and dangerous test voltages, which cause heightened probability of electric shock.

There are numerous types of electrical equipment that need to be inspected and tested during the manufacturing process. Metrel has developed a special model MI 3394 CE MultiTesterXS machine safety tester. With its safety modules and optional accessories it conforms to the European Standard EN 50191: Erection and operation of electrical test equipment.

This guide covers a basic introduction to electrical safety and an overview of the EN 50191 standard. The test diagrams presented are designed as a guideline for people involved in testing on production lines equipped with the CE MultiTesterXS.

The guide itself cannot replace the standard EN 50191 which was used as a reference for preparation of this booklet. For clarification on any part of this guide, contact Metrel d.d. This document is intended as help when setting up work stations for testing electrical equipment safety. The standard EN 50191 should be considered wherever dangerous voltages, current, residual charges and other hazards can occur in the working place.

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1. Working places according to EN 50191

1.1. Scope of this document

This document is intended as a help when making work stations for testing safety of electrical equipment. If dangerous voltages, currents, residual charges and other hazard can occur in the work place the standard **EN 50191: Erection and operation of electrical test equipment** should be considered.

Warning:
This document is additional help with understanding the standard. It shall not be used as a substitute for the standard or other required documents. It does not reflect all points covered in EN 50191.

1.1.1 WHEN TO CONSIDER THE EN 50191?

The standard EN 50191 is applicable to erection and operation of fixed and temporary electrical installation. This application guide focuses on production lines and related testing stations:

- Test stations in operation in production lines, with or without automatic protection against direct contact.
- Test laboratories and experimental stations.
- Temporary test stations.
- Test stations without personnel in permanent attendance.
- Test stations with additional requirements when using safety test probes.

The EN 50191 shall be considered if dangerous voltages can appear on live parts on the work place. The limits are following:

- Voltage is higher than 25 Va.c. (up to 500 Hz) or 60 V d.c .
- The touch current is higher than 3 mA a.c. (up to 500 Hz)or 12 mA d.c.
- The discharging energy is higher than 350 mJ.

Appendix A (Table A.1) in EN 50191 should be considered for frequencies above 500 Hz. Other risks should also be considered: possible dangers due to electric arcs, explosion, fire, formation of gases, etc. The risk is much higher where high voltages are involved in the testing, which is why the standard includes additional demands for voltages exceeding 1000 V.

Many Metrel test instruments generate high test voltages. We strongly recommend that all users are familiar with requirements of EN 50191. For any questions regarding the safety of working places they can contact Metrel d.d. or local distributors.

1.1.2 GERMAN BGI 891

BGI 891 is a German guideline for erection and operation of electrical test installations. The guideline refers to EN 50191 (VDE 0104) and explains it in detail. Additionally the guideline makes recommendations outside of the scope of EN 50191. For example, it advises (see chapter 3.1) conformance to standards for safety of machines (use of risk assessment, safety components, control circuits, safety categories, etc.) for all workplaces.

1.1.3. CONDITIONS WHERE CONFORMING TO EN 50191 IS NOT REQUIRED

EN 50191 states that compliance is not necessary if contact with live parts of the work place presents no danger. This is true under one of the following conditions at live exposed points:

a) The voltage at frequencies above 500 Hz does not exceed 25 V a.c. or 60 V d.c. and complies with the requirements for SELV or for PELV in accordance with HD 60364-4-41.

b) In case of voltages at frequencies up to 500 Hz that exceed 25 V a.c. or 60 V d.c., the resultant current through a non-inductive resistance of 2 kΩ does not exceed 3 mA a.c. (r.m.s.) or 12 mA d.c.

c) At frequencies above 500 Hz, the nationally determined current and voltage values shall be applied. If there are no national requirements determined, reference values for permissible body currents and contact voltages will be taken from Table A.1.

d) The discharge energy does not exceed 350 mJ.

1.2. General protective measures in test installations

In this chapter the key elements of protection in test installations are described.

1.2.1. PROTECTION AGAINST DIRECT CONTACT

Protection against direct contact is the essential and the most important protective measure. It can be made by:

- **insulation of live parts** everywhere in the installation (on test object, test equipment and test connections).
- Assuring **safe distances** to live parts with barriers, covers, enclosures, obstacles etc.
- Using **two hand control** devices that comply with EN 574.
- Using **two safety test probes**. Clamping devices are not allowed.

1.2.2.PROTECTION AGAINST INDIRECT CONTACT (FAULT PROTECTION)

This is the protection against electric contact with exposed conductive parts which can rise to a dangerous voltage under fault conditions. It is usually provided by:

- **earthing,**
- **double or reinforced insulation,**
- **protection by automatic disconnection, use of protective components** like RCDs,
- **use of isolating transformers** (acc. to EN 61558) for supplying the test equipment.

The tested object must be isolated from earth. If this is not possible, potential dangers (touch voltage, touch current) due voltages transfers must be taken in account. Test benches must be made from insulating materials.

1.2.3.PROHIBITION ZONE

Prohibition zone is the space around live parts which must not be breached. For voltages ≤ 1 kV the boundary of the prohibition zone is the surface of live parts.

For higher voltages a certain distance needs to be added. At 6 kV a.c., the highest voltage to be considered for CE MultiTesterXS MI 3394, the prohibition zone is 35 mm. Size of prohibition zone and dependency on test and impulse voltages are specified in Annex A (Table A.2) of EN 50191

1.2.4. USE OF BARRIERS

Barriers Barriers are used to separate the test

area from other work areas.
Their purpose is to prevent people other than the test personnel from:

- accessing to the test area,
- reaching the prohibition zone,
- reaching the operating devices inside the test area.

The minimum space the barriers provide are defined in Annex A (Table A.3 and Table A.4) of EN 50191. If barriers are conductive, they must be earthed or otherwise protected against indirect contact in case of fault.

1.2.5. USE OF INDICATOR LIGHTS, SIGNAL LIGHTS, WARNING SIGNS

Indicators, lights, or signs on the control panels inside the test area should indicate the switching status (indicator lights) and the operating status . Indicator lights must be clearly visible to the test personnel. Signal lights must be clearly visible to people outside the test area. Test installation and test area shall be indicated by means of warning signs.

See chapter 2 for definitions of types of test installations, test area, etc.

1.2.6. EMERGENCY SWITCH-OFF

The emergency switch-off devices immediately cut off all electrical energy that is causing danger. An adequate number of devices inside and outside of test area should be installed. Emergency stop devices must comply with EN 418. For further information and exceptions see EN 50191, chapter 4.1.3, 4.2.4.

1.2.7. PREVENTING UNAUTHORIZED OR UNINTENDED SWITCHING ON AND AUTOMATIC REENERGIZING

Test circuits in the test installation shall be secured against unintentional and unauthorized switching on. This can be provided by barriers, obstacles, locks, etc. Automatic reenergizing of test circuits after a recovery of mains voltage must not be possible. This can be achieved with a start switch.

1.2.8. PROTECTION AGAINST RESIDUAL VOLTAGES AND TRANSFER OF VOLTAGES

Residual voltages are the voltages caused by the test installation staying charged after the test. In this case safe discharge of energy must be provided. Any possibility of voltage transferring to accessible parts outside the test area must be considered and prevented by earthing, equipotential bonding, short circuiting, use of isolating materials, protection measures inside test instruments, etc.

Metrel test equipment includes different means of protection for the user against transfer of voltages even in case of a fault. For example, a transfer of voltage will occur if the same test points are used for both HV and insulation test (for example L,N – PE). During the HV test, high voltage will be distributed from the leads for insulation test to the other outputs of switches and instruments.

1.2.9. PROTECTION AGAINST OTHER HAZARDS

Other hazards should be considered. Examples include arcing, moving parts, fire, noise, etc.

2. Types of test installations

2.1. Test installation

The test installation is the combination of all test devices, appliances and facilities necessary for testing. When designing a new work place the type of test installations needs to be defined.

A test installation can be performed as:

- **Test station with automatic protection against direct contact.**
  This type is common on serial production lines, and is also preferred in workshops, repair and service shops.

- **Test station without automatic protection against direct contact.**
  This type is common in workshops or laboratories. The test station is an appropriately identified test installation within a defined area where normally only one test person is working.

- **Test laboratory or experimental station.**
  This type is common in research and development work. They are not intended for performing routine tests.

- **Temporary test station.**
  This type is common for performing tests on individual test objects or in case the testing places and configurations need to change for different tests.

2.2. Test station with automatic protection against direct contact

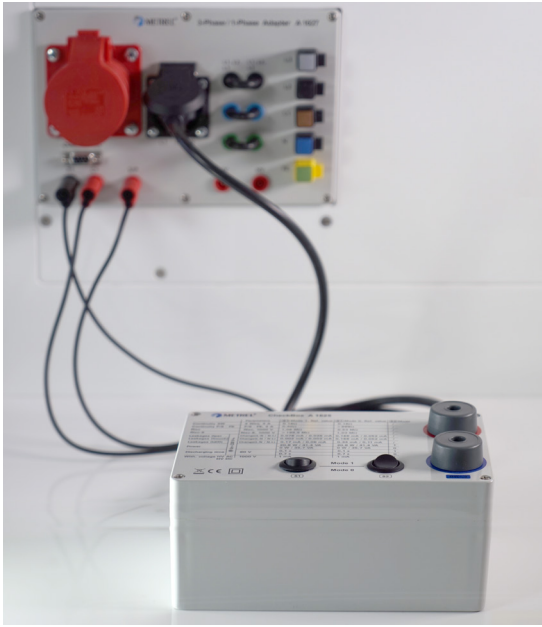
This is the preferred test installation type. Test station with automatic protection against direct contact is the preferred choice when setting up a work place. There are very few justified reasons to choose a different type and they are collected in in EN 50191, chapter 4.3.1. Mainly different types are chosen where automatic protection against direct contact is not possible or economical.

2.2.1. ARRANGEMENT OF AUTOMATIC PROTECTION AGAINST DIRECT CONTACT

Protection grade of IP3X or higher
Appropriate isolation (achieved with barriers, covers, and test cages) that prevents contact with the live parts shall be provided. The protection rating should be at least IP3X. This level requires that an object with diameter > 2.5 mm should not penetrate into the place. There are no special requirements regarding ingress of liquid and dust. Test cages are a typical solution.

Controlled activation of test signals
- It shall not be possible to switch test signals on until the protective measures are in effect and operation. Protective measures include isolations, covers, locks, control components and devices.
- Activation of a protective measure must immediately disconnect the test voltage.
- Any dangerous residual voltages on active parts after activation of protection the voltages must fall below the safety limits before the parts can be touched.

Operation in case of a single fault
Single fault is a condition where a single protection measure or a single component or a device does not work as intended.
- The protective measures in a test installation must stay effective (for example no hazardous voltage on accessible parts, disconnection of supply in due time).
- It shall not be possible to switch the test voltage on again after a failure.
- Protective measures must be designed to be tamper and bypass resistant.



Comments in BGI 891 (chapter 3.2.6)
According to EN 50191, one still effective protective measure in case of a single fault is enough to protect against indirect contact. For the test and measuring equipment, protection in case of a single fault must be guaranteed by design (with CE declaration - LVD, IEC/ EN 61010).

However one protection in case of a single fault does not provide 100% safety.
If another fault occurs, or in case of a combined fault, there is still a possibility of a dangerous electric shock.

It is possible to make test installations with a higher degrees of protection. For example, in Machine safety, effective protection even in case of a combination of multiple single faults is categorized in standards (as Category 4, PLe, SIL3). The safety level of machines was formerly described with categories (up to 4, standard EN 954-1). More recently the level of safety is categorized with SIL (EN 62061) or PL levels (ISO 13849-1). Compliance with EN 50191 is comparable to former category 3 at the minimum. BGI 891 recommends considering category 4 since the investment is usually not much higher.

Common design principles for achieving high safety categories:

- Redundancy of safety components (switches, relays, contactors, etc.)
  For example, two relays are used in series. If one fails, the other still guarantees protection.
- Monitoring, feedback information
  Safety relays share information about the state of the working contacts via an additional control contact. If the working contacts reach a fault or an unacceptable state this can be immediately detected by monitoring the control contact. The combination of redundancy and feedback principles can result in the highest level of safety.

Safety components, devices and control systems developed for functional safety of machines can be used in test installations as well.

BGI 891 states that in case of a single fault the protection must remain functional. This fact determines the basic level of safety in the testing system.

Category 3 of machine safety is comparable to the safety of test installation with automatic protection against direct contact. Category 4 provides even higher safety level at low additional cost and is the more recommended.

It is strongly recommended to consider the 'machine safety' approach also when designing work places for electrical testing.

2.2.2. ALLOWABLE ALTERNATIVES – WHEN IP3X CAN BE OMITTED

Sometimes the IP3X protection is difficult to achieve or too complicated for the application. A typical example is testing of large electrical equipment.

Light barriers
At the operation side, a light barrier with a

distance between beams not more than 14 mm can be used instead of the enclosure. Safety distance between the prohibition zone and detection zone, approach (breaching) speed and respond times of the protection/ switching devices must be considered. Instructions for calculation can be found in EN 999 Safety of machinery - the positioning of protective equipment in respect of approach speeds of parts of the human body.

Solid walls or grids
Barrier with height of least 1.8m (with mesh size < 40 mm or solid wall) must be placed as a barrier to the prohibition zone. Distances are given in EN 50191, tables A.2, A.3 and A.4. Access doors must be locked until the test voltage has been switched off and secured against switching on again. Consider additional protective measures like earthing or shorting are necessary.

Live parts are already protected
All live parts (including inside test objects) are fully protected against direct contact and measures for protection against indirect contact are effective for the complete testing setup (test object + installation), for example an RCD (see example BGI 891, chapter 3.2.8).

2.2.3. OTHER POSSIBLE OMISSIONS

Barriers that prevents access to the test station and emergency switching off devices may be omitted - no need to separate the test area from others, EN 50191, chapter 4.2.4.

This kind of protection is intrinsically less safe. It should be used only if the automatic protection against direct contact is not applicable.

Typical situations are:
- frequently changing the test duties.
- frequently changing the type of test objects,
- very complicated test sequence,
- only occasional use.

Not using the safer option with automatic protection must be carefully evaluated and justified!

2.3. Test station without automatic protection against direct contact

2.3.1. ARRANGEMENTS FOR TEST STATIONS WITHOUT PROTECTION AGAINST DIRECT CONTACT

Protective measures

- Use of protective measures as defined in chapter General protective measures in test installations (test pistols, two hand devices, etc.).
- Permanent audio and visual contact with the operator. Auditory and visual contact with the operator from outside of the test area must be possible all the time. This means that at least one second person must be present. For more information, see BGI 891 chapter 4.4.4.

Signal lights

Red (always obligatory) and green (obligatory where U > 1kV) signal lights shall be installed to indicate the operational status inside the test area – they must be clearly visible from outside the test area.

Effective fault protection

Effective fault protection measures must be incorporated for all electrical test equipment and the test objects. Supplying equipment using isolating transformers is preferred.

Permitted exceptions

For some exceptions, see EN 50191 chapter 4.3.8

Separation of test area from other areas by barriers

The separation must prevent access to persons other than the test personnel to the test area, prohibition zone and operating instruments in the test area. Minimum distances are given in EN 50191, Tables A. 2, A. 3, A. 4. Barriers can be walls, ropes, grids, chains, bars (national regulations to be considered). If the barriers are made of conductive materials, measures for protection against indirect contact should be considered.

Emergency switch off

At least one emergency stop device must be installed outside the test area and be easy accessible.

RCD protection

If any test circuits or the instrument are

electrically connected to the mains supply, RCD protection must be installed. The RCD shall have IdN ≤ 30 mA and appropriate sensitivity (a.c., pulsed a.c., d.c.).

Movement inside the test area
Movement of test personnel inside the test area must be unimpeded. BGI 891 recommends the area free from obstacles should be ≥ 1.50 m2 in size and at least 1 m wide at all points.

2.4. Test Laboratories and experimental stations

A test laboratory is a test installation with one or more test stations that is securely enclosed or separated from other work areas. In the test laboratories generally several people are employed, working on larger test objects and remaining there for longer periods of time.

An experimental station is a test installation with one or more test stations for performing experiments in scope of R&D. No routine tests are normally performed.

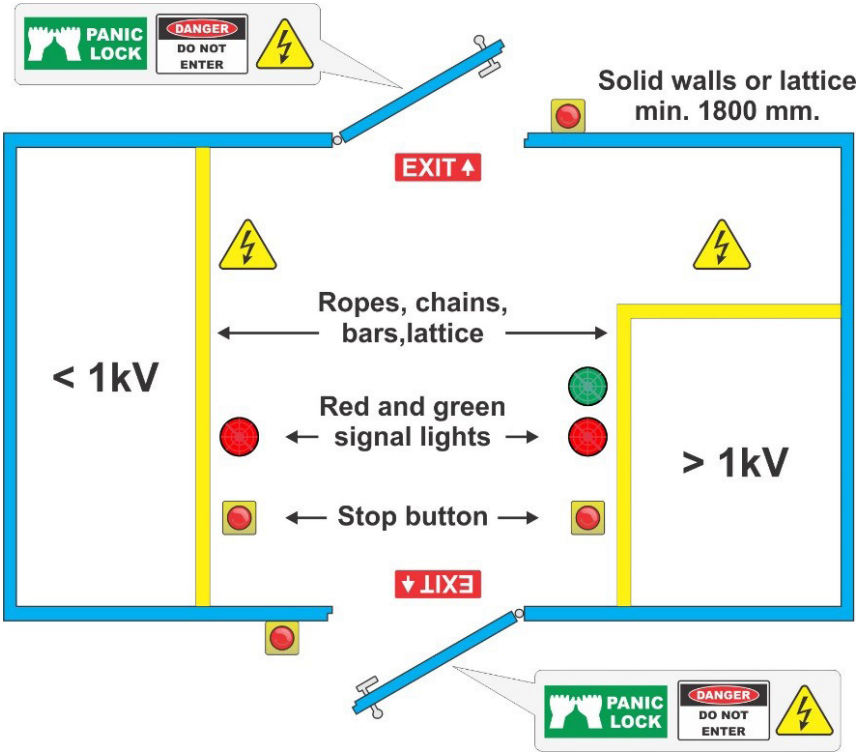
2.4.1. ARRANGEMENTS

Barriers

For tests when U≥ 1 kV barriers must be at least a 1.8m high solid walls or grids, see EN 50191 Table A. 4. For tests when U ≤ 1kV barriers can be simpler: tapes, ropes, chains, or similar can be used, fixed in a height between 1 m and 1.4 m. Warning sign Not access for unauthorized persons shall be placed.

Entries

Unauthorized entry into the test laboratory must be prevented by door locks.
There must be nothing to hinder people from leaving the test laboratory (use of 'panic locks').



Test Laboratory with two test stations.

National regulations on escape routes and emergency exits must be considered.

Signal lights

- **Test areas**
  Red (always) and green (if U > 1kV) signal lights must be installed to indicate the operational status of each test area and must be clearly visible from outside the test area.
- **Entire laboratory**
  Red signal lights shall indicate danger for the entire test laboratory whenever the 'red operational status' exists in at least one of the individual test area.

Other

If Utest > 1 kV, devices and means for earthing must be available (acc. to EN 50110-1 and EN 61219). All affected areas, including those outside the test area where capacitive charging could take place, must be separated by additional barriers during the testing. Barriers can bewalls, grids, tapes, ropes etc. Entrance should be marked with a warning sign ***'No unauthorized persons beyond this point'.*** This is to prevent access of unauthorized persons to the test area.

2.5. Temporary test installations

A temporary test installation is a test installation with one or more test stations erected for a short time to test individual test objects. Unauthorised persons must be prevented from access to temporary test areas by means of walls, grids, ropes, chains, bars or similar barriers. Entrances must be provided with a warning sign

'No unauthorised persons beyond this point'.

If devices with Utest > 1 kV are used, a means for earthing must be available (acc. to EN 50110-1 and EN 61219) and all areas, including those outside the test area where capacitive charging could take place, must be separated by additional barriers during the testing.

Red (always) and green (if U > 1kV) signal lights must be installed to indicate the operational status inside the test area and they must be clearly visible from outside the test area.

2.6. Test station without test personnel in permanent attendance

This type of test station is intended for operation without permanent presence of the test personnel. Examples include endurance or ageing tests. This type of test station shall be erected in compliance:

- With requirements for test stations with automatic protection against direct contact.
- Or with requirements for test laboratories.

Emergency stop equipment with an adequate number of manual controls must be provided in accordance with requirements of EN ISO 13850:2008. Prevention of automatic energising may be omitted, provided that this will not cause any hazards.

3. Operation of test installations – further requirements

3.1. Responsibilities, checking and documentation

Generally, test installations may only be operated under the control of a skilled person.

This does not apply for test stations with automatic protection against direct contact. See EN 50191, 4.2.1 and 4.2.2.

- Test installation must have operating instructions with information for safe operation.
- Before use, the test installation must be visually inspected. If there are any signs of damage or defects it must not be operated.
- Proper condition and efficiency of safety devices must be maintained and tested at regular periods. It must be done by a skilled person.

In BGI 891 (chapter 4.1.1) the term responsibility is further explained. The skilled person supervises selected parts of testing. Supervision of operation does not necessarily mean permanent presence at the location. The skilled person decides about the supervision based on skills of the instructed personnel, voltage magnitude, possible other hazards and similar criteria. Supervision can mean anything from occasional check-ups to permanent presence at the test station.

3.2. Personnel

- A **skilled person** is a person with relevant education and experience to enable them to avoid possible hazards.
- An **instructed person** is a person adequately advised by a skilled person to enable them to avoid possible dangers.
- A **nominated person** is in control of work activity and is the person who directly manages and takes responsibility for the work activity. Parts of this responsibility can be delegated.

Only skilled or instructed persons may work with test installations.

All personnel involved must be appropriately instructed about the safety requirements. The instruction must be repeated at least once per year.

Written records of the training must be kept.

Personnel using safety test probes shall receive additional training regarding specific risks involved. Personnel working in test laboratories, experimental stations and temporary test stations can only work under the supervision of a nominated person in control of the work activities.

Test areas must be entered only by personnel employed there or by other adequately instructed persons. Other persons shall be accompanied by a skilled person. If Utest > 1kV, the permission of the nominated person is required.

Any person working in test laboratories, experimental stations and areas with temporary test stations must be fully aware of the hazards and has the duty to take appropriate safety precautions to protect himself and others.

3.2.1 PREPARATIONS FOR TESTING AND SWITCHING OPERATIONS

Precautions shall be taken in case the enclosure of the test equipment can be exposed to dangerous voltage. Examples of protective measures include external isolation or earthing. Test probes and leads must be visually checked before starting work.

3.2.2. RESPONSIBILITIES OF THE NOMINATED PERSON

Responsibility of the nominated person is to supervise the work activity before the test installation is switched on (≤ 1kV) or ready for operation (≥1 kV).:

- The nominated person checks the instructions are followed, order for operation to begin and that unauthorized people have left the test area, etc.
- Once testing is finished, the 'out of operation' state must be established. For more information see EN 50191, chapters 5.3.6 to 5.3.8.

3.3. Performing the tests

3.3.1. EXCEPTIONAL CASES

In general assembly work and testing should not be carried out at the same time. In exceptional cases work activities have to be carried out during the 'ready to switch' or 'in operation' phase. Special attention is required in such cases. Activities must comply with EN 50110-1 ('The 5 safety rules!'). For more information see EN 50191, chapters 5.4.1 to 5.4.3.

3.3.2. SURVEILLANCE IN TEST STATIONS WITHOUT AUTOMATIC PROTECTION AGAINST DIRECT CONTACT

In a test station without automatic protection against direct contact during the 'ready to switch on' and 'in operation' phases, another person should be present in visual and auditory contact. They must be on high alert to immediately perform emergency switch off in case of danger.

3.3.3. SURVEILLANCE IN TEMPORARY TEST STATIONS

For temporary test stations additional surveillance may be needed, see EN 50191, 5.4.5.

3.3.4. OTHER

Before touching test objects after the test has been switched off, it shall be ensured that no dangerous voltage is still present on accessible parts – can be prevented by earthing and short circuiting.

Emergency routes should be kept clear.

4. Erection and performance of test installations

4.1.Operational statuses of test installation

In the table, the functions of protection devices, protective measures and signalling devices in different operation modes are shown.

	Entries to test area	Signal lights	Signal lights	Power to test installation	Power to signalling / control circuits	Power to test voltage
		>1 kV	<1 kV			
Out of operation	allowed	○	○	Off	–	–
Ready for operation**	allowed	●	○	On	On	Off
Ready to switch on**	prohibited	●	●	On	On	Off
In operation	prohibited	●	●	On	On	On

	Preventive protective measures earthing, short circuiting	Secured against Unauthorized On	Secured against Unitended On
	>1 kV		
Out of operation	activated*	On	On
Ready for operation	activated*		On
Ready to switch on	deactivated		
In operation	deactivated		

* if neccessary, also before entering the test area

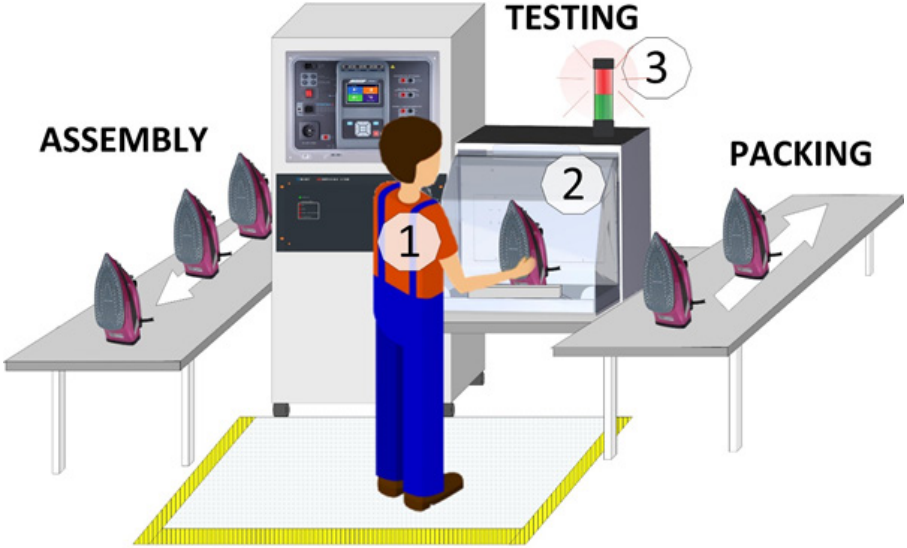
** the technical devices for setting up this operational status are only required for certain test installations exceeding 1 kV

4.2. Test station with automatic protection against direct contact

1 Electrically skilled or electrically instructed person

2 Test cage with integrated safety module for automatic disconnection of test voltage if opened.

3 Control lights can be placed inside test area. They indicate the status of the test panel. Due to automatic protection against direct contact, barriers and emergency devices can be omitted.



Test station with automatic protection against direct contact

4.3. Test station without automatic protection against direct contact

1 Electrically skilled or electrically instructed person.

2 Operator has visual and auditory contact with people outside the test area.

3 Barriers to prevent third persons from access to the test area.

4 Use of two hand devices to prevent operator from breaching the prohibition zone.

5 Test object is placed on insulating material during test

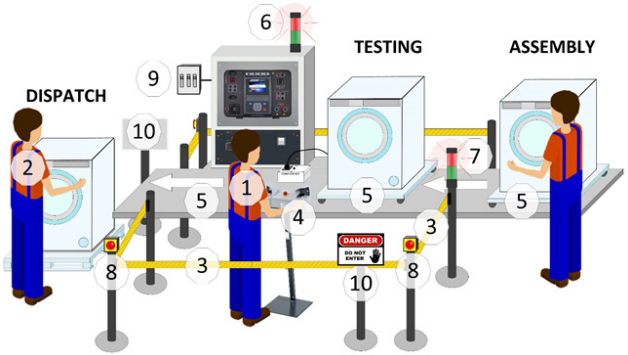
6 Control lights indicating operation status on test panel inside test area.

7 Signal lights outside test area indicating operational status of the test station.

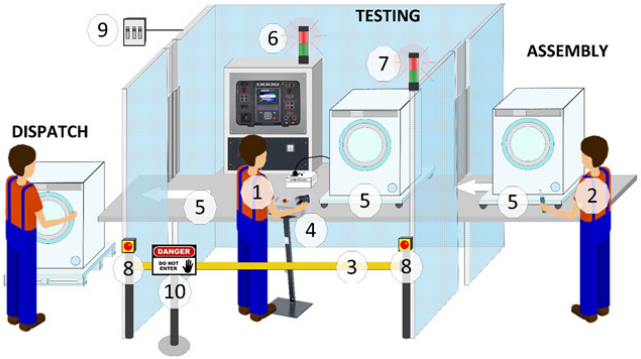
8 Emergency power switch off outside the test area (optionally inside test area too).

9 RCD protection of the test installation.

10 Warning signs.



Test station without automatic protection Example I.



Test station without automatic protection Example II.

4.4. Test Laboratory

1 Electrically skilled or electrically instructed person.

2 Test stations with solid wall barriers.

3 Test tables made from insulating material.

4 Signal lights outside test area indicating operational status of individual test stations and overall status of the laboratory.

5 Control lights indicating the switching status on a test panel inside the test area.

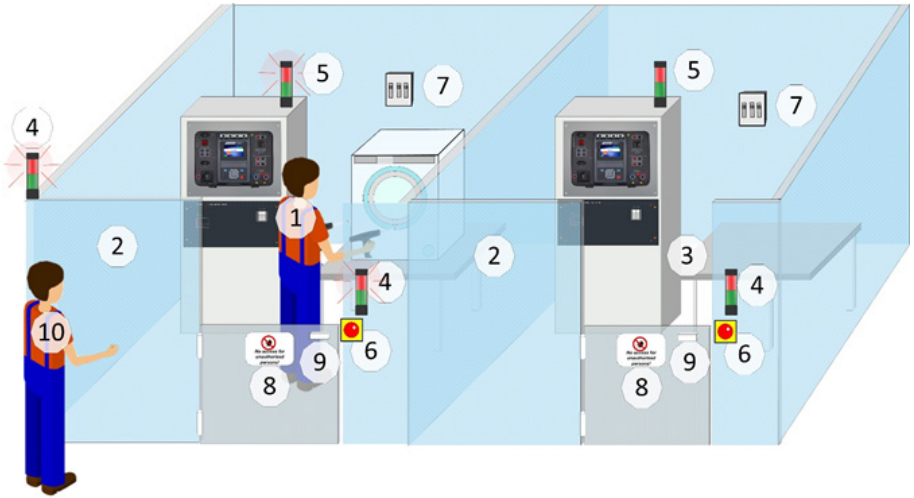
6 Emergency power switch off outside test area (optionally inside test area too).

7 RCD protection of the test stations.

8 Warning signs.

9 Panic locks.

10 Operators have visual and auditory contact with people outside the test area.



Test laboratory

4.5. Temporary test station

1 Electrically skilled or electrically instructed person.

2 Test station separated by barriers.

3 Test tables made from insulating material.

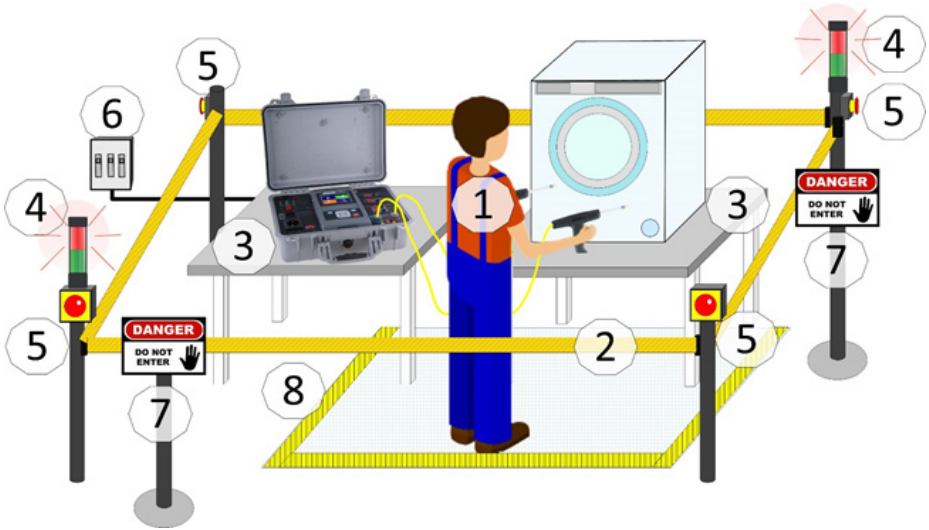
4 Signal lights outside test area indicating operational status of individual test stations.

5 Emergency power switch off outside test area (optionally inside test area too).

6 RCD protection of the test stations.

7 Warning signs.

8 Operator has visual and auditory contact with people outside the test area.



Temporary test station

Appendix A

Permissible body current and contact voltages

Table 1 contains reference values for permissible sinusoidal body currents and contact voltages at frequencies above 500 Hz which are considered harmless for permanent exposure. If it is guaranteed that these values cannot be exceeded, measures in accordance with EN 50191 are not required. The permissible values in this table are the maximum permitted values under normal and dry conditions.

For values for frequencies above 3.8 kHz see Table A.1 in this European Standard are not required (1.2 c).

Frequency (f)	Permissable body current (mA)	Permissable contact voltage (V)
500 Hz ≤ f ≤ 2 kHz	1,75. (f / kHz) + 3,3	25
2 kHz ≤ f ≤ 3,8 kHz	1,4. (f / kHz) + 4,2	25

Prohibition zone and test area

The prohibition zone is the distance around live parts which must not be breached or reached. For alternating voltages above 10 kV, lightning impulse voltages above 100 kV, and switching impulse voltages above 900 kV see Table A.2 of EN 50191. For alternating voltages >10 kV, see Table A.2, of EN 50191.

For 6 kV a.c. (highest voltage to be considered for CE MultiTesterXS MI 3394) prohibition zone is 35 mm.

Alternating test voltage 50/60 Hz (r.m.s. value)		Lightning impulse voltage 1,2/50 µs (peak value)		Switching impulse voltage 250/2 500 µs (peak value)	
U	S[a]	U	S	U	S
kV	mm	kV	mm	kV	mm
≤ 1	No contact	20	100	500	2000
3	20	40	175	600	2600
5	30	60	250	700	3300
6	**35**	80	325	800	4100
10	60	100	400	900	4900

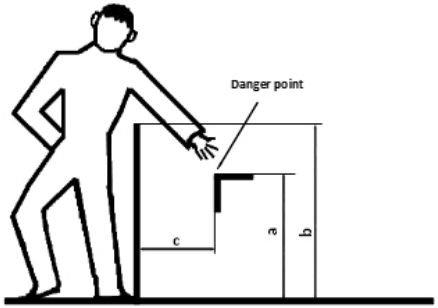
Intermediate values may be obtained by interpolation; however, linear extrapolation beyond the highest specified values is not permissible.

For d.c. test voltages up to 1 000 kV the distance s shall comply with the value for lightning impulse voltages.
The table is not applicable to high-frequency voltages or any voltages other than those specified.
a s is the distance in air from live parts.

Horizontal distance between the barrier and the prohibition zone

The values are given as ratio between the height of the barrier and the distance to the point of danger from the floor (Table A.3.). Point of danger is the point on the boundary of the prohibition zone closest to the edge of the means of protection.

a- Distance between the point of danger and the floor.
b- Height of the edge of the means of protection.
c- Horizontal distance between the edge of the means of protection and the point of danger.



Distance of the danger point from the floor, **a** (mm)	Height of the edge of the means of protection (barrier) **b** (mm)							
	1000	1200	1400	1600	1800	2000	2200	2400
	Horizontal distance **c** between means of protection (barrier) and the danger point, (mm)							
2 400	100	100	100	100	100	100	100	100
2 200	600	600	500	500	400	350	250	
2 000	1 100	900	700	600	500	350		
1 800	1 100	1 000	900	900	600			
1 600	1 300	1 000	900	900	500			
1 400	1 300	1 000	900	800	100			
1 200	1 400	1 000	900	500				
1 000	1 400	1 000	900	300				
800	1 300	900	600					
600	1 200	500						
400	1 200	300						
200	1 100	200						

Values below 1 000 mm for edge b are not specified as this would not increase the arm's reach and in addition there would be a risk of falling into the test area.
Barriers, e. g. tapes, ropes, chains or bars, shall be fixed between 1 000 mm and 1 400 mm distance from the floor. The minimum distance to the floor (sag) shall not drop below 800 mm.

Minimum distance between openings in the barrier and the prohibition zone in relation to the width of the opening

Width of opening (diameter or side length) (mm)	Minimum distance from the prohibition zone (mm)		
	Slot	Square	Circle
over 4 to 6	10	5	5
over 6 to 8	20	15	5
over 8 to 10	80	25	20
over 10 to 12	100	80	80
over 12 to 20	120	120	120
over 20 to 30	850	120	120
over 30 to 40	850	200	120
over 40 to 120	850	850	850

Table A.4 from the EN 50191

Appendix B

Example of an application illustrating the prohibition zone and test area

P	Test object or in this case the envelope around a live object, 2 200 mm high
V	Prohibition zone
G	Test area
B	Operator´s console
W	Barriers separating the test area:
W1	Solid wall, to room height
W2	Wire mesh, 2 400 mm high, mesh size 40 mm
W3	Wire mesh, 1 800 mm high
W4	Barrier constructed as a bar, tape, chain or rope, 1 000 mm high
s	Distance according to Table A.2 (EN 50191)
c	Horizontal distances according to Table A.3 (EN 50191)
d	Distance according to Table A.4 (EN 50191)
x	Distance > striking distance (= s/2)

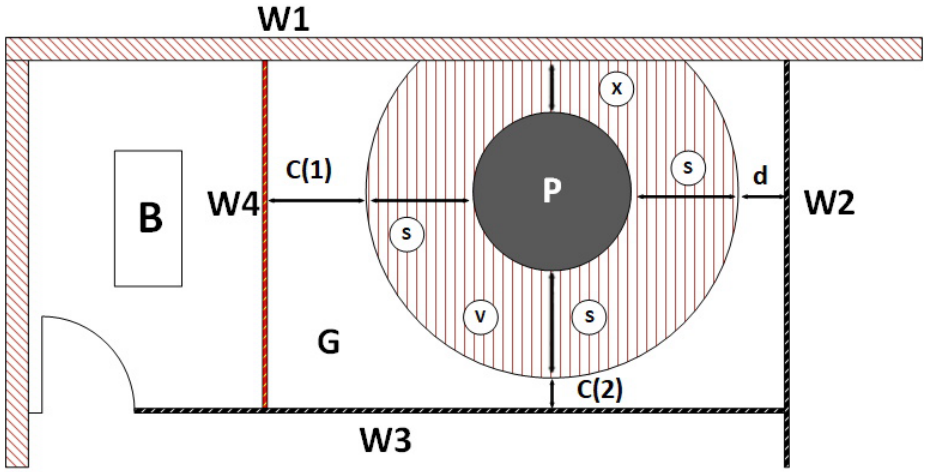


Figure 1 b, showing the example of a test laboratory (Source: EN 50191 Figure B.1).

Distances in case of a.c. test voltage 50 Hz, 190 kV to earth: example of calculation of test distance.

Reference	Distance	Notes
Table A.2, Alternating test voltage, U= 190 kV	s = 1 100 mm	
Table A.3, b = 1000 mm, a = 1000 mm (worst case barrier W4)	c(1) = 1 400 mm	
Table A.3, b = 1800 mm, a = 1800 mm (worst case for barrier W3)	c(2) = 600 mm	
Table A.3, b = 2400 mm, a = 2200 mm (worst case for barrier W2) Table A.4 mesh size 40 mm	d = 200 mm	c= 0 mm
Table A.2, Alternating test voltage, U= 190 kV	x = 600 mm	C= 0 mm (solid wall, height (b) = headroom) Recommendation x > s/2

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