



IEC 61992-6

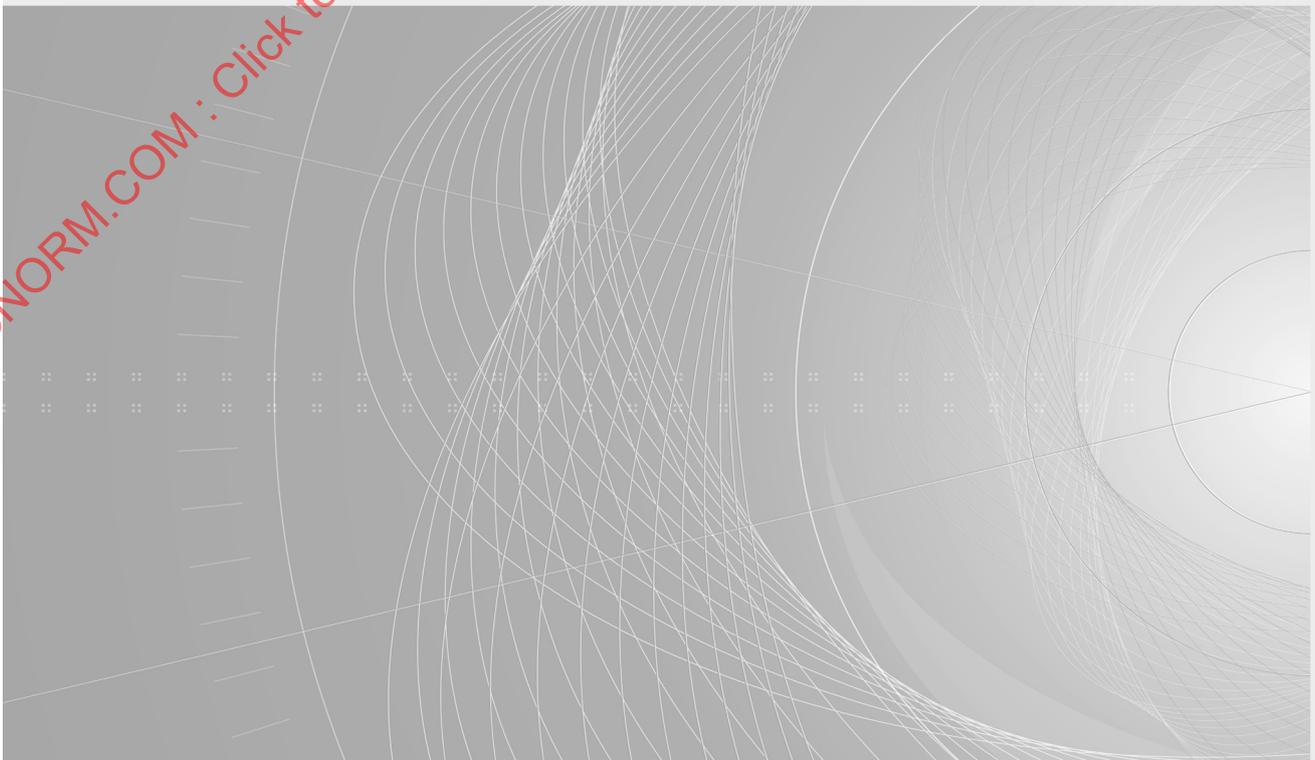
Edition 1.2 2020-05
CONSOLIDATED VERSION

INTERNATIONAL STANDARD



**Railway applications – Fixed installations – DC switchgear –
Part 6: DC switchgear assemblies**

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IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 45.060.01

ISBN 978-2-8322-8411-7

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CONTENTS

1	Scope	6
2	Normative references	6
3	Terms and definitions	6
4	Service requirements	7
5	Characteristics of the assemblies	7
6	Construction characteristics	7
6.1	General	7
6.2	Insulation requirements	8
6.3	Primary connections	9
6.4	Location of the primary connections	9
6.5	Earthing	9
6.5.1	Earthing of the main circuit	9
6.5.2	Earthing of the enclosure	9
6.6	Degree of protection and internal fault	10
6.6.1	Protection against approach to live parts and contact with moving parts	10
6.6.2	Internal arcing	11
6.7	Covers and doors	11
6.8	Inspection windows	11
6.9	Ventilating openings	12
6.10	Partitions and shutters	12
6.10.1	General	12
6.10.2	Partitions	12
6.10.3	Shutters	12
6.10.4	Isolating distances	13
6.11	Interlocks	13
6.12	Temperature-rises	14
6.13	Dielectric strength	14
6.14	Painting and finishing	14
6.15	Noise emission	14
6.16	Cooling and heating	14
6.17	Operating temperature of auxiliary and control equipment	14
6.18	Rated short-time withstand current of busbars	14
7	Information and marking	15
7.1	Information	15
7.2	Marking	15
8	Tests	15
8.1	General	15
8.2	List of the applicable tests	16
8.3	Performance of tests	16
8.3.1	Verification of conformity to the manufacturing drawings and to characteristics of the assembly	16
8.3.2	Operation test	17
8.3.3	Dielectric tests	17
8.3.4	Short-time withstand current tests	19
8.3.5	Mechanical operation test	21

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8.3.6	Verification of the degree of protection	21
8.3.7	Temperature-rise tests	21
8.3.8	Electrical operation test	23
8.3.9	Internal arc test	24
Annex A (informative)	Information required	25
A.1	General	25
A.2	Procurement specification	25
A.3	Manufacturer's tender specification	26
A.4	Information and data to be supplied by the manufacturer during the delivery stage	27
Annex B (normative)	Method for testing under conditions of arcing due to an internal fault	29
B.1	Purpose of the test	29
B.2	Characteristics – Rated short-circuit current under internal arcing conditions (I_{Narc})	29
B.3	Test arrangements	29
B.3.1	Test specimen	29
B.3.2	Test circuit	30
B.3.3	Voltage	30
B.3.4	Duration of the test	30
B.4	Test procedure	30
B.4.1	Supply circuit	30
B.4.2	Arc initiation	31
B.4.3	Indicators	32
B.4.4	Repetition of the test	32
B.5	Assessment of the test	32
B.6	Test report	33
Figure 1	– Test arrangement for short-time current withstand test on busbars	20
Figure 2	– Test arrangement for temperature-rise test on main circuits	22
Figure 3	– Test arrangement for temperature-rise test on the busbars	23
Figure B.1	– Room simulation and indicator positioning, functional unit fitted with roof	34
Figure B.2	– Mounting frame for vertical indicators	35
Figure B.3	– Indicators arranged in a checkerboard pattern	35
Table 1	– Degrees of protection	11
Table 2	– List of applicable tests	16
Table B.1	– Sizes of the copper ignition wire	31

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RAILWAY APPLICATIONS –
FIXED INSTALLATIONS –
DC SWITCHGEAR –**

Part 6: DC switchgear assemblies

FOREWORD

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IEC 61992-6 edition 1.2 contains the first edition (2006-02) [documents 9/891/FDIS and 9/913/RVD], its amendment 1 (2014-04) [documents 9/1792/CDV and 9/1852/RVC] and its amendment 2 (2020-05) [documents 9/2542/CDV and 9/2584A/RVC].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendments 1 and 2. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 61992-6 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

IEC 61992 consists of the following parts, under the general title *Railway applications – Fixed installations – DC switchgear*:

- Part 1: General
- Part 2: D.C. circuit breakers
- Part 3: Indoor d.c. disconnectors, switch-disconnectors and earthing switches
- Part 4: Outdoor d.c. disconnectors, switch-disconnectors and earthing switches
- Part 5: Surge arresters and low-voltage limiters for specific use in d.c. systems
- Part 6: D.C. switchgear assemblies
- Part 7-1: Measurement, control and protection devices for specific use in d.c. traction systems – Application guide
- Part 7-2: Measurement, control and protection devices for specific use in d.c. traction systems – Isolating current transducers and other current measuring devices
- Part 7-3: Measurement, control and protection devices for specific use in d.c. traction systems – Isolating voltage transducers and other voltage measuring devices

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

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RAILWAY APPLICATIONS – FIXED INSTALLATIONS – DC SWITCHGEAR –

Part 6: DC switchgear assemblies

1 Scope

This part of IEC 61992 covers d.c. metal-enclosed and non-metallic enclosed switchgear assemblies used in indoor stationary installations of traction systems, with nominal voltage not exceeding 3 000 V.

It is intended that individual items of equipment, for example circuit breakers, housed in the assembly are designed, manufactured and individually tested (simulating the enclosure when necessary) in accordance with their respective parts of IEC 61992 or, when appropriate, with another applicable standard.

NOTE 1 The requirements covered in this part of IEC 61992 are those concerning the assembly as such, its enclosure and the mutual influence of the equipment enclosed.

NOTE 2 EMC requirements are covered by IEC 62236-5 and additional requirements concerning dependability (RAMS) are covered by IEC 62278.

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.

IEC 60243-1:1998, *Electrical strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 61992-1:2006+A1:2014, *Railway applications – Fixed installations – DC switchgear – Part 1: General*

IEC 61992-2:2006+A1:2014, *Railway applications – Fixed installations – DC switchgear – Part 2: DC circuit-breakers*

IEC 61992-3:2006, *Railway applications – Fixed installations – DC switchgear – Part 3: Indoor d.c. disconnectors, switch-disconnectors and earthing switches*

3 Terms and definitions

~~For the purposes of this document, the terms and definitions given in IEC 61992-1 apply.~~

For the purposes of this document, the terms and definitions given in IEC 61992-1 and the following 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 <http://www.iso.org/obp>

3.1

internal arc

arcing within a switchgear assembly arising from a fault between active parts and/or between active parts and other conductive parts

3.2

rated short-circuit current under internal arcing conditions

I_{Narc}

current, during the test duration of 150 ms, indicating the maximum allowable value of sustained short-circuit current at the terminals of the incoming unit for which the requirements of this test specification are fulfilled

Note 1 to entry: The value is the maximum value of the prospective sustained short-circuit current.

3.3

compartment under test

compartment of a switchgear assembly which is subject to an internal arc test

4 Service requirements

Normal service requirements are detailed in Clause 4 and Annex B of IEC 61992-1 for indoor installations. In this standard, the pollution degree PD4 and overvoltage categories (see notes to Table 1 of IEC 61992-1) as described in EN 50124-1 are considered to be the normal condition.

5 Characteristics of the assemblies

The main characteristics of an assembly shall be indicated in the procurement specification as follows:

- a) type of the assembly enclosure;
- b) list of functional units enclosed;
- c) rated insulation voltages;
- d) rated values of the equipment enclosed as required in relevant standards;
- e) if constructed for an earth fault protection;
- f) detailed protection and control requirements (see IEC 61992-7).

Other important characteristics are listed in Clause A.2.

6 Construction characteristics

6.1 General

Enclosures are either metallic or non-metallic. Non-metallic enclosed switchgear shall not be used for nominal voltages above 1,5 kV.

All requirements specified herein also apply when both conductive and insulating materials are used, except for insulating clearances which shall be designed and tested as appropriate.

A cell made of masonry shall not be considered as an enclosure, as far as this standard is concerned.

The floor surface may be considered as part of an enclosure. The measures to be taken in order to obtain the degree of protection provided by floor surfaces shall be subject to an agreement between purchaser and supplier.

The walls of a room shall not be considered as parts of the enclosure.

Switchgear assemblies and relevant enclosures shall be designed so that normal service, inspection and maintenance operations, earthing of connected cables or busbars, locating of cable faults, voltage tests on connected cables or other apparatus and the elimination of electrostatic charges, can be carried out easily and safely.

All materials used shall be of the quality and of the class most suitable for working under the conditions specified. Special attention is to be paid to its ability to withstand moisture and fire: unless fire behaviour Class F0 is allowed (see Annex B of IEC 61992-1), materials used shall be metallic or of the self-extinguishing type, so that the risk of propagation of fire from one cubicle or compartment to another is minimised.

The selection of materials and the construction of the assembly shall be such that corrosion due to atmospheric and electrolytic effects are minimised.

All identical devices, forming part of an assembly for a given use and with the same characteristics, shall be interchangeable.

Withdrawable switching devices shall be prevented from insertion into functional units on the same switchgear assembly, having a different function or higher current ratings.

Sufficient space shall be provided inside the compartments for the entry and termination of incoming cables without their minimum bending radii being infringed.

The detachable parts of the protection enclosures shall be firmly attached to the fixed parts as specified in 6.7. Accidental untightening or detachment shall not occur because of the operation of the equipment.

All apparatus and connections for the safe operation, control and protection of the equipment concerned, shall be provided whether or not specifically mentioned. The equipment shall be adequately earthed, insulated, screened or enclosed as may be appropriate to ensure the protection of the equipment and safety of those concerned in its operation and maintenance.

Control and auxiliary circuits and contacts shall comply with the requirements of 5.2 of IEC 61992-1.

All components contained within the enclosure shall comply with their relevant standards.

6.2 Insulation requirements

Test voltages and clearances are given in Table 1 of IEC 61992-1. Recommended values for creepage distances are given in Annex D of IEC 61992-1.

The adverse effect of ionisation (due to arcs) on the clearances of other equipment in the assembly shall be taken into account. The minimum clearances between the arc chute of a switching device and metallic or non-metallic parts (i.e. above the arc chute and to the sides) shall be in accordance with those given by the switching device manufacturer.

Insulating material used to fully or partially line a metallic enclosure shall be firmly secured to the enclosure.

In case of withdrawable units, where access within the enclosure is required during maintenance operations, the busbars and all other conductors shall be separated by a barrier. Openings through such a barrier for the circuit and busbar connectors, etc. shall be shuttered and capable of being locked closed.

6.3 Primary connections

Non-withdrawable functional units may be equipped with fixed, removable (bolted or clamped) connectors. Withdrawable functional units may be equipped with plug-in connectors.

6.4 Location of the primary connections

In case of non-withdrawable assemblies, the terminals for the primary connections shall be accessible with the functional units as in normal operating conditions.

6.5 Earthing

NOTE Depending on the d.c. system earthing requirements, "earthing" means connection either to earth or to the return circuit.

6.5.1 Earthing of the main circuit

To ensure safety during maintenance work, all parts of the main circuit to which access is required or provided shall be capable of being earthed through suitable means. This does not apply to those parts, which are withdrawable or removable and which become accessible after being separated from the switchgear.

A withdrawable part, however, shall not be removed from the enclosure unless capacitors on it have been discharged to safe values.

In case of withdrawable circuit breakers, the earth connection shall be made before the shutters are opened and the shutters shall be closed before the earth connection is disconnected.

Earthing switches shall comply with IEC 61992-3. The requirement that it shall be possible to know the operating position of the earthing switch is met if one of the following conditions is fulfilled:

- the isolating distance is visible;
- the position of the earthing switch is clearly visible and the position corresponding to full connection and full isolation are clearly identified;
- the position of the earthing switch is indicated by a reliable indicating device.

6.5.2 Earthing of the enclosure

The purchaser shall indicate in the enquiry how to earth the enclosure (e.g. the return circuit or to earth) in accordance with 6.5.8 of IEC 61992-7-1.

The metallic parts of the enclosures, such as frames, structure and fixed elements, shall be connected to each other and to a suitable earthing terminal, placed in an accessible position, in order to allow the connection to the main earth system of the installation. The earthing terminal shall be suitably protected against corrosion. The standard earth symbol shall be clearly and permanently marked.

An earthing conductor shall be provided extending the whole length of the metal-enclosed switchgear to connect the individual earthing terminals. The current density of the earthing conductor, if of copper, shall not exceed 200 A/mm² based on a specified earth fault of

10 000 A for 1 s; therefore, its cross-section area shall be not less than 50 mm². The earthing conductor shall be terminated by a clearly and permanently marked main earthing terminal.

The continuity of the earth system shall be ensured taking into account the thermal and mechanical stresses caused by the magnitude and duration of the current it may have to carry.

The purchaser shall indicate in the enquiry if the earthing system shall differ from the above.

The purchaser shall specify in the enquiry the maximum earth fault current. The standard value for the duration is 0,25 s due to the typical breaking time of the a.c. rectifier circuit breaker(s). If the purchaser requires a longer duration, he shall specify this in the enquiry.

The terminals and connections shall be adequately dimensioned for the earth fault current.

The enclosure of each functional unit shall be connected to this earthing conductor. All the metallic parts within a functional unit and not belonging to a main, control or auxiliary circuit, shall also be connected to the earthing conductor directly or through metallic structural parts.

In the latter case, earthing of said elements, such as walls and doors of compartments, may be fulfilled by normal construction elements, ensuring an adequate electrical continuity and suitable dimensioning. For any bolts or similar fixing used for earth continuity, the maintenance instructions shall state the requirements for cleaning surfaces and ensuring tightness.

The metallic parts of a withdrawable part which are normally earthed in the service position, shall also remain earth-connected in the test and disconnected positions and between each position.

The purchaser shall indicate in the enquiry if the earthing system deviates from the requirements stated in this subclause.

6.6 Degree of protection and internal fault

6.6.1 Protection against approach to live parts and contact with moving parts

For metal-clad and for compartmented switchgear, the degree of protection shall be specified. If required, separate degrees of protection for doors and walls, for partitions and for the roof of the enclosure shall be specified. For cubicle switchgear, it is only necessary to specify the degree of protection for the enclosure.

The degree of protection against contact of persons with live parts of auxiliary circuits and with any moving parts (other than smooth rotating shafts and moving linkages) shall be indicated by means of the designation specified in Table 1 below, taken from IEC 60529.

Normally, no degree of protection is provided for indoor switchgear assemblies against ingress of water.

Table 1 – Degrees of protection

Degree of protection	Protection against approach of live parts and contact with moving parts
IP20	By fingers or similar objects of diameter greater than 12 mm
IP30	By tools, wires, etc. of diameter of thickness greater than 2,5 mm
IP40	By tools, wires, etc. of diameter of thickness greater than 1,0 mm

NOTE 1 The first characteristic numeral indicates the degree of protection provided by the enclosure against the ingress of solid bodies and approach to live parts for all given enclosure conditions.

NOTE 2 Protection against ingress of water is given by the second numeral.

6.6.2 Internal arcing

Failure within the enclosure of switchgear due to a defect or an exceptional service condition or mal-operation may initiate an exceptional internal arc.

Ventilating openings and vent outlets shall be arranged in such a way that gas or vapour escaping under pressure does not endanger the operator.

A manufacturer may assign a rated short-circuit current under internal arcing conditions I_{Narc} to the equipment. Requirements are given in Clause B.2.

6.7 Covers and doors

Covers and doors which are part of the enclosure shall be metallic if the enclosure is metallic. When they are closed, they shall provide the degree of protection specified for the enclosure.

Covers or doors shall not be made of woven wire mesh, expanded metal or similar. When ventilating openings and vent outlets are incorporated in the cover or door, reference is made to 6.9.

Two categories of covers or doors are recognized with regard to access to compartments at main circuit potential:

- a) those which need not to be opened for the normal purposes of operation or maintenance (fixed covers): it shall not be possible for them to be opened, dismantled or removed without the use of tools or other provisions which may be required by the purchaser;
- b) those which need to be opened for the normal purposes of operation (removable covers, doors): these shall not require tools for their opening or removal; they shall be provided with locking facilities (for example provisions for padlocks), unless the safety of persons is assured by a suitable interlocking device.

NOTE It is recommended, with metal-clad or compartmented switchgear, that doors giving access to live parts be suitable for opening only when the part of the exposed main circuit contained in the compartment being made accessible is dead. Equivalent provisions may also be provided.

6.8 Inspection windows

Inspection windows shall provide at least the degree of protection specified for the enclosure.

They shall be covered by a transparent sheet of mechanical strength comparable to that of the enclosure.

The insulation between live parts of the main circuit and the inspection windows shall withstand the test voltages specified in Table 1 of IEC 61992-1.

6.9 Ventilating openings

Ventilating openings shall be so arranged or shielded that the same degree of protection as that specified for the enclosure is obtained. Such openings may make use of wire mesh or the like, provided that it is of suitable mechanical strength.

6.10 Partitions and shutters

6.10.1 General

Partitions and shutters shall provide at least the degree of protection specified in Table 1.

Partitions and shutters made of insulating material shall meet the following requirements:

- a) the insulation between live parts of the main circuit and the accessible surface of insulating partitions and shutters shall withstand the test voltages specified in Table 1 of IEC 61992-1;
- b) apart from mechanical strength, the insulating material shall withstand the test voltages specified in item a); the appropriate test method given in IEC 60243-1 shall be applied;
- c) if a leakage current reaches the accessible side of the insulating partitions and shutters by a continuous path over insulating surfaces or by a path broken only by small air gaps, this current shall be not greater than 0,5 mA under the specified test conditions (see 8.3.3.1 a)).

Openings in the enclosure of the switchgear assembly and in partitions of metal-clad or compartmented switchgear, through which contacts of removable parts engage fixed contacts, shall be provided with automatic shutters properly operated in normal service operations to ensure the protection of persons in any of the positions defined in 3.3.24 to 3.3.27 of IEC 61992-1.

If maintenance requirements imply that one set of fixed contacts shall be accessible through opened shutters, all the shutters shall be provided with means of locking them independently in the closed position or it shall be possible to insert a screen to prevent the live set of the fixed contacts being exposed.

Conductors other than busbars passing through metallic partitions are insulated by bushings or other equivalent means and the openings may be provided by bushings or shutters having non-metallic parts.

6.10.2 Partitions

Partitions of metal-clad switchgear shall be metallic and earthed.

Partitions of compartmented and cubicle switchgear may be non-metallic, provided (unless otherwise agreed between purchaser and supplier) they do not become part of the enclosure with the removable part in any of the positions defined in 3.3.25 to 3.3.27 of IEC 61992-1. If partitions become part of the enclosure with the removable part in any of these positions, they shall be of the same material as the enclosure and shall provide the degree of protection specified for the enclosure. Metallic partitions shall be earthed.

NOTE 1 A partition becomes part of the enclosure, if it is accessible in any of the positions defined in 3.3.25 to 3.3.27 of IEC 61992-1.

NOTE 2 If a door which can be closed in the positions defined in 3.3.25 to 3.3.27 of IEC 61992-1 is provided, the partition behind the door is not considered to be a part of the enclosure.

6.10.3 Shutters

The shutters of all types of switchgear assemblies may be either metallic or non-metallic.

If shutters are of insulating material, they shall not become part of the enclosure. If shutters are metallic, they shall be earthed and, if they become part of the enclosure, they shall provide the degree of protection specified for the enclosure.

6.10.4 Isolating distances

The devices for ensuring the isolating distance between the main circuit conductors are considered to be disconnectors which shall comply with IEC 61992-3, except for the mechanical operation test (see 8.3.5).

The requirement that it shall be possible to know the operating position of the disconnector is met if one of the following conditions is fulfilled:

- the isolating distance is visible;
- the position of the withdrawable part, in relation to the fixed part, is clearly visible and the positions corresponding to full connection and full isolation are clearly identified;
- the position of the disconnector is indicated by a reliable indicating device.

Any removable part shall be so attached to the fixed part that its contacts will not open inadvertently due to forces which may occur in service, in particular those due to short circuit.

The dielectric requirements stated in 6.2 shall be observed.

6.11 Interlocks

Interlocks between different components of the equipment are provided for reasons of safety and for convenience of operation. The following provisions are mandatory for main circuits:

a) Switchgear with removable parts

The withdrawal or engagement of a circuit breaker, switch, disconnector or contactor shall be impossible unless it is in the open position.

The operation of a circuit breaker, switch, disconnector or contactor shall be impossible unless it is in the service, disconnected, removed, test or earthing position.

It shall be impossible to close the circuit breaker, switch, disconnector or contactor in the service position unless it is connected to the auxiliary and control circuit, unless it is designed to open automatically without the use of a separate auxiliary and control circuit.

b) Switchgear without removable parts and provided with disconnectors

Interlocks shall be provided to prevent operation of disconnectors under conditions other than those uses for which they are intended (see IEC 61992-3). The operation of a disconnector shall be impossible unless the associated circuit breaker, switch or contactor is in the open position. No interlock is required if all currents (including fault currents) in the circuit to be switched on or off, are within the making and breaking capacity of the disconnector.

The operation of the circuit breaker, switch or contactor shall be impossible unless the associated disconnector is in the closed, open or earthing position (if provided).

The provision of alternative interlocks shall be subject to agreement between purchaser and supplier. The supplier shall give all necessary information on the character and function of interlocks.

Earthing switches having a short-circuit making capacity less than the peak short circuit current I_{SS} of the circuit shall be interlocked with the associated disconnectors.

Apparatus installed in main circuits, the incorrect operation of which can cause damage or which are used for assuring isolating distances during maintenance work, shall be provided with locking facilities (for example provision of padlocks).

NOTE Whenever practical, preference should be given to mechanical interlocks.

6.12 Temperature-rises

Maximum temperature-rises are detailed in Clause 6 of IEC 61992-1.

These temperature-rises shall not be exceeded for operation at rated service current and/or conventional thermal current I_{Ne} or I_{the} and at overloads as specified by the purchaser for normal service conditions as specified in Annex B of IEC 61992-1. The effects on temperature-rise caused by adjacent functional units and any permanently energized anti-condensation heaters shall be taken into consideration.

In addition, the auxiliary and control circuits, as well as the auxiliary devices, shall carry their conventional thermal current (for switching devices) or their rated service current (for other equipment).

Through faults may produce temperature-rises in excess of those mentioned above, but shall not cause permanent damage or distortion in the switchgear assembly.

6.13 Dielectric strength

Dielectric withstand strength and isolating distances shall conform to the requirements specified in 4.2 of IEC 61992-1.

When it is not practical to disconnect the cable for the dielectric tests from the switchgear assembly, those parts which remain connected to the cable shall be capable of withstanding the cable test voltages specified for the cables.

6.14 Painting and finishing

Steelwork (other than stainless steel) and other materials of the enclosure shall be treated in accordance with an approved type of corrosion protection.

6.15 Noise emission

Noise emission from all equipment shall be minimized. The level of the noise emission during the breaking of the rated normal service current I_{Ne} shall be indicated by the supplier, if requested.

The method of measuring is to be indicated.

6.16 Cooling and heating

All equipment shall be naturally air cooled unless otherwise agreed between purchaser and supplier.

Space heaters, positioned to prevent the accumulation of moisture on internal components, shall be provided where necessary for the service conditions specified by the purchaser.

6.17 Operating temperature of auxiliary and control equipment

Auxiliary and control equipment, when installed in the switchgear, shall be suitable for operating at rated performance at the recorded local ambient temperature within their enclosure.

6.18 Rated short-time withstand current of busbars

Busbars shall have a short-time withstand current rating (I_{Ncw}).

NOTE The I_{NcW} rating is the same value as the I_{Nss} rating of the line circuit breaker for a time duration of 0,25 s.

By mutual agreement between manufacturer and purchaser, a tie interconnecting station switchboard may be supplied with a reduced I_{NcW} busbar rating, as I_{cW} fault current is normally of lower magnitude than at a substation. If a tie station needs to be upgraded to a rectifier substation at a later date, then the purchaser shall indicate this at the time of the enquiry and order and shall define the I_{NcW} requirement.

7 Information and marking

7.1 Information

Both parties shall exchange any necessary information in order to assure that the switchgear assembly is suitable for the intended duty. A summary of this information is given in Annex A.

7.2 Marking

All necessary labelling shall be indelibly marked and provided as necessary for the purposes of safety, identification, instruction and information. Lifting attachments and the earth terminal shall be marked by their symbols. The following indications shall be placed on the assembly enclosure on one or more rating plates in an accessible visible position on a non-removable structure.

- a) name of the manufacturer or trademark;
- b) the reference to this part of IEC 61992;
- c) type designation;
- d) serial number designation;
- e) year of manufacture;
- f) rated voltage U_{Ne} of main circuits;
- g) rated voltage(s) U_{Ne} of auxiliary and control circuits;
- h) rated service current I_{Ne} of busbars and main circuits;
- i) rated short-circuit current I_{Nss} ;
- j) rated short-time withstand current of busbars I_{NcW} ;
- k) rated earth fault current I_{NcWe} ;
- l) degree of protection for the enclosure and partitions (if different);
- m) compliance with service requirements differing from those indicated as normal (see Clause 4 of IEC 61992-1 – preferably by a separate label).

8 Tests

8.1 General

General requirements concerning tests are shown in Clause 7 of IEC 61992-1.

The tests shall be carried out as described in the relevant clauses of this standard and, as far as applicable, of IEC 61992-1. For procedural matters not covered in either of those standards, reference may be made to other IEC or European Standards covering similar equipment.

Unless otherwise indicated, the tests shall be performed at the rated service values: current, voltage, frequency (if applicable), air pressure (if applicable). The same applies for the whole of the assembly (main, control and auxiliary) and in accordance with the values indicated in Clause 5.

Unless explicitly specified, the test variables shall be within the tolerances indicated in Table 6 of IEC 61992-1.

For all the tests, the ambient temperature is measured and recorded in the test report.

The tests detailed in this standard are only those verifying the correctness of the design of the switchgear assembly as such, as well as the correctness of the assembling and cabling.

Each component shall be tested before being assembled, in accordance with the applicable standard.

When a manufacturer is supplying both the internal equipment and the switchgear assembly, he may perform combined tests to test the equipment in its final compartment (or in an equivalent compartment), so avoiding duplication in tests.

8.2 List of the applicable tests

Based on the above requirements, the applicable tests are summarized in Table 2.

Table 2 – List of applicable tests

Test description	Kind	Subclause
Verification of conformity to the manufacturing drawings and to characteristics of assembly	Routine	8.3.1
Operation	Routine	8.3.2
Dielectric withstand:		
– impulse withstand	Type	8.3.3.2
– power-frequency voltage	Type and routine	8.3.3.3
Short-time withstand current		
– main circuits	Type	8.3.4.1
– busbars	Type	8.3.4.2
– earthing circuits	Type	8.3.4.3
Mechanical operation	Type	8.3.5
Verification of degree of protection	Type	8.3.6
Temperature-rise	Type	8.3.7
Electrical operation	Type	8.3.8
Internal arc test	Type	8.3.9

Routine and type tests are mandatory tests if related characteristics are assigned to the equipment.

8.3 Performance of tests

8.3.1 Verification of conformity to the manufacturing drawings and to characteristics of the assembly

8.3.1.1 Verification of conformity to the manufacturing drawings

The assembly to be tested shall be representative of the manufactured type and shall correspond in all essential details to the manufacturing drawings.

8.3.1.2 Measurement of the resistance of the main circuits

Resistance measurements of the main circuits shall be made with the assembly at ambient temperature. This measurement shall confirm correctness in the assembling operations, by comparison with the resistance values recorded during tests on similar components or assemblies.

8.3.2 Operation test

Operation tests are made to ensure that the switching devices and removable parts comply with the prescribed operating conditions and that the mechanical interlocks work properly.

This test is carried out at the laboratory ambient temperature, in accordance with 7.3.1 of IEC 61992-1.

Auxiliary and control circuits will be supplied at their rated voltage (if in parallel) or at a suitable current (if in series).

Each switching device, removable part, mechanical interlock and sequence of electrical or mechanical operations shall be tested with five operations or five attempts in each direction. The test shall include visual checking.

The purchaser may require that these tests are repeated on site after installation.

8.3.3 Dielectric tests

8.3.3.1 Test conditions

Reference shall be made to 7.5 of IEC 61992-1.

The test values shall be as specified in Table 1 of IEC 61992-1.

The enclosure to be tested shall be mounted complete as in normal service and under the ambient conditions stated in Annex B of IEC 61992-1.

Because of the great variety of designs, it is not feasible to give specific indications of the tests to be performed on the main circuit, but, in principle, they shall cover the following tests.

a) Between main circuit and earth

The test voltage specified shall be applied by connecting the positive conductor of the main circuit to the high-voltage terminal of the test supply. The negative conductor of the main circuit and the auxiliary circuits are to be connected to the earthing conductor or the frame and to the earth terminal of the test supply. The test shall be repeated with the negative conductor energised and the positive conductor to earth.

The dielectric test shall be made with all switching devices open and all removable parts in their service position.

Electrical connections shall bridge the contacts of switching devices.

For these dielectric tests, current transducers, any direct overcurrent release or overcurrent indicator and the cable terminal boxes (placed, if necessary, in several configurations if in doubt about the most unfavourable situation) are recommended to be installed as in normal service.

Attention shall be paid to the fact that transducers (or a.c. transformers if any), lightning arresters, fuses and electronic equipment may not be suitable for a test voltage applied at the compartment or assembly terminals and shall be disconnected, earthed, shorted out, as applicable, before testing and separately tested.

Moreover, when the equipment is connected to the return circuit or to earth, this connection shall be removed before testing at the rated insulation level of the switchgear.

Inspection windows, partitions and shutters of insulating material shall be covered on the side accessible during operation and maintenance, in the most unfavourable situation for the test, with a circular or square metal foil having an area as large as possible but not exceeding 0,01 m², which shall be connected to earth. In case of doubt about the most unfavourable situation, the test shall be repeated with different situations. For convenience of testing, subject to agreement between purchaser and supplier, more than one metal foil may be applied simultaneously or larger parts of the insulating material may be covered.

b) Across the isolating distance

Each isolating distance of the main circuit shall be tested using the test voltages specified in Table 1 of IEC 61992-1 and to comply with the requirements of 6.2. The isolating distance may be the distance between the two parts of the main circuit intended to be connected by a removable or withdrawable part.

If, in the disconnected position, an earthed metallic shutter is interposed between the disengaged contacts to ensure segregation, the gap between the earthed metallic shutter and the live parts shall withstand only the test voltages required to earth:

If, in the disconnected position and, where provided, test position, there is no earthed metallic shutter or partition between the fixed part and the withdrawable part, the test voltages specified across the isolating distance shall be applied:

- between the fixed and moving isolating contacts intended to engage, and
- between the fixed isolating contact on busbar side and the fixed isolating contact on the circuit side. Both the direct isolating distance between fixed isolating contacts and the isolating distance established through the closed withdrawable switching part shall be tested.

When specified by the purchaser, the withstand performance between the busbar side and the circuit side shall be proved using test voltages specified across isolating distance with a withdrawable circuit breaker in the service position and open.

8.3.3.2 Impulse withstand voltage test

This type test is applicable to those circuits in switchgear assemblies having a rated insulation voltage exceeding 2 500 V.

The switchgear shall be impulse tested in accordance with 7.5.1 of IEC 61992-1. Three positive and three negative pulses shall be applied and there shall be no flashovers. At the conclusion of the test, a power frequency withstand test shall be performed in accordance with the requirements of 8.3.3.3.

Voltage transducers, transformers, fuses, etc. (see 8.3.3.1 a)) may be replaced by replicas reproducing the field configuration of high-voltage connections.

Overvoltage protective devices shall be disconnected or removed. Current transducer secondaries shall be short-circuited and earthed.

During the impulse voltage tests, the earthed terminal of the impulse generator shall be connected to earth and to the metal enclosures, if any. Except during the tests in accordance with 8.3.3.1 b), the mid point or another intermediate point of the voltage source shall be connected to earth and to the metal enclosure so that the voltage appearing between any of the live parts and the enclosure does not exceed the test voltage specified in 8.3.3.1 a).

8.3.3.3 Power-frequency voltage withstand test for main circuit and auxiliary circuits

This test is a routine test, to be performed in accordance with 7.5.2 of IEC 61992-1. It is also part of the impulse type test of 8.3.3.2. The test is carried out by applying to the terminals of each circuit section the power-frequency test voltage relating to the rated insulation level assigned to the circuit section concerned, with all other sections earthed.

The test shall be carried out with withdrawable equipment in the connected position and repeated when in the disconnected position.

As indicated in 8.3.3.1 a), the circuit sections shall be segregated, and electronic equipment, transducers and transformers (if any) shall be disconnected or short-circuited.

NOTE The term “circuit section” is defined in 1.3.1.3 of EN 50124-1.

The test voltage shall be reached, from 0 V to the specified level, in 5 s and maintained for 60 s.

The switchgear shall be considered to have passed the test if no disruptive discharge occurs.

8.3.4 Short-time withstand current tests

8.3.4.1 Tests on main circuits

Main circuits are only tested for this condition when they are fitted with switching devices, which also have a short-time current rating. Such devices are disconnectors and all devices for the return current. See 3.2.7 of IEC 61992-1.

Main circuits shall be tested to verify their capability of carrying the rated short-time and peak withstand currents under the intended conditions of installation and use, i.e. they shall be tested as installed in the switchgear with all associated components which have an influence on the performance or modifying the short circuit current.

For these tests, short connections to transducers are not considered as parts of the main circuit.

Short and direct connections between circuits having a high short-circuit current and current limiting devices may be tested with a reduced short circuit current.

Circuits containing current limiting devices or circuit breakers employing bidirectional series trip devices need not be tested. However, unidirectional circuit-breaker circuits shall be tested with the current direction in a manner which does not cause tripping.

The I_{NCW} value of the main circuit need not be the same as that of the main busbars, but shall be at least the proportion of the short-circuit current which it sees in service. Since this test is in general only applied to incomer/rectifier circuits, the requirements are stated in 5.3.4.2, Table 2-3 of IEC 61992-2.

The configuration of the test arrangement shall be recorded in the test report and shall follow the rules laid down in 8.3.9 of IEC 61992-2.

The test is considered satisfactory if no permanent deformation or damage is sustained by the main circuits, components and enclosure.

8.3.4.2 Test of the busbars

The tests on the main busbars shall be at the assigned value of the rated short-time withstand current I_{NCW} of the busbars. This rating can be different to that assigned to the main circuit connections.

The configuration of the test arrangement shall be recorded in the test report and shall follow the rules laid down in 8.3.9 of IEC 61992-2.

The busbars shall be tested to verify their capability of carrying the rated short-time and peak withstand current under the intended condition of installation and use, i.e. they shall be tested

as installed in the switchgear with all associated components which have an influence on the performance.

The arrangement for testing is shown in Figure 1 and shall comprise busbars in at least three sections of the switchgear, including at least one main circuit connection (tee-off). The main circuit connection conductor size shall be the minimum section which have the same assigned I_{NCw} rating, unless otherwise agreed between purchaser and supplier.

One test connection shall be made to the main circuit connection via the busbar side disconnect at one end of the busbar. The other test connection shall be to the busbar at the opposite end of the busbar or, at the option of the manufacturer, to the main circuit connection via the busbar side disconnect at the end of the busbar.

Where the busbar has the same I_{NCw} rating as the main circuit, then a combined test with that described in 8.3.4.1 is permitted.

The test procedure and pass criteria are as in 8.3.4.1.

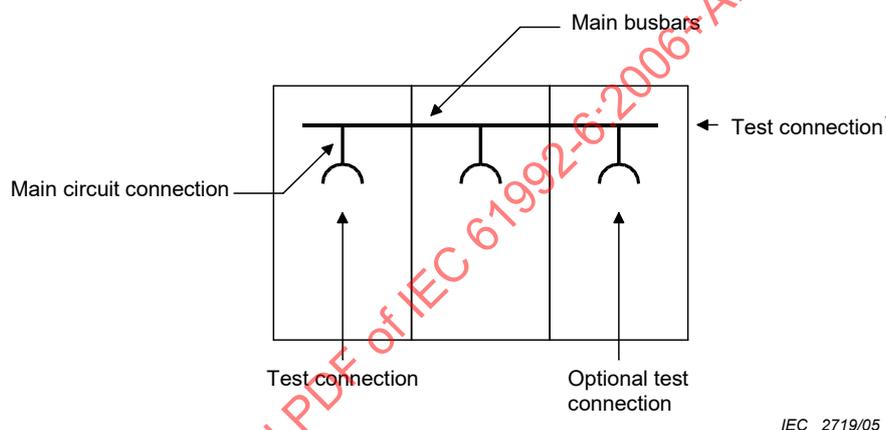


Figure 1 – Test arrangement for short-time current withstand test on busbars

8.3.4.3 Test on earthing circuits

Earthing conductors, earthing connections and earthing devices of switchgear shall be tested to verify their capability to withstand the rated earth fault current I_{NCwe} for the specified time under the return and/or earthing condition of the system, i.e. they shall be tested as installed in the switchgear with all associated components influencing the performance or modifying the short-circuit current. The minimum value of the earth fault current shall be 10 kA (sustained) unless otherwise agreed between purchaser and supplier.

The rated earth fault current test shall be carried out using a d.c. supply.

This test only applies when earthing devices are employed which connect the main conductors to the switchboard earth. The rated earth fault current is assigned on this basis. The purchaser shall assign this rating based on the return path associated with the earthing circuit. Otherwise, it is subject to agreement between the purchaser and supplier.

When the earthing devices are themselves removable parts, then the earthing connection between the fixed part and the removable part shall be tested under earth fault conditions. The earth fault current shall flow between the earthing conductor and the frame of the removable part.

After the test, some deformation and degradation of the earthing conductor (but not the return conductor), earthing connections or earthing devices is permissible, but the continuity of the circuit shall be preserved.

8.3.5 Mechanical operation test

8.3.5.1 Switching devices and removable parts

Switching devices shall successfully complete the tests specified in IEC 61992-2 or IEC 61992-3 before being installed. As a type test, when installed in the switchgear, switching devices shall be operated 50 times with the main-circuit de-energised. Removable parts shall be inserted 25 times and withdrawn 25 times to verify satisfactory operation of the equipment.

8.3.5.2 Interlocks

The interlocks shall be set in the position intended to prevent the operation of the switching devices and the insertion or withdrawal of removable parts. 50 attempts shall be made to operate the switching devices and 25 attempts shall be made to insert and 25 attempts to withdraw the removable parts. During these tests, only normal operating forces shall be employed and no adjustment shall be made to the switching devices, removable parts or interlocks.

The interlocks are considered to be satisfactory if

- a) the switching devices cannot be operated;
- b) the insertion and withdrawal of the removable parts are prevented;
- c) the switching devices, removable parts and the interlocks are in proper working order and the effort to operate them is practically the same before and after the tests.

8.3.6 Verification of the degree of protection

The tests to verify the protection indicated by the first numeral shall be performed in accordance with the requirements specified in Clause 12 of IEC 60529 for protection against access to hazardous parts. General requirements for the tests shall comply with Clause 11 of IEC 60529.

8.3.7 Temperature-rise tests

The temperature-rises of the different components shall be referred to the ambient air temperature and shall not exceed the values specified in Clause 6 of IEC 61992-1.

NOTE The local ambient air temperature within the equipment may differ from the reference ambient temperature, which is taken outside the enclosure, because of the mutual heating from adjacent apparatus.

Where the switchgear design provides for alternative components or arrangements, the test of the switchgear shall be performed with those components or arrangements for which the most severe conditions are obtained.

8.3.7.1 Ambient temperature

The reference ambient air temperature as defined in 3.2.26 of IEC 61992-1 is the average temperature of the air outside the enclosure. It shall be measured during the last quarter of the test period by means of at least three temperature-measuring devices equally distributed around the assembly, at half height and a distance of 1 m from the enclosure. The devices shall be protected from external air currents and sources of heating or cooling.

8.3.7.2 Temperature-rise test of the main circuits and busbars

The test shall be performed in accordance with 7.4 of IEC 61992-1.

The dimensions of the test conductors and the configuration of the test arrangement shall be recorded in the test report and shall follow the rules laid down in 7.4 of IEC 61992-1.

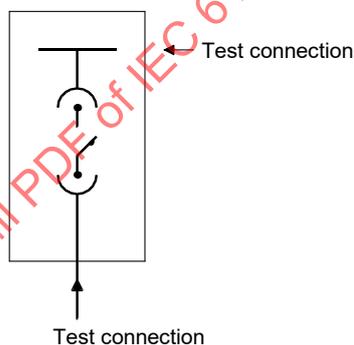
The arrangement for the temperature-rise tests on main circuits may be made on a single switchgear section as shown in Figure 2. The main circuit shall carry its rated service current I_{Ne} and/or its conventional thermal current I_{the} (as agreed).

The arrangement for the temperature-rise tests on busbars is shown in Figure 3 and shall comprise busbars in at least three sections of the switchgear. Each section of switchgear shall contain its main circuit connection which shall be the minimum normal current rating for the associated range of equipment if it is not carrying the test current. The busbars shall carry its rated service current I_{Ne} and/or its conventional thermal current I_{the} (as agreed).

The test connections shall be to the ends of the busbar or alternatively to one or both main circuit connections in the end sections of the switchgear via the busbar side disconnects. These connections shall then have conductor ratings no greater than the busbars.

Where the busbars and the main circuit have the same current rating, the manufacturer may combine the main circuit and busbar tests.

The main circuit temperature-rise test results are those measured on that section of main circuit and the busbar temperature-rise test results are those measured on the centre section of the switchgear busbars.



IEC 2720/05

Figure 2 – Test arrangement for temperature-rise test on main circuits

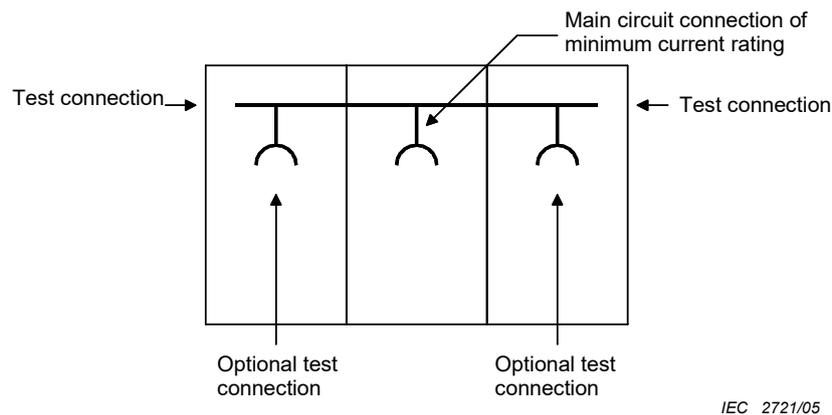


Figure 3 – Test arrangement for temperature-rise test on the busbars

Care shall be taken to minimize indication errors due to high temperature gradients.

When testing individual functional units, the neighbouring units should carry the currents which produce the power loss corresponding to the rated condition. It is admissible to simulate equivalent conditions by means of heaters or heat insulation, if the test cannot be performed under actual conditions.

8.3.7.3 Temperature-rise test for auxiliary and control equipment circuits

When it is impracticable to simultaneously load all auxiliary and control circuits during the test under 8.3.7.2, the maximum local temperatures in all compartments and locations where control and auxiliary circuits are located shall be measured and recorded. The test shall be considered satisfactory if the maximum local ambient temperatures are within the design ambient temperature range for the auxiliary and control equipment.

For intermittent operation of circuits and components, the requirements of 7.4.4 of IEC 61992-1 shall apply.

8.3.8 Electrical operation test

This type test applies when several main or main and auxiliary switching devices are mounted in a single compartment in order to assess the mutual influence of equipment within a compartment. This applies both to switching devices intended to be separately operated and to those intended to be sequentially operated. The test is carried out in laboratory conditions.

The test arrangement shall follow the requirements of 7.3.2 of IEC 61992-1.

The test procedure provides the opening in turn of all switching devices in the main circuit.

Where switching devices are intended to be separately operated, then they are operated one after the other, i.e. from the larger to the smaller, with a maximum interval between successive openings of 2 s.

Where switching devices are intended to be operated in sequence, then this shall be reproduced in service within their own intended time scale.

The opening sequences shall be repeated 5 times. The time-interval between two successive opening sequences shall not exceed 7 s.

All switching devices shall be operated in such a way that they break their rated service current I_{Ne} at their rated service voltage U_{Ne} in a circuit having a circuit time-constant t_c of not less than 0,01 s.

Other switching devices shall break the rated service current or the maximum breaking current, whichever is lower.

All switching devices shall have satisfactorily passed the test if they still work correctly and withstand a voltage test as per 8.3.3.3 but with a voltage having a r.m.s. a.c. value equal to $I_{Ne} \times \sqrt{2}$.

All switching devices which have been separately type tested in conditions differing from the requirements of this subclause (i.e. in open air or in a larger compartment than required by the compartment of the assembly) shall have their electrical operation tests, as type tests, performed again in this compartment of the assembly.

8.3.9 Internal arc test

The internal arc test is a type test and shall be performed if a rated short-circuit current under internal arcing conditions (I_{Narc}) is assigned to the equipment. The test shall be performed according to the procedure specified in Annex B. The criteria for successful passing are given in Clause B.5.

Annex A (informative)

Information required

A.1 General

With reference to Clause 7, this annex gives a summary of the information which may be used as guidance to fulfil Clause 7.

A.2 Procurement specification

The following items should be included, where applicable, within the procurement specification issued by the purchaser in order to provide the precise technical requirements for particular installations.

- a) Particulars of the system
 - 1) the system voltage;
 - 2) a comprehensive description of the traction system including voltages, overhead/third rail/fourth rail, earthing (including any bonding of the return to earth electrodes);
 - 3) a description of the transient and short term over-voltage that occur including frequency of occurrences, peak values and duration;
 - 4) system earth fault and short-circuit levels, including frequency of faults;
 - 5) description, quantities and rated characteristics of any surge arrestors fitted on the system.
- b) Service conditions
 - 1) service conditions differing from those defined as "normal" (see 4.1 of IEC 61992-1).
- c) Particulars of the installation and its components
 - 1) details of the buildings in which the equipment has to be accommodated;
 - 2) details of site requirements including site plans and national grid references;
 - 3) details of arrangements for transport and delivery to site including maximum packing dimensions and, where appropriate, nominated delivery points;
 - 4) details of requirements for work at site including anticipated working hours and arrangement for access, the supply of electrical energy, etc.
- d) Switchgear rating and tests
 - 1) the data mentioned in Clause 5 to be provided by the purchaser;
 - 2) the current rating of the enclosed busbars;
 - 3) short-time current withstand rating of the busbars;
 - 4) requirements for special tests.
- e) Switchboard configuration and characteristics
 - 1) single line diagram for the locations concerned identifying the equipment covered by the specification;
 - 2) list of the functional units to be provided and basic scheme of the assembly;
 - 3) particular features concerning Clause 6;
 - 4) IP degree required (see Table 1);
 - 5) special constructional requirements, for example:

- i) segregation of traction, auxiliary and control circuits,
 - ii) separate compartments for auxiliary and control equipment,
 - iii) safety interlocking,
 - iv) fixed/withdrawable switching devices and test positions,
 - v) entries for external connections;
- 6) special requirements for noise limits;
- 7) special earthing requirements.
- f) Connection details
- 1) the details of the number and type of the cables/conductors to the rectifier/incomer terminals;
 - 2) number, type and size of return cables;
 - 3) number, type and size of outgoing track feeder cables to be connected to each track feeder terminal.
- g) Electrical protection requirements
- 1) details on the protection scheme intended;
 - 2) detail of the types (including duties use and categories), numbers and locations of switching devices which the frame leakage system shall trip and details of the inputs to the frame leakage system from remote sites and rectifier equipment;
 - 3) requirements for SCADA (“Supervisory Control And Data Acquisition”) interface;
 - 4) details of busbar alive and track alive indications if required;
 - 5) whether bus-section isolators are required;
 - 6) duties for auto-reclosing.
- h) Auxiliary supply details
- 1) nominal voltage, together with maximum and minimum limits, maximum short circuit and frequency (where relevant) of all auxiliary supplies, including traction voltage, if applicable;
 - 2) rated characteristics of all auxiliary equipment including those on main switching devices;
 - 3) details of intertripping and emergency tripping and intertripping overriding facilities, if required;

A.3 Manufacturer’s tender specification

The following information shall be given in the manufacturer's tender specification.

- a) Identification
- 1) name of the manufacturer or trademark;
 - 2) type designation;
 - 3) reference to the National Standard corresponding to this standard, which the manufacturer declares compliance with;
 - 4) registration number of type test certificates.
- b) Characteristics
- 1) confirmation of compliance with the purchaser's requirements and a list of any non-compliances;
 - 2) confirmation of suitability for use with special service conditions (if specified);
 - 3) rated voltages, including maximum operating limits, for main, auxiliary and control circuits;
 - 4) rated characteristics of the equipment;

- 5) rated insulation voltages and rated impulse voltages for the various parts of the assembly;
- 6) power required at rated voltage for control and auxiliary circuits;
- 7) guaranteed maximum temperature-rises at rated service current I_{Ne} and/or conventional enclosed thermal current I_{the} for the various parts of the assembly at the specified ambient;
- 8) noise levels produced by switching devices when breaking rated service current (6.15);
- 9) rated air pressure and pressure variation limits and air consumption (for devices with pneumatic control);
- 10) access and space requirements for external connections;
- 11) space requirements for operating and maintaining the switchgear, and for removing withdrawable items;
- 12) access required at rear;
- 13) estimated weights of the complete switchgear assembly and of the heaviest transport unit;
- 14) principles of the electric protection scheme envisaged;
- 15) principles of the safety related protections and interlocks.

NOTE The above characteristics are only used where they specifically apply to the application.

c) Documentation

When requested by the purchaser, the following documentation will be supplied:

- 1) general arrangement;
- 2) copy of type test certificates.

The language to be used for documentation shall be agreed between purchaser and manufacturer.

A.4 Information and data to be supplied by the manufacturer during the delivery stage

The following information and data should be supplied by the manufacturer by the delivery stage unless previously contained in catalogues or descriptions supplied at the tender stage.

a) Identification

- 1) manufacturing year and serial number;
- 2) identification of positive, negative and earth busbars and connections.

b) Characteristics

- 1) weights of the complete switchgear assembly and of the heaviest transport unit;
- 2) details of the electric protection scheme envisaged;
- 3) details of the safety related protections and interlocks;
- 4) continuous rating of each auxiliary contact for remote circuits;
- 5) minimum amperage of the fuse(s) (if any) for the auxiliary power supply;
- 6) detail of the equipment, if any, supplied loose for remote installation;
- 7) method of fixing the switchgear assembly to floor;
- 8) details of arrangements for manoeuvrability of functional unit trucks, if any;
- 9) ventilation requirements.

NOTE The above characteristics are only used where they specifically apply to the application.

c) Drawings

When requested by the purchaser, the following documentation should be supplied:

- 1) general arrangement and sectional elevations of switchgear assembly showing overall dimensions and space required for unit withdrawal, maximum shipping dimensions, shipping weight and estimated gross weights and shock loading for floors;
- 2) circuit and schematic diagrams of all circuits;
- 3) schematic diagram of the circuits arranged for testing purposes;
- 4) identification of terminal strips;
- 5) schematic arrangement of the equipment during test and maintenance;
- 6) general arrangement of any floor irons and area to be left unscreened for the contractor to finish and loading details;
- 7) installation, operation and maintenance manuals.

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Annex B (normative)

Method for testing under conditions of arcing due to an internal fault

B.1 Purpose of the test

Annex B applies to metal-enclosed DC switchgear assemblies - hereinafter called assemblies - used in indoor stationary installations.

The test procedure described below is intended:

- to assess the ability of the assembly to limit the risk of personal injury,
- to verify the effectiveness of the design in protecting persons,

in case of an internal arc.

The testing conditions take into account that assemblies are installed in areas restricted to authorized personnel.

NOTE This is equivalent to accessibility class A of IEC 62271-200:2011.

B.2 Characteristics – Rated short-circuit current under internal arcing conditions (I_{Narc})

If a rated short-circuit current under internal arcing conditions I_{Narc} is assigned by the manufacturer to the equipment the value shall be equal to the rated earth fault current I_{Ncwe} . The peak of the short-circuit current value is conventionally assumed to be 1,42 times the prospective sustained short-circuit current (fault of negligible impedance).

NOTE The current level during internal arcing depends on the earthing of the switchboard frame (see IEC 61992-7-1:2006, 6.5.7). High fault currents can be expected where the switchboard frame is:

- directly connected to the return circuit as shown in IEC 61992-7-1:2006, 6.5.7, Figure 4b, or
- connected to substation earth as shown in IEC 61992-7-1:2006, 6.5.7, Figure 4a, and a voltage limiting device is installed between substation earth and the return circuit.

Lower fault currents can be expected where the bedding resistance of the track and the earth resistance limit the fault current.

B.3 Test arrangements

B.3.1 Test specimen

The test shall be carried out on representative samples. In case of an assembly with a continuous main busbar, consisting of extensible (modular) standalone units, the test specimen shall consist of minimum two units connected together as in service.

The following points shall be observed.

- The test shall be carried out on a test specimen not previously subjected to an arcing test or on a specimen cleaned and prepared accordingly. The specimen and the equipment in it may be repaired or replaced before each test.

NOTE Degradation of insulation due to carbonisation or moderate erosion of metal parts is not necessarily considered to render a unit unsuitable for a further test.

- The test specimen shall be placed in an open area and shall be fixed by its designed means.
- Vertical indicators shall be installed all around.

- A ceiling shall be located at a distance of (200 ± 50) mm from the upper part of the test specimen unless differently stated by the manufacturer.

If a test specimen includes a roof according to the following specification, and as shown in Figure B.1, it shall be tested with the roof installed and an additional ceiling is not required. The roof:

- covers the top surface completely, and
- is of a protection degree of IPX1 or higher, and
- is mounted at minimum distance d_c to the top of the assembly of no more than 200 mm.
- The test specimen shall be fully equipped. Earthing and bonding shall be as for normal service.
- Mock-ups of internal components are permitted provided that:
 - they have the same volume and shape as the original items,
 - similar external materials, with any metallic external material is earthed in a similar manner to normal service.
- All doors and covers provided are closed.
- The test specimen shall be earthed at the earthing point provided.
- Secondary devices need not be installed if inside a separate compartment for control circuits. Means for wiring from the control compartment to the compartment under test shall be installed.

B.3.2 Test circuit

A typical diagram of the test circuit is shown in IEC 61992-1:2006/AMD1:2014, Figure A.1, with typical calibration and characteristics shown in IEC 61992-1:2006/AMD1:2014, Figure A.2. The supply source S feeds a circuit comprising adjustable resistors R, adjustable reactors L and the test object A.

If the supply source is not a generator, then the minimum converter pulse number shall be 6 with a minimum supply frequency of 50 Hz.

The test current produced by the test circuit shall have a peak current with the characteristic illustrated as calibration 1 in IEC 61992-1:2006/AMD1:2014, Figure A.2.

NOTE If the waveform of the test current is in accordance with the one illustrated as calibration 1, RMS value of the test current is approximately equal to the value of the prospective sustained short-circuit current (I_{Narc}).

B.3.3 Voltage

The applied voltage of the test circuit shall be equal to the rated voltage U_{Ne} .

B.3.4 Duration of the test

The test duration shall be 150 ms.

B.4 Test procedure

B.4.1 Supply circuit

The test sample is connected and supplied corresponding to the normal service arrangement. The earthing of the enclosure is to be connected to the negative conductor of the supply source.

Infeed and earth connection shall be to the same switchgear panel.

Any device (for example, protection relay or direct overcurrent release) that may automatically trip the circuit before the end of the prospective duration of the test shall be made inoperative or ineffective during the test.

If compartments or functional units are equipped with devices intended to limit the duration of the arc itself by other means (for example, by transferring the current to a metallic short circuit), they shall be made inoperative or ineffective during the test.

B.4.2 Arc initiation

Each compartment containing main supply voltage shall be tested in a typical configuration. Tests with each of the following locations for arc initiation shall be performed:

- main busbar to closest earthed part;
- cable connection to closest earthed part;
- circuit breaker or disconnector to closest earthed part.

The compartment under test and inside the point of initiation shall be located at the furthest point, downstream in the current path from the supply.

NOTE 1 It is assumed that the most onerous conditions are met by using the furthest point downstream.

An additional test on the main busbar shall be performed in the panel next to the panel under test if an open busbar system without or with reduced segregation is used.

NOTE 2 This test is to verify that a possibly different footpoint does not lead to a hazard.

Circuit breakers shall be and remain closed during the tests.

Compartments containing main supply voltage and protected by fuses need to be tested as follows.

- Compartments which contain fuses have to be tested once upstream of the fuse nearest to the operators wall.
- Compartments which are protected by type-tested current-limiting fuses external to the compartment shall be tested with the fuse type that causes the highest cut-off current (let-through current). The actual duration of the current flow will be controlled by the fuses.
- A compartment needs not to be tested if the circuit is protected by a fuse external to the compartment with a rated current of not more than 60 A.

The arc shall be initiated by means of a bare copper ignition wire connected between live part and nearest earthed part.

The copper ignition wire shall have a maximum cross-section with regard to the test current as given in Table B.1 but not smaller than 0,75 mm².

Table B.1 – Sizes of the copper ignition wire

Test current (RMS value) kA	Wire size mm ²
≤ 25	0,75
> 25 ≤ 40	1,0
> 40	1,5

The ignition wire shall be connected to points without solid insulation. Insulation shall not be destroyed, removed or punctured when the ignition wire is connected.

B.4.3 Indicators

B.4.3.1 General

The indicators to be used are pieces of black cotton cloth so arranged that their cut edges do not point towards the test unit. Care should be taken in mounting the indicators to ensure that they do not ignite each other. This can be achieved by fitting them, for example, in a mounting frame of steel sheets (see Figure B.2).

The indicator dimensions shall be about 150 mm × 150 mm. Black cretonne (cotton fabric approximately 150 g/m²) shall be used for the indicators.

The indicators shall be evenly distributed, arranged in a checkerboard pattern, covering 40 % to 50 % of the area (Figure B.3).

B.4.3.2 Fitting of the indicators

Indicators shall be fitted vertically on all sides of the assembly.

They shall be placed, up to a minimum height of 2 000 mm ± 50 mm and a distance of 300 mm ± 15 mm from the assembly, facing all points where gas is likely to be emitted (e.g. joints, inspection windows, doors) (refer to Figure B.4).

The indicators that are fitted vertically to the assembly are measured from:

- the height from the bottom of the assembly, disregarding any item not part of the assembly (e.g. transport facilities);
- the distance from the surface of the assembly, disregarding protruding elements not expected to influence the evacuation of hot gases (e.g. handles or transport facilities).

If a test specimen includes a roof indicators shall be placed as shown in Figure B.1.

B.4.4 Repetition of the test

A test shall be repeated when the arc extinguishes within the first half of the full intended test duration without being ignited again. The same point of initiation shall be used as for the first test. A further repetition is not required.

B.5 Assessment of the test

The following criteria are used to assess the characteristics under arcing conditions.

Criterion 1:

- Correctly secured doors, covers, etc., do not open.
- Deformations are accepted, provided that no part comes as far as the position of the indicators on every side. The assembly does not need to comply with its IP code after the test. To extend the acceptance criterion to an installation mounted closer to a wall than the indicators during test, the permanent deformation shall be less than the intended distance to the wall.

Criterion 2:

- No fragmentation of the enclosure occurs.
- No ejection of fragments or of other parts of the switchgear of an individual mass of 60 g or more occurs.

- Objects of an individual mass of 60 g or more falling to the floor in the immediate vicinity of the switchgear are accepted (this means between the switchgear and the indicator rack).

Criterion 3:

- Arcing does not cause holes by burning through the external surfaces up to a height of 2 000 mm.

NOTE Holes in the enclosure, which are created after the duration of test by other effects than burning through caused by the internal arc, are disregarded.

Criterion 4:

- The indicators arranged vertically do not ignite (indicators ignited as a result of paint or stickers burning are excluded from this assessment).

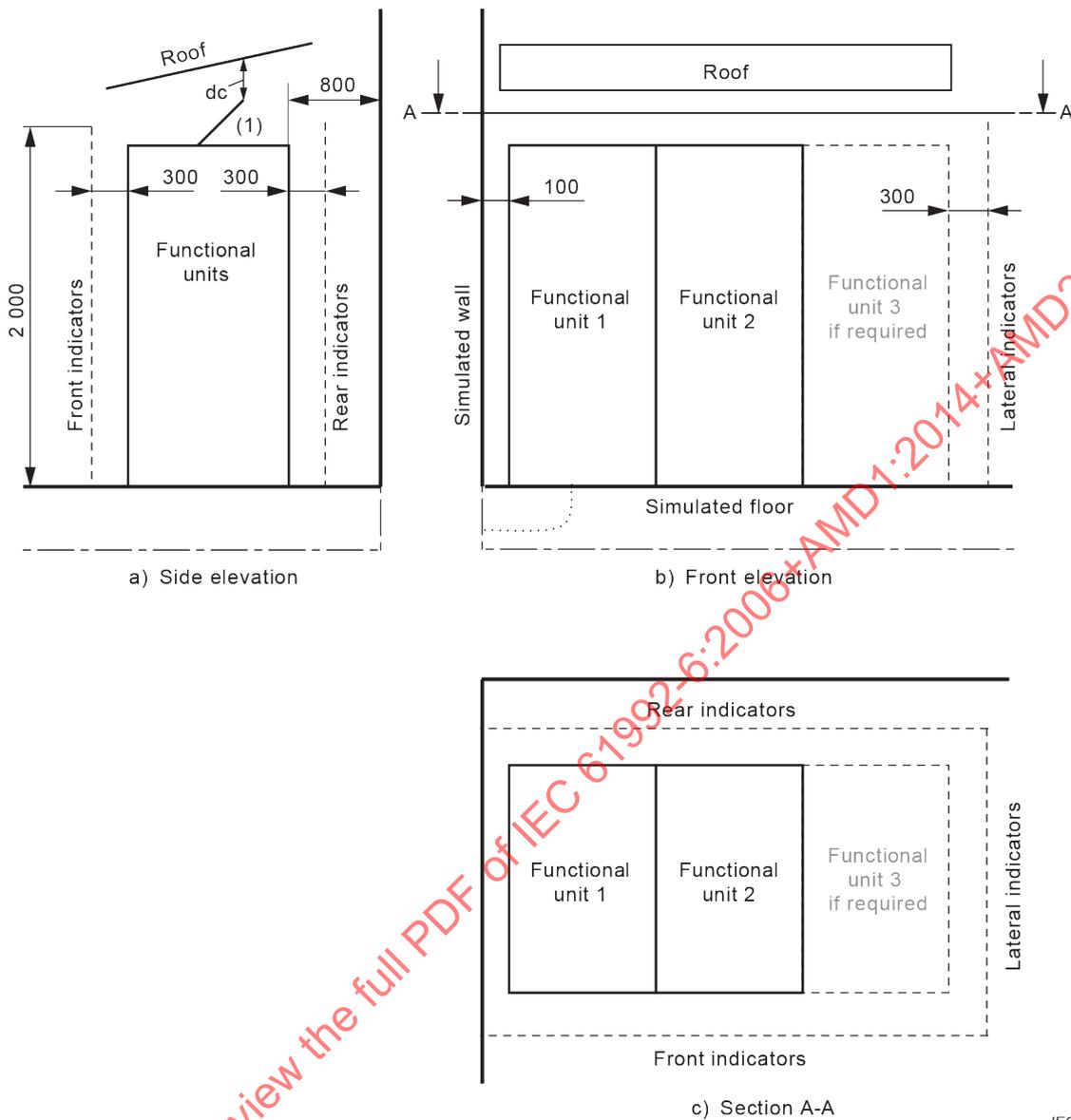
Criterion 5:

- The enclosure remains connected to its earthing point. Visual inspection is generally sufficient to assess compliance. In case of doubt, the continuity of the earthing connection shall be checked.

B.6 Test report

The following information shall be given in the test report:

- rating of the tested assembly;
- description of the tested assembly with a drawing showing the main dimensions, details relevant to the mechanical strength, the arrangement of the pressure relief system (e.g. flaps and ducts if any) and the method of fixing the assembly to the floor and the walls;
- arrangement of the test connections and the point(s) of initiation of the arc(s);
- point and method of initiation of the internal fault;
- for the prospective and the test current:
 - prospective sustained short-circuit current;
 - peak prospective value of the short-circuit current;
 - test duration;
 - Joule integral;
 - arc energy;
- oscillograms showing currents and voltages;
- assessment of the test results for personal protection against each of the criteria 1 to 5 of Clause B.5;
- photographs, before and after test:
 - assembly by its own on the test stand including the external surface(s) of the compartment(s) under test;
 - assembly with the arrangement of the indicators and ceiling (if any);
 - earthing connection;
 - location of arc initiation.

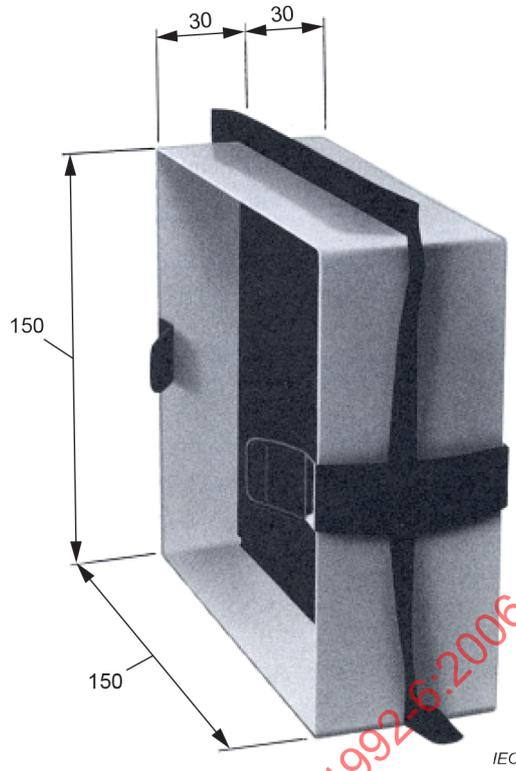


Key

(1) open pressure relief flap

d_c distance to ceiling

Figure B.1 – Room simulation and indicator positioning, functional unit fitted with roof



NOTE Exposed edges of the indicator material may be taped or covered.

Figure B.2 – Mounting frame for vertical indicators

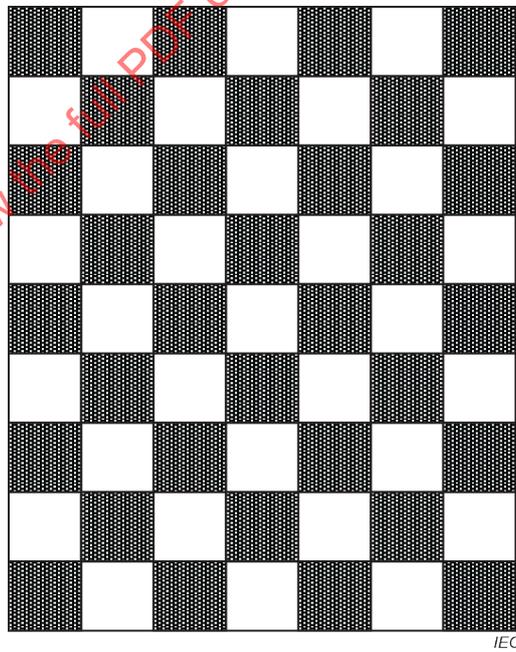
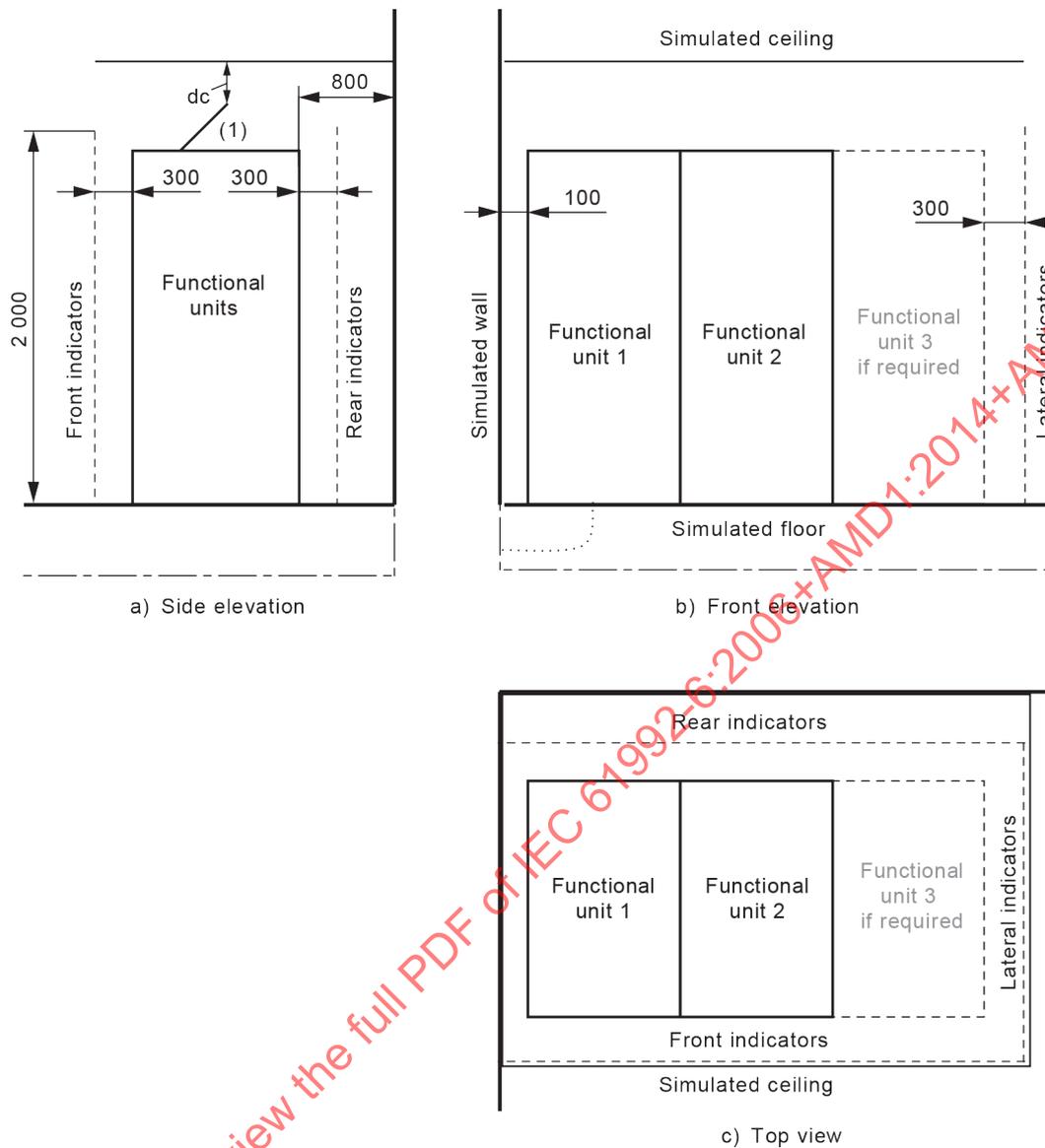


Figure B.3 – Indicators arranged in a checkerboard pattern



Key

(1) open pressure relief flap

d_c distance to ceiling

Figure B.4 – Room simulation and indicator positioning, functional unit of any height

FINAL VERSION

**Railway applications – Fixed installations – DC switchgear –
Part 6: DC switchgear assemblies**

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CONTENTS

1	Scope	6
2	Normative references	6
3	Terms and definitions	6
4	Service requirements	7
5	Characteristics of the assemblies	7
6	Construction characteristics	7
6.1	General	7
6.2	Insulation requirements	8
6.3	Primary connections	9
6.4	Location of the primary connections	9
6.5	Earthing	9
6.5.1	Earthing of the main circuit	9
6.5.2	Earthing of the enclosure	9
6.6	Degree of protection and internal fault	10
6.6.1	Protection against approach to live parts and contact with moving parts	10
6.6.2	Internal arcing	10
6.7	Covers and doors	11
6.8	Inspection windows	11
6.9	Ventilating openings	11
6.10	Partitions and shutters	11
6.10.1	General	11
6.10.2	Partitions	12
6.10.3	Shutters	12
6.10.4	Isolating distances	12
6.11	Interlocks	13
6.12	Temperature-rises	13
6.13	Dielectric strength	14
6.14	Painting and finishing	14
6.15	Noise emission	14
6.16	Cooling and heating	14
6.17	Operating temperature of auxiliary and control equipment	14
6.18	Rated short-time withstand current of busbars	14
7	Information and marking	14
7.1	Information	14
7.2	Marking	15
8	Tests	15
8.1	General	15
8.2	List of the applicable tests	16
8.3	Performance of tests	16
8.3.1	Verification of conformity to the manufacturing drawings and to characteristics of the assembly	16
8.3.2	Operation test	16
8.3.3	Dielectric tests	17
8.3.4	Short-time withstand current tests	19
8.3.5	Mechanical operation test	20

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8.3.6	Verification of the degree of protection	21
8.3.7	Temperature-rise tests	21
8.3.8	Electrical operation test	23
8.3.9	Internal arc test	23
Annex A (informative)	Information required	24
A.1	General	24
A.2	Procurement specification	24
A.3	Manufacturer's tender specification	25
A.4	Information and data to be supplied by the manufacturer during the delivery stage	26
Annex B (normative)	Method for testing under conditions of arcing due to an internal fault	28
B.1	Purpose of the test	28
B.2	Characteristics – Rated short-circuit current under internal arcing conditions (I_{Narc})	28
B.3	Test arrangements	28
B.3.1	Test specimen	28
B.3.2	Test circuit	29
B.3.3	Voltage	29
B.3.4	Duration of the test	29
B.4	Test procedure	29
B.4.1	Supply circuit	29
B.4.2	Arc initiation	30
B.4.3	Indicators	31
B.4.4	Repetition of the test	31
B.5	Assessment of the test	31
B.6	Test report	32
Figure 1	– Test arrangement for short-time current withstand test on busbars	20
Figure 2	– Test arrangement for temperature-rise test on main circuits	22
Figure 3	– Test arrangement for temperature-rise test on the busbars	22
Figure B.1	– Room simulation and indicator positioning, functional unit fitted with roof	33
Figure B.2	– Mounting frame for vertical indicators	34
Figure B.3	– Indicators arranged in a checkerboard pattern	34
Table 1	– Degrees of protection	10
Table 2	– List of applicable tests	16
Table B.1	– Sizes of the copper ignition wire	30

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RAILWAY APPLICATIONS –
FIXED INSTALLATIONS –
DC SWITCHGEAR –**

Part 6: DC switchgear assemblies

FOREWORD

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This consolidated version of the official IEC Standard and its amendments has been prepared for user convenience.

IEC 61992-6 edition 1.2 contains the first edition (2006-02) [documents 9/891/FDIS and 9/913/RVD], its amendment 1 (2014-04) [documents 9/1792/CDV and 9/1852/RVC] and its amendment 2 (2020-05) [documents 9/2542/CDV and 9/2584A/RVC].

This Final version does not show where the technical content is modified by amendments 1 and 2. A separate Redline version with all changes highlighted is available in this publication.

International Standard IEC 61992-6 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

IEC 61992 consists of the following parts, under the general title *Railway applications – Fixed installations – DC switchgear*:

- Part 1: General
- Part 2: D.C. circuit breakers
- Part 3: Indoor d.c. disconnectors, switch-disconnectors and earthing switches
- Part 4: Outdoor d.c. disconnectors, switch-disconnectors and earthing switches
- Part 5: Surge arresters and low-voltage limiters for specific use in d.c. systems
- Part 6: D.C. switchgear assemblies
- Part 7-1: Measurement, control and protection devices for specific use in d.c. traction systems – Application guide
- Part 7-2: Measurement, control and protection devices for specific use in d.c. traction systems – Isolating current transducers and other current measuring devices
- Part 7-3: Measurement, control and protection devices for specific use in d.c. traction systems – Isolating voltage transducers and other voltage measuring devices

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

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RAILWAY APPLICATIONS – FIXED INSTALLATIONS – DC SWITCHGEAR –

Part 6: DC switchgear assemblies

1 Scope

This part of IEC 61992 covers d.c. metal-enclosed and non-metallic enclosed switchgear assemblies used in indoor stationary installations of traction systems, with nominal voltage not exceeding 3 000 V.

It is intended that individual items of equipment, for example circuit breakers, housed in the assembly are designed, manufactured and individually tested (simulating the enclosure when necessary) in accordance with their respective parts of IEC 61992 or, when appropriate, with another applicable standard.

NOTE 1 The requirements covered in this part of IEC 61992 are those concerning the assembly as such, its enclosure and the mutual influence of the equipment enclosed.

NOTE 2 EMC requirements are covered by IEC 62236-5 and additional requirements concerning dependability (RAMS) are covered by IEC 62278.

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.

IEC 60243-1:1998, *Electrical strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 61992-1:2006+A1:2014, *Railway applications – Fixed installations – DC switchgear – Part 1: General*

IEC 61992-2:2006+A1:2014, *Railway applications – Fixed installations – DC switchgear – Part 2: DC circuit-breakers*

IEC 61992-3:2006, *Railway applications – Fixed installations – DC switchgear – Part 3: Indoor d.c. disconnectors, switch-disconnectors and earthing switches*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61992-1 and the following 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 <http://www.iso.org/obp>

3.1

internal arc

arcing within a switchgear assembly arising from a fault between active parts and/or between active parts and other conductive parts

3.2

rated short-circuit current under internal arcing conditions

I_{Narc}

current, during the test duration of 150 ms, indicating the maximum allowable value of sustained short-circuit current at the terminals of the incoming unit for which the requirements of this test specification are fulfilled

Note 1 to entry: The value is the maximum value of the prospective sustained short-circuit current.

3.3

compartment under test

compartment of a switchgear assembly which is subject to an internal arc test

4 Service requirements

Normal service requirements are detailed in Clause 4 and Annex B of IEC 61992-1 for indoor installations. In this standard, the pollution degree PD4 and overvoltage categories (see notes to Table 1 of IEC 61992-1) as described in EN 50124-1 are considered to be the normal condition.

5 Characteristics of the assemblies

The main characteristics of an assembly shall be indicated in the procurement specification as follows:

- a) type of the assembly enclosure;
- b) list of functional units enclosed;
- c) rated insulation voltages;
- d) rated values of the equipment enclosed as required in relevant standards;
- e) if constructed for an earth fault protection;
- f) detailed protection and control requirements (see IEC 61992-7).

Other important characteristics are listed in Clause A.2.

6 Construction characteristics

6.1 General

Enclosures are either metallic or non-metallic. Non-metallic enclosed switchgear shall not be used for nominal voltages above 1,5 kV.

All requirements specified herein also apply when both conductive and insulating materials are used, except for insulating clearances which shall be designed and tested as appropriate.

A cell made of masonry shall not be considered as an enclosure, as far as this standard is concerned.

The floor surface may be considered as part of an enclosure. The measures to be taken in order to obtain the degree of protection provided by floor surfaces shall be subject to an agreement between purchaser and supplier.

The walls of a room shall not be considered as parts of the enclosure.

Switchgear assemblies and relevant enclosures shall be designed so that normal service, inspection and maintenance operations, earthing of connected cables or busbars, locating of cable faults, voltage tests on connected cables or other apparatus and the elimination of electrostatic charges, can be carried out easily and safely.

All materials used shall be of the quality and of the class most suitable for working under the conditions specified. Special attention is to be paid to its ability to withstand moisture and fire: unless fire behaviour Class F0 is allowed (see Annex B of IEC 61992-1), materials used shall be metallic or of the self-extinguishing type, so that the risk of propagation of fire from one cubicle or compartment to another is minimised.

The selection of materials and the construction of the assembly shall be such that corrosion due to atmospheric and electrolytic effects are minimised.

All identical devices, forming part of an assembly for a given use and with the same characteristics, shall be interchangeable.

Withdrawable switching devices shall be prevented from insertion into functional units on the same switchgear assembly, having a different function or higher current ratings.

Sufficient space shall be provided inside the compartments for the entry and termination of incoming cables without their minimum bending radii being infringed.

The detachable parts of the protection enclosures shall be firmly attached to the fixed parts as specified in 6.7. Accidental untightening or detachment shall not occur because of the operation of the equipment.

All apparatus and connections for the safe operation, control and protection of the equipment concerned, shall be provided whether or not specifically mentioned. The equipment shall be adequately earthed, insulated, screened or enclosed as may be appropriate to ensure the protection of the equipment and safety of those concerned in its operation and maintenance.

Control and auxiliary circuits and contacts shall comply with the requirements of 5.2 of IEC 61992-1.

All components contained within the enclosure shall comply with their relevant standards.

6.2 Insulation requirements

Test voltages and clearances are given in Table 1 of IEC 61992-1. Recommended values for creepage distances are given in Annex D of IEC 61992-1.

The adverse effect of ionisation (due to arcs) on the clearances of other equipment in the assembly shall be taken into account. The minimum clearances between the arc chute of a switching device and metallic or non-metallic parts (i.e. above the arc chute and to the sides) shall be in accordance with those given by the switching device manufacturer.

Insulating material used to fully or partially line a metallic enclosure shall be firmly secured to the enclosure.

In case of withdrawable units, where access within the enclosure is required during maintenance operations, the busbars and all other conductors shall be separated by a barrier. Openings through such a barrier for the circuit and busbar connectors, etc. shall be shuttered and capable of being locked closed.

6.3 Primary connections

Non-withdrawable functional units may be equipped with fixed, removable (bolted or clamped) connectors. Withdrawable functional units may be equipped with plug-in connectors.

6.4 Location of the primary connections

In case of non-withdrawable assemblies, the terminals for the primary connections shall be accessible with the functional units as in normal operating conditions.

6.5 Earthing

NOTE Depending on the d.c. system earthing requirements, "earthing" means connection either to earth or to the return circuit.

6.5.1 Earthing of the main circuit

To ensure safety during maintenance work, all parts of the main circuit to which access is required or provided shall be capable of being earthed through suitable means. This does not apply to those parts, which are withdrawable or removable and which become accessible after being separated from the switchgear.

A withdrawable part, however, shall not be removed from the enclosure unless capacitors on it have been discharged to safe values.

In case of withdrawable circuit breakers, the earth connection shall be made before the shutters are opened and the shutters shall be closed before the earth connection is disconnected.

Earthing switches shall comply with IEC 61992-3. The requirement that it shall be possible to know the operating position of the earthing switch is met if one of the following conditions is fulfilled:

- the isolating distance is visible;
- the position of the earthing switch is clearly visible and the position corresponding to full connection and full isolation are clearly identified;
- the position of the earthing switch is indicated by a reliable indicating device.

6.5.2 Earthing of the enclosure

The purchaser shall indicate in the enquiry how to earth the enclosure (e.g. the return circuit or to earth) in accordance with 6.5.8 of IEC 61992-7-1.

The metallic parts of the enclosures, such as frames, structure and fixed elements, shall be connected to each other and to a suitable earthing terminal, placed in an accessible position, in order to allow the connection to the main earth system of the installation. The earthing terminal shall be suitably protected against corrosion. The standard earth symbol shall be clearly and permanently marked.

An earthing conductor shall be provided extending the whole length of the metal-enclosed switchgear to connect the individual earthing terminals. The current density of the earthing conductor, if of copper, shall not exceed 200 A/mm² based on a specified earth fault of 10 000 A for 1 s; therefore, its cross-section area shall be not less than 50 mm². The earthing conductor shall be terminated by a clearly and permanently marked main earthing terminal.

The continuity of the earth system shall be ensured taking into account the thermal and mechanical stresses caused by the magnitude and duration of the current it may have to carry.

The purchaser shall indicate in the enquiry if the earthing system shall differ from the above.

The purchaser shall specify in the enquiry the maximum earth fault current. The standard value for the duration is 0,25 s due to the typical breaking time of the a.c. rectifier circuit breaker(s). If the purchaser requires a longer duration, he shall specify this in the enquiry.

The terminals and connections shall be adequately dimensioned for the earth fault current.

The enclosure of each functional unit shall be connected to this earthing conductor. All the metallic parts within a functional unit and not belonging to a main, control or auxiliary circuit, shall also be connected to the earthing conductor directly or through metallic structural parts:

In the latter case, earthing of said elements, such as walls and doors of compartments, may be fulfilled by normal construction elements, ensuring an adequate electrical continuity and suitable dimensioning. For any bolts or similar fixing used for earth continuity, the maintenance instructions shall state the requirements for cleaning surfaces and ensuring tightness.

The metallic parts of a withdrawable part which are normally earthed in the service position, shall also remain earth-connected in the test and disconnected positions and between each position.

The purchaser shall indicate in the enquiry if the earthing system deviates from the requirements stated in this subclause.

6.6 Degree of protection and internal fault

6.6.1 Protection against approach to live parts and contact with moving parts

For metal-clad and for compartmented switchgear, the degree of protection shall be specified. If required, separate degrees of protection for doors and walls, for partitions and for the roof of the enclosure shall be specified. For cubicle switchgear, it is only necessary to specify the degree of protection for the enclosure.

The degree of protection against contact of persons with live parts of auxiliary circuits and with any moving parts (other than smooth rotating shafts and moving linkages) shall be indicated by means of the designation specified in Table 1 below, taken from IEC 60529.

Normally, no degree of protection is provided for indoor switchgear assemblies against ingress of water.

Table 1 – Degrees of protection

Degree of protection	Protection against approach of live parts and contact with moving parts
IP20	By fingers or similar objects of diameter greater than 12 mm
IP30	By tools, wires, etc. of diameter of thickness greater than 2,5 mm
IP40	By tools, wires, etc. of diameter of thickness greater than 1,0 mm
NOTE 1 The first characteristic numeral indicates the degree of protection provided by the enclosure against the ingress of solid bodies and approach to live parts for all given enclosure conditions.	
NOTE 2 Protection against ingress of water is given by the second numeral.	

6.6.2 Internal arcing

Failure within the enclosure of switchgear due to a defect or an exceptional service condition or mal-operation may initiate an exceptional internal arc.

Ventilating openings and vent outlets shall be arranged in such a way that gas or vapour escaping under pressure does not endanger the operator.

A manufacturer may assign a rated short-circuit current under internal arcing conditions I_{Narc} to the equipment. Requirements are given in Clause B.2.

6.7 Covers and doors

Covers and doors which are part of the enclosure shall be metallic if the enclosure is metallic. When they are closed, they shall provide the degree of protection specified for the enclosure.

Covers or doors shall not be made of woven wire mesh, expanded metal or similar. When ventilating openings and vent outlets are incorporated in the cover or door, reference is made to 6.9.

Two categories of covers or doors are recognized with regard to access to compartments at main circuit potential:

- a) those which need not to be opened for the normal purposes of operation or maintenance (fixed covers): it shall not be possible for them to be opened, dismantled or removed without the use of tools or other provisions which may be required by the purchaser;
- b) those which need to be opened for the normal purposes of operation (removable covers, doors): these shall not require tools for their opening or removal; they shall be provided with locking facilities (for example provisions for padlocks), unless the safety of persons is assured by a suitable interlocking device.

NOTE It is recommended, with metal-clad or compartmented switchgear, that doors giving access to live parts be suitable for opening only when the part of the exposed main circuit contained in the compartment being made accessible is dead. Equivalent provisions may also be provided.

6.8 Inspection windows

Inspection windows shall provide at least the degree of protection specified for the enclosure.

They shall be covered by a transparent sheet of mechanical strength comparable to that of the enclosure.

The insulation between live parts of the main circuit and the inspection windows shall withstand the test voltages specified in Table 1 of IEC 61992-1.

6.9 Ventilating openings

Ventilating openings shall be so arranged or shielded that the same degree of protection as that specified for the enclosure is obtained. Such openings may make use of wire mesh or the like, provided that it is of suitable mechanical strength.

6.10 Partitions and shutters

6.10.1 General

Partitions and shutters shall provide at least the degree of protection specified in Table 1.

Partitions and shutters made of insulating material shall meet the following requirements:

- a) the insulation between live parts of the main circuit and the accessible surface of insulating partitions and shutters shall withstand the test voltages specified in Table 1 of IEC 61992-1;
- b) apart from mechanical strength, the insulating material shall withstand the test voltages specified in item a); the appropriate test method given in IEC 60243-1 shall be applied;

- c) if a leakage current reaches the accessible side of the insulating partitions and shutters by a continuous path over insulating surfaces or by a path broken only by small air gaps, this current shall be not greater than 0,5 mA under the specified test conditions (see 8.3.3.1 a)).

Openings in the enclosure of the switchgear assembly and in partitions of metal-clad or compartmented switchgear, through which contacts of removable parts engage fixed contacts, shall be provided with automatic shutters properly operated in normal service operations to ensure the protection of persons in any of the positions defined in 3.3.24 to 3.3.27 of IEC 61992-1.

If maintenance requirements imply that one set of fixed contacts shall be accessible through opened shutters, all the shutters shall be provided with means of locking them independently in the closed position or it shall be possible to insert a screen to prevent the live set of the fixed contacts being exposed.

Conductors other than busbars passing through metallic partitions are insulated by bushings or other equivalent means and the openings may be provided by bushings or shutters having non-metallic parts.

6.10.2 Partitions

Partitions of metal-clad switchgear shall be metallic and earthed.

Partitions of compartmented and cubicle switchgear may be non-metallic, provided (unless otherwise agreed between purchaser and supplier) they do not become part of the enclosure with the removable part in any of the positions defined in 3.3.25 to 3.3.27 of IEC 61992-1. If partitions become part of the enclosure with the removable part in any of these positions, they shall be of the same material as the enclosure and shall provide the degree of protection specified for the enclosure. Metallic partitions shall be earthed.

NOTE 1 A partition becomes part of the enclosure, if it is accessible in any of the positions defined in 3.3.25 to 3.3.27 of IEC 61992-1.

NOTE 2 If a door which can be closed in the positions defined in 3.3.25 to 3.3.27 of IEC 61992-1 is provided, the partition behind the door is not considered to be a part of the enclosure.

6.10.3 Shutters

The shutters of all types of switchgear assemblies may be either metallic or non-metallic.

If shutters are of insulating material, they shall not become part of the enclosure. If shutters are metallic, they shall be earthed and, if they become part of the enclosure, they shall provide the degree of protection specified for the enclosure.

6.10.4 Isolating distances

The devices for ensuring the isolating distance between the main circuit conductors are considered to be disconnectors which shall comply with IEC 61992-3, except for the mechanical operation test (see 8.3.5).

The requirement that it shall be possible to know the operating position of the disconnector is met if one of the following conditions is fulfilled:

- the isolating distance is visible;
- the position of the withdrawable part, in relation to the fixed part, is clearly visible and the positions corresponding to full connection and full isolation are clearly identified;
- the position of the disconnector is indicated by a reliable indicating device.

Any removable part shall be so attached to the fixed part that its contacts will not open inadvertently due to forces which may occur in service, in particular those due to short circuit.

The dielectric requirements stated in 6.2 shall be observed.

6.11 Interlocks

Interlocks between different components of the equipment are provided for reasons of safety and for convenience of operation. The following provisions are mandatory for main circuits:

a) Switchgear with removable parts

The withdrawal or engagement of a circuit breaker, switch, disconnecter or contactor shall be impossible unless it is in the open position.

The operation of a circuit breaker, switch, disconnecter or contactor shall be impossible unless it is in the service, disconnected, removed, test or earthing position.

It shall be impossible to close the circuit breaker, switch, disconnecter or contactor in the service position unless it is connected to the auxiliary and control circuit, unless it is designed to open automatically without the use of a separate auxiliary and control circuit.

b) Switchgear without removable parts and provided with disconnectors

Interlocks shall be provided to prevent operation of disconnectors under conditions other than those uses for which they are intended (see IEC 61992-3). The operation of a disconnecter shall be impossible unless the associated circuit breaker, switch or contactor is in the open position. No interlock is required if all currents (including fault currents) in the circuit to be switched on or off, are within the making and breaking capacity of the disconnecter.

The operation of the circuit breaker, switch or contactor shall be impossible unless the associated disconnecter is in the closed, open or earthing position (if provided).

The provision of alternative interlocks shall be subject to agreement between purchaser and supplier. The supplier shall give all necessary information on the character and function of interlocks.

Earthing switches having a short-circuit making capacity less than the peak short circuit current \hat{I}_{ss} of the circuit shall be interlocked with the associated disconnectors.

Apparatus installed in main circuits, the incorrect operation of which can cause damage or which are used for assuring isolating distances during maintenance work, shall be provided with locking facilities (for example provision of padlocks).

NOTE Whenever practical, preference should be given to mechanical interlocks.

6.12 Temperature-rises

Maximum temperature-rises are detailed in Clause 6 of IEC 61992-1.

These temperature-rises shall not be exceeded for operation at rated service current and/or conventional thermal current I_{Ne} or I_{the} and at overloads as specified by the purchaser for normal service conditions as specified in Annex B of IEC 61992-1. The effects on temperature-rise caused by adjacent functional units and any permanently energized anti-condensation heaters shall be taken into consideration.

In addition, the auxiliary and control circuits, as well as the auxiliary devices, shall carry their conventional thermal current (for switching devices) or their rated service current (for other equipment).

Through faults may produce temperature-rises in excess of those mentioned above, but shall not cause permanent damage or distortion in the switchgear assembly.

6.13 Dielectric strength

Dielectric withstand strength and isolating distances shall conform to the requirements specified in 4.2 of IEC 61992-1.

When it is not practical to disconnect the cable for the dielectric tests from the switchgear assembly, those parts which remain connected to the cable shall be capable of withstanding the cable test voltages specified for the cables.

6.14 Painting and finishing

Steelwork (other than stainless steel) and other materials of the enclosure shall be treated in accordance with an approved type of corrosion protection.

6.15 Noise emission

Noise emission from all equipment shall be minimized. The level of the noise emission during the breaking of the rated normal service current I_{Ne} shall be indicated by the supplier, if requested.

The method of measuring is to be indicated.

6.16 Cooling and heating

All equipment shall be naturally air cooled unless otherwise agreed between purchaser and supplier.

Space heaters, positioned to prevent the accumulation of moisture on internal components, shall be provided where necessary for the service conditions specified by the purchaser.

6.17 Operating temperature of auxiliary and control equipment

Auxiliary and control equipment, when installed in the switchgear, shall be suitable for operating at rated performance at the recorded local ambient temperature within their enclosure.

6.18 Rated short-time withstand current of busbars

Busbars shall have a short-time withstand current rating (I_{Ncw}).

NOTE The I_{Ncw} rating is the same value as the I_{Nss} rating of the line circuit breaker for a time duration of 0,25 s.

By mutual agreement between manufacturer and purchaser, a tie interconnecting station switchboard may be supplied with a reduced I_{Ncw} busbar rating, as I_{cw} fault current is normally of lower magnitude than at a substation. If a tie station needs to be upgraded to a rectifier substation at a later date, then the purchaser shall indicate this at the time of the enquiry and order and shall define the I_{Ncw} requirement.

7 Information and marking

7.1 Information

Both parties shall exchange any necessary information in order to assure that the switchgear assembly is suitable for the intended duty. A summary of this information is given in Annex A.

7.2 Marking

All necessary labelling shall be indelibly marked and provided as necessary for the purposes of safety, identification, instruction and information. Lifting attachments and the earth terminal shall be marked by their symbols. The following indications shall be placed on the assembly enclosure on one or more rating plates in an accessible visible position on a non-removable structure.

- a) name of the manufacturer or trademark;
- b) the reference to this part of IEC 61992;
- c) type designation;
- d) serial number designation;
- e) year of manufacture;
- f) rated voltage U_{Ne} of main circuits;
- g) rated voltage(s) U_{Ne} of auxiliary and control circuits;
- h) rated service current I_{Ne} of busbars and main circuits;
- i) rated short-circuit current I_{Nss} ;
- j) rated short-time withstand current of busbars I_{Ncw} ;
- k) rated earth fault current I_{Ncwe} ;
- l) degree of protection for the enclosure and partitions (if different);
- m) compliance with service requirements differing from those indicated as normal (see Clause 4 of IEC 61992-1 – preferably by a separate label).

8 Tests

8.1 General

General requirements concerning tests are shown in Clause 7 of IEC 61992-1.

The tests shall be carried out as described in the relevant clauses of this standard and, as far as applicable, of IEC 61992-1. For procedural matters not covered in either of those standards, reference may be made to other IEC or European Standards covering similar equipment.

Unless otherwise indicated, the tests shall be performed at the rated service values: current, voltage, frequency (if applicable), air pressure (if applicable). The same applies for the whole of the assembly (main, control and auxiliary) and in accordance with the values indicated in Clause 5.

Unless explicitly specified, the test variables shall be within the tolerances indicated in Table 6 of IEC 61992-1.

For all the tests, the ambient temperature is measured and recorded in the test report.

The tests detailed in this standard are only those verifying the correctness of the design of the switchgear assembly as such, as well as the correctness of the assembling and cabling.

Each component shall be tested before being assembled, in accordance with the applicable standard.

When a manufacturer is supplying both the internal equipment and the switchgear assembly, he may perform combined tests to test the equipment in its final compartment (or in an equivalent compartment), so avoiding duplication in tests.

8.2 List of the applicable tests

Based on the above requirements, the applicable tests are summarized in Table 2.

Table 2 – List of applicable tests

Test description	Kind	Subclause
Verification of conformity to the manufacturing drawings and to characteristics of assembly	Routine	8.3.1
Operation	Routine	8.3.2
Dielectric withstand: – impulse withstand	Type	8.3.3.2
– power-frequency voltage	Type and routine	8.3.3.3
Short-time withstand current		
– main circuits	Type	8.3.4.1
– busbars	Type	8.3.4.2
– earthing circuits	Type	8.3.4.3
Mechanical operation	Type	8.3.5
Verification of degree of protection	Type	8.3.6
Temperature-rise	Type	8.3.7
Electrical operation	Type	8.3.8
Internal arc test	Type	8.3.9

Routine and type tests are mandatory tests if related characteristics are assigned to the equipment.

8.3 Performance of tests

8.3.1 Verification of conformity to the manufacturing drawings and to characteristics of the assembly

8.3.1.1 Verification of conformity to the manufacturing drawings

The assembly to be tested shall be representative of the manufactured type and shall correspond in all essential details to the manufacturing drawings.

8.3.1.2 Measurement of the resistance of the main circuits

Resistance measurements of the main circuits shall be made with the assembly at ambient temperature. This measurement shall confirm correctness in the assembling operations, by comparison with the resistance values recorded during tests on similar components or assemblies.

8.3.2 Operation test

Operation tests are made to ensure that the switching devices and removable parts comply with the prescribed operating conditions and that the mechanical interlocks work properly.

This test is carried out at the laboratory ambient temperature, in accordance with 7.3.1 of IEC 61992-1.

Auxiliary and control circuits will be supplied at their rated voltage (if in parallel) or at a suitable current (if in series).

Each switching device, removable part, mechanical interlock and sequence of electrical or mechanical operations shall be tested with five operations or five attempts in each direction. The test shall include visual checking.

The purchaser may require that these tests are repeated on site after installation.

8.3.3 Dielectric tests

8.3.3.1 Test conditions

Reference shall be made to 7.5 of IEC 61992-1.

The test values shall be as specified in Table 1 of IEC 61992-1.

The enclosure to be tested shall be mounted complete as in normal service and under the ambient conditions stated in Annex B of IEC 61992-1.

Because of the great variety of designs, it is not feasible to give specific indications of the tests to be performed on the main circuit, but, in principle, they shall cover the following tests.

a) Between main circuit and earth

The test voltage specified shall be applied by connecting the positive conductor of the main circuit to the high-voltage terminal of the test supply. The negative conductor of the main circuit and the auxiliary circuits are to be connected to the earthing conductor or the frame and to the earth terminal of the test supply. The test shall be repeated with the negative conductor energised and the positive conductor to earth.

The dielectric test shall be made with all switching devices open and all removable parts in their service position.

Electrical connections shall bridge the contacts of switching devices.

For these dielectric tests, current transducers, any direct overcurrent release or overcurrent indicator and the cable terminal boxes (placed, if necessary, in several configurations if in doubt about the most unfavourable situation) are recommended to be installed as in normal service.

Attention shall be paid to the fact that transducers (or a.c. transformers if any), lightning arresters, fuses and electronic equipment may not be suitable for a test voltage applied at the compartment or assembly terminals and shall be disconnected, earthed, shorted out, as applicable, before testing and separately tested.

Moreover, when the equipment is connected to the return circuit or to earth, this connection shall be removed before testing at the rated insulation level of the switchgear.

Inspection windows, partitions and shutters of insulating material shall be covered on the side accessible during operation and maintenance, in the most unfavourable situation for the test, with a circular or square metal foil having an area as large as possible but not exceeding 0,01 m², which shall be connected to earth. In case of doubt about the most unfavourable situation, the test shall be repeated with different situations. For convenience of testing, subject to agreement between purchaser and supplier, more than one metal foil may be applied simultaneously or larger parts of the insulating material may be covered.

b) Across the isolating distance

Each isolating distance of the main circuit shall be tested using the test voltages specified in Table 1 of IEC 61992-1 and to comply with the requirements of 6.2. The isolating distance may be the distance between the two parts of the main circuit intended to be connected by a removable or withdrawable part.

If, in the disconnected position, an earthed metallic shutter is interposed between the disengaged contacts to ensure segregation, the gap between the earthed metallic shutter and the live parts shall withstand only the test voltages required to earth.

If, in the disconnected position and, where provided, test position, there is no earthed metallic shutter or partition between the fixed part and the withdrawable part, the test voltages specified across the isolating distance shall be applied

- between the fixed and moving isolating contacts intended to engage, and
- between the fixed isolating contact on busbar side and the fixed isolating contact on the circuit side. Both the direct isolating distance between fixed isolating contacts and the isolating distance established through the closed withdrawable switching part shall be tested.

When specified by the purchaser, the withstand performance between the busbar side and the circuit side shall be proved using test voltages specified across isolating distance with a withdrawable circuit breaker in the service position and open.

8.3.3.2 Impulse withstand voltage test

This type test is applicable to those circuits in switchgear assemblies having a rated insulation voltage exceeding 2 500 V.

The switchgear shall be impulse tested in accordance with 7.5.1 of IEC 61992-1. Three positive and three negative pulses shall be applied and there shall be no flashovers. At the conclusion of the test, a power frequency withstand test shall be performed in accordance with the requirements of 8.3.3.3.

Voltage transducers, transformers, fuses, etc. (see 8.3.3.1 a)) may be replaced by replicas reproducing the field configuration of high-voltage connections.

Overvoltage protective devices shall be disconnected or removed. Current transducer secondaries shall be short-circuited and earthed.

During the impulse voltage tests, the earthed terminal of the impulse generator shall be connected to earth and to the metal enclosures, if any. Except during the tests in accordance with 8.3.3.1 b), the mid point or another intermediate point of the voltage source shall be connected to earth and to the metal enclosure so that the voltage appearing between any of the live parts and the enclosure does not exceed the test voltage specified in 8.3.3.1 a).

8.3.3.3 Power-frequency voltage withstand test for main circuit and auxiliary circuits

This test is a routine test, to be performed in accordance with 7.5.2 of IEC 61992-1. It is also part of the impulse type test of 8.3.3.2. The test is carried out by applying to the terminals of each circuit section the power-frequency test voltage relating to the rated insulation level assigned to the circuit section concerned, with all other sections earthed.

The test shall be carried out with withdrawable equipment in the connected position and repeated when in the disconnected position.

As indicated in 8.3.3.1 a), the circuit sections shall be segregated, and electronic equipment, transducers and transformers (if any) shall be disconnected or short-circuited.

NOTE The term "circuit section" is defined in 1.3.1.3 of EN 50124-1.

The test voltage shall be reached, from 0 V to the specified level, in 5 s and maintained for 60 s.

The switchgear shall be considered to have passed the test if no disruptive discharge occurs.

8.3.4 Short-time withstand current tests

8.3.4.1 Tests on main circuits

Main circuits are only tested for this condition when they are fitted with switching devices, which also have a short-time current rating. Such devices are disconnectors and all devices for the return current. See 3.2.7 of IEC 61992-1.

Main circuits shall be tested to verify their capability of carrying the rated short-time and peak withstand currents under the intended conditions of installation and use, i.e. they shall be tested as installed in the switchgear with all associated components which have an influence on the performance or modifying the short circuit current.

For these tests, short connections to transducers are not considered as parts of the main circuit.

Short and direct connections between circuits having a high short-circuit current and current limiting devices may be tested with a reduced short circuit current.

Circuits containing current limiting devices or circuit breakers employing bidirectional series trip devices need not be tested. However, unidirectional circuit-breaker circuits shall be tested with the current direction in a manner which does not cause tripping.

The I_{Ncw} value of the main circuit need not be the same as that of the main busbars, but shall be at least the proportion of the short-circuit current which it sees in service. Since this test is in general only applied to incomer/rectifier circuits, the requirements are stated in 5.3.4.2, Table 3 of IEC 61992-2.

The configuration of the test arrangement shall be recorded in the test report and shall follow the rules laid down in 8.3.9 of IEC 61992-2.

The test is considered satisfactory if no permanent deformation or damage is sustained by the main circuits, components and enclosure.

8.3.4.2 Test of the busbars

The tests on the main busbars shall be at the assigned value of the rated short-time withstand current I_{Ncw} of the busbars. This rating can be different to that assigned to the main circuit connections.

The configuration of the test arrangement shall be recorded in the test report and shall follow the rules laid down in 8.3.9 of IEC 61992-2.

The busbars shall be tested to verify their capability of carrying the rated short-time and peak withstand current under the intended condition of installation and use, i.e. they shall be tested as installed in the switchgear with all associated components which have an influence on the performance.

The arrangement for testing is shown in Figure 1 and shall comprise busbars in at least three sections of the switchgear, including at least one main circuit connection (tee-off). The main circuit connection conductor size shall be the minimum section which have the same assigned I_{Ncw} rating, unless otherwise agreed between purchaser and supplier.

One test connection shall be made to the main circuit connection via the busbar side disconnect at one end of the busbar. The other test connection shall be to the busbar at the opposite end of the busbar or, at the option of the manufacturer, to the main circuit connection via the busbar side disconnect at the end of the busbar.

Where the busbar has the same I_{Ncw} rating as the main circuit, then a combined test with that described in 8.3.4.1 is permitted.

The test procedure and pass criteria are as in 8.3.4.1.

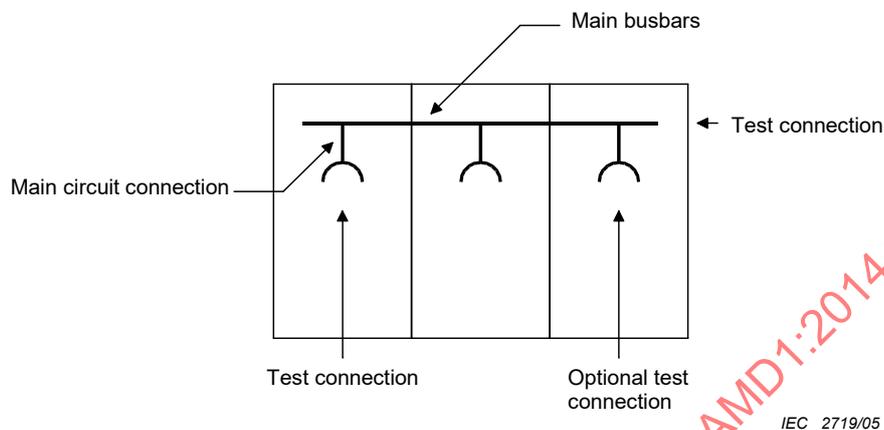


Figure 1 – Test arrangement for short-time current withstand test on busbars

8.3.4.3 Test on earthing circuits

Earthing conductors, earthing connections and earthing devices of switchgear shall be tested to verify their capability to withstand the rated earth fault current I_{Ncwe} for the specified time under the return and/or earthing condition of the system, i.e. they shall be tested as installed in the switchgear with all associated components influencing the performance or modifying the short-circuit current. The minimum value of the earth fault current shall be 10 kA (sustained) unless otherwise agreed between purchaser and supplier.

The rated earth fault current test shall be carried out using a d.c. supply.

This test only applies when earthing devices are employed which connect the main conductors to the switchboard earth. The rated earth fault current is assigned on this basis. The purchaser shall assign this rating based on the return path associated with the earthing circuit. Otherwise, it is subject to agreement between the purchaser and supplier.

When the earthing devices are themselves removable parts, then the earthing connection between the fixed part and the removable part shall be tested under earth fault conditions. The earth fault current shall flow between the earthing conductor and the frame of the removable part.

After the test, some deformation and degradation of the earthing conductor (but not the return conductor), earthing connections or earthing devices is permissible, but the continuity of the circuit shall be preserved.

8.3.5 Mechanical operation test

8.3.5.1 Switching devices and removable parts

Switching devices shall successfully complete the tests specified in IEC 61992-2 or IEC 61992-3 before being installed. As a type test, when installed in the switchgear, switching devices shall be operated 50 times with the main-circuit de-energised. Removable parts shall be inserted 25 times and withdrawn 25 times to verify satisfactory operation of the equipment.

8.3.5.2 Interlocks

The interlocks shall be set in the position intended to prevent the operation of the switching devices and the insertion or withdrawal of removable parts. 50 attempts shall be made to operate the switching devices and 25 attempts shall be made to insert and 25 attempts to withdraw the removable parts. During these tests, only normal operating forces shall be employed and no adjustment shall be made to the switching devices, removable parts or interlocks.

The interlocks are considered to be satisfactory if

- a) the switching devices cannot be operated;
- b) the insertion and withdrawal of the removable parts are prevented;
- c) the switching devices, removable parts and the interlocks are in proper working order and the effort to operate them is practically the same before and after the tests.

8.3.6 Verification of the degree of protection

The tests to verify the protection indicated by the first numeral shall be performed in accordance with the requirements specified in Clause 12 of IEC 60529 for protection against access to hazardous parts. General requirements for the tests shall comply with Clause 11 of IEC 60529.

8.3.7 Temperature-rise tests

The temperature-rises of the different components shall be referred to the ambient air temperature and shall not exceed the values specified in Clause 6 of IEC 61992-1.

NOTE The local ambient air temperature within the equipment may differ from the reference ambient temperature, which is taken outside the enclosure, because of the mutual heating from adjacent apparatus.

Where the switchgear design provides for alternative components or arrangements, the test of the switchgear shall be performed with those components or arrangements for which the most severe conditions are obtained.

8.3.7.1 Ambient temperature

The reference ambient air temperature as defined in 3.2.26 of IEC 61992-1 is the average temperature of the air outside the enclosure. It shall be measured during the last quarter of the test period by means of at least three temperature-measuring devices equally distributed around the assembly, at half height and a distance of 1 m from the enclosure. The devices shall be protected from external air currents and sources of heating or cooling.

8.3.7.2 Temperature-rise test of the main circuits and busbars

The test shall be performed in accordance with 7.4 of IEC 61992-1.

The dimensions of the test conductors and the configuration of the test arrangement shall be recorded in the test report and shall follow the rules laid down in 7.4 of IEC 61992-1.

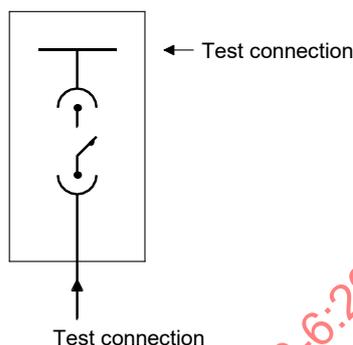
The arrangement for the temperature-rise tests on main circuits may be made on a single switchgear section as shown in Figure 2. The main circuit shall carry its rated service current I_{Ne} and/or its conventional thermal current I_{the} (as agreed).

The arrangement for the temperature-rise tests on busbars is shown in Figure 3 and shall comprise busbars in at least three sections of the switchgear. Each section of switchgear shall contain its main circuit connection which shall be the minimum normal current rating for the associated range of equipment if it is not carrying the test current. The busbars shall carry its rated service current I_{Ne} and/or its conventional thermal current I_{the} (as agreed).

The test connections shall be to the ends of the busbar or alternatively to one or both main circuit connections in the end sections of the switchgear via the busbar side disconnects. These connections shall then have conductor ratings no greater than the busbars.

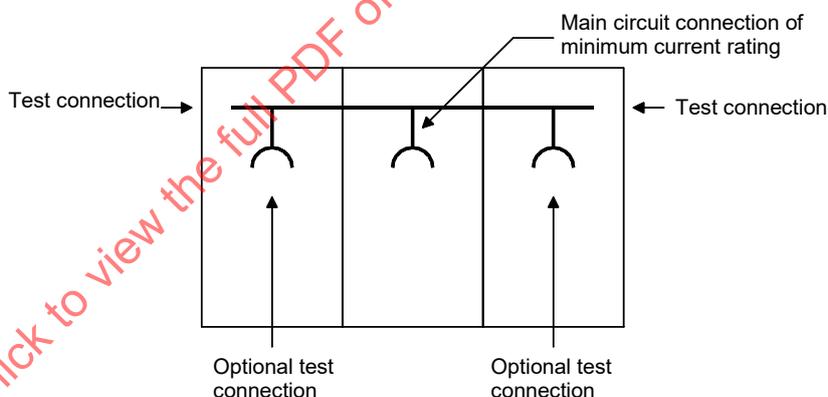
Where the busbars and the main circuit have the same current rating, the manufacturer may combine the main circuit and busbar tests.

The main circuit temperature-rise test results are those measured on that section of main circuit and the busbar temperature-rise test results are those measured on the centre section of the switchgear busbars.



IEC 2720/05

Figure 2 – Test arrangement for temperature-rise test on main circuits



IEC 2721/05

Figure 3 – Test arrangement for temperature-rise test on the busbars

Care shall be taken to minimize indication errors due to high temperature gradients.

When testing individual functional units, the neighbouring units should carry the currents which produce the power loss corresponding to the rated condition. It is admissible to simulate equivalent conditions by means of heaters or heat insulation, if the test cannot be performed under actual conditions.

8.3.7.3 Temperature-rise test for auxiliary and control equipment circuits

When it is impracticable to simultaneously load all auxiliary and control circuits during the test under 8.3.7.2, the maximum local temperatures in all compartments and locations where control and auxiliary circuits are located shall be measured and recorded. The test shall be