

Specification for

**A.C. metal-enclosed
switchgear and controlgear for
rated voltages above 1 kV and
up to and including 52 kV**

(Implementation of CENELEC HD 187 S5)

Appareillage sous enveloppe métallique pour
courant alternatif de tensions assignées
supérieures à 1 kV et inférieures ou égales à
52 kV

Metallgekapselte Wechselstrom-Schaltanlagen
für Nennspannungen über 1 kV bis
einschließlich 52 kV

UDC 621.316.51+213.3-654 : 621.3.027.7

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Power Electrical Engineering Standards Policy Committee (PEL/-) to Technical Committee PEL/92, upon which the following bodies were represented:

ASTA Certification Services
Association of Manufacturers Allied to the Electrical and Electronic Industry (BEAMA Ltd.)
British Railways Board
Department of the Environment (Property Services Agency)
ERA Technology Ltd.
Electricity Supply Industry in England and Wales
GAMBICA (BEAMA Ltd.)
Health and Safety Executive
Transmission and Distribution Association (BEAMA Ltd.)

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Association of Consulting Engineers
British Cable Makers' Confederation
Engineering Equipment and Materials Users' Association

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Contents

	Page
Committees responsible	Inside front cover
National foreword	i
Foreword	2
Text of HD 187 S5	3
National annex NA (informative) Cross-references	Inside back cover

National foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Policy Committee. It supersedes BS 5227 : 1984 which is withdrawn.

This British Standard is based on IEC 298 : 1990 *A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*, published by the International Electrotechnical Commission (IEC), which has been endorsed by CENELEC as HD 187 S5.

A special national condition applicable to Belgium is given in annex ZB. A-deviations applicable to Finland and Italy are given in annex ZC.

National annex NA gives details of international standards quoted in this standard for which there is an identical or technically equivalent British Standard.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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Descriptors: High-voltage switchgear and controlgear ($1 \text{ kV} < \text{rated voltage} \leq 52 \text{ kV}$), switches, disconnectors, switch-disconnectors, fuse-combination units

English version

A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

(IEC 298 : 1990)

Appareillage sous enveloppe métallique pour courant alternatif de tensions assignées supérieures à 1 kV et inférieures ou égales à 52 kV
(CEI 298 : 1990)

Metallgekapselte Wechselstrom-Schaltanlagen für Nennspannungen über 1 kV bis einschließlich 52 kV
(IEC 298 : 1990)

This Harmonization Document was approved by CENELEC on 1992-03-24. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for implementation of this Harmonization Document on a national level.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German).

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
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Foreword

The CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 298 : 1990 could be accepted without textual changes, has shown that no common modifications were necessary for the acceptance as Harmonization Document.

The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as HD 187 S5 on 24 March 1992.

The following dates were fixed:

- latest date of announcement of the HD at national level (doa) 1992-09-01
- latest date of publication of a harmonized national standard (dop) 1993-03-01
- latest date of withdrawal of conflicting national standards (dow) 1993-03-01

For products which have complied with HD 187 S4 : 1989 before 1993-03-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 1998-03-01.

Annexes designated 'normative' are part of the body of the standard. Annexes designated 'informative' are given only for information. In this standard, annexes AA to GG, ZA and ZB are normative and annex ZC is informative.

CONTENTS

	Page
SECTION ONE — GENERAL	
1. Scope	5
SECTION TWO — SERVICE CONDITIONS	
2. Normal and special service conditions	5
SECTION THREE — TERMS AND DEFINITIONS	
3. Definitions	6
SECTION FOUR — RATED CHARACTERISTICS	
4. Rating	10
4.1 Rated voltage	10
4.2 Rated insulation level	10
4.3 Rated frequency	10
4.4 Rated normal current and temperature rise	10
4.5 Rated short-time withstand current	11
4.6 Rated peak withstand current	11
4.7 Rated duration of short circuit	11
4.8 Rated supply voltage of closing and opening devices and auxiliary circuits	11
4.9 Rated supply frequency of operating devices and auxiliary circuits	11
4.10 Rated pressure of compressed gas supply for operation	11
4.101 Rated filling pressure (of gas-filled compartments)	11
SECTION FIVE — RULES FOR DESIGN AND CONSTRUCTION	
5. Design and construction	11
5.1 Requirements for liquids in switchgear and controlgear	12
5.2 Requirements for gases in switchgear and controlgear	12
5.3 Earthing	12
5.4 Auxiliary equipment	13
5.5 Dependent power closing	13
5.6 Stored energy closing	13
5.7 Operation of releases	13
5.8 Low and high pressure interlocking devices	13
5.9 Nameplates	13
5.101 Degree of protection and internal fault	14
5.102 Enclosure	15
5.103 Partitions and shutters	17
5.104 Pressure relief of gas-filled compartments	18
5.105 Disconnectors and earthing switches	18
5.106 Interlocks	19
5.107 Provisions for dielectric tests on cables	20
SECTION SIX — RULES FOR TYPE TESTS	
6. Type tests	20
6.1 Dielectric tests	21
6.2 Radio interference voltage (RIV) tests	24
6.3 Temperature-rise tests	24
6.4 Measurement of the resistance of the main circuit	24

	Page
6.5 Short-time and peak withstand current tests	24
6.101 Verification of making and breaking capacities	25
6.102 Mechanical operation tests	26
6.103 Verification of the degree of protection	26
6.104 Pressure withstand test for gas-filled compartments	26
6.105 Gas tightness tests of gas-filled compartments	26
6.106 Measurement of leakage currents	27
6.107 Weatherproofing test	27
6.108 Arcing due to internal fault	27

SECTION SEVEN — RULES FOR ROUTINE TESTS

7. Routine tests	28
7.1 Power-frequency voltage tests on the main circuit	28
7.2 Dielectric tests on auxiliary and control circuits	28
7.3 Measurement of the resistance of the main circuit	28
7.101 Partial discharge measurement	29
7.102 Mechanical operation tests	29
7.103 Pressure tests of gas-filled compartments	29
7.104 Gas tightness tests of gas-filled compartments	29
7.105 Tests of auxiliary electrical, pneumatic and hydraulic devices	29
7.106 Verification of correct wiring	29
7.107 Tests after erection on site	29
7.108 Measurement of gas condition after filling on site	30

SECTION EIGHT — GENERAL INFORMATION

8. Guide to the selection of switching devices for service	30
9. Information to be given with enquiries, tenders and orders	30
9.101 Information with enquiries and orders	30
9.102 Information with tenders	31
10. Rules for transport, storage, erection and maintenance	32
10.1 Conditions during transport, storage and erection	32
10.2 Erection (mounting)	32
10.3 Maintenance	32
FIGURE 1 — Standard test finger	33
ANNEX AA — Internal fault	34
ANNEX BB — Method of calculating the cross-sectional area of bare conductors with regard to thermal stresses due to currents of short duration	42
ANNEX CC — Recommended method for the weatherproofing test for outdoor metal-enclosed switchgear and controlgear	43
ANNEX DD — Guide for voltage tests after erection on site	46
ANNEX EE — Rated insulation level for Series II	47
ANNEX FF — Partial discharge measurement	48
ANNEX GG — Gas tightness specifications and tests	53
ANNEX ZA (normative) Other international publications quoted in this standard with the references of the relevant European publications	61
ANNEX ZB (normative) Special national conditions	62
ANNEX ZC (informative) A-deviations	62

A.C. METAL-ENCLOSED SWITCHGEAR AND CONTROLGEAR FOR RATED VOLTAGES ABOVE 1 kV AND UP TO AND INCLUDING 52 kV

SECTION ONE — GENERAL

1. Scope

This standard specifies requirements for factory-assembled metal-enclosed switchgear and controlgear for alternating current of rated voltages above 1 kV and up to and including 52 kV for indoor and outdoor installation, and for service frequencies up to and including 60 Hz.

For metal-enclosed switchgear and controlgear containing gas-filled compartments, the design pressure is limited to a maximum of 3 bar (gauge). Gas-filled compartments having a design pressure exceeding 3 bar (gauge) shall be designed and tested in accordance with I E C 517.

Metal-enclosed switchgear and controlgear for special use, for example in flammable atmospheres, in mines or on board ships, may be subject to additional requirements.

This standard does not deal with components contained in metal-enclosed switchgear and controlgear for which individual specifications exist.

NOTES

- 1 Switchgear and controlgear assemblies having an insulation enclosure are covered by I E C 466.
- 2 Metal-enclosed switchgear and controlgear for rated voltages above 52 kV insulated by air at atmospheric pressure may be covered by this standard taking into account the insulation levels of I E C 694.
- 3 Liquid-insulated hermetically sealed compartments are equal to gas-filled compartments with respect to independence from ambient atmosphere.

SECTION TWO — SERVICE CONDITIONS

2. Normal and special service conditions

Unless otherwise specified in this standard, the metal-enclosed switchgear and controlgear is designed to be used under normal service conditions.

Refer to Clause 2 of I E C 694.

For outdoor installation it is assumed that inside the enclosure, normal indoor conditions prevail. If necessary, appropriate measures shall be taken, such as air conditioning, so that common indoor components may be used. This does not apply to gas-filled compartments.

SECTION THREE — TERMS AND DEFINITIONS

3. Definitions

For the definitions of general terms used in this standard, reference is made to the International Electrotechnical Vocabulary (IEV), namely I E C 50 (441) and I E C 50 (151).

The following definitions apply for the purpose of this standard:

3.101 *Switchgear and controlgear*

A general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures (IEV 441-11-01).

3.102 *Metal-enclosed switchgear and controlgear*

Switchgear and controlgear assemblies with an external metal enclosure intended to be earthed and complete except for external connections (IEV 441-12-04).

NOTE — The metal-enclosed switchgear and controlgear is subdivided into three types:

- metal-clad switchgear and controlgear;
- compartmented switchgear and controlgear (with one or more non-metallic partitions);
- cubicle switchgear and controlgear.

3.102.1 *Metal-clad switchgear and controlgear*

Metal-enclosed switchgear and controlgear in which components are arranged in separate compartments with metal partitions intended to be earthed.

NOTES

1 This term applies to metal-enclosed switchgear and controlgear with metal partitions providing the degree of protection included in table 1 (or higher) and having separate compartments at least for the following components:

- a) each main switching device;
- b) components connected to one side of a main switching device, for example feeder circuit;
- c) components connected to the other side of the main switching device, for example busbars; where more than one set of busbars is provided, each set being in a separate compartment.

2 Metal-enclosed switchgear and controlgear having metal partitions and meeting all the requirements of note 1, may utilize an insulating shutter barrier as a part of the shutter arrangement, the combination of which provides the degree of protection included in table 1 (or higher) and satisfies the requirements of Sub-clause 5.103.1 for partitions and shutters made of insulating material.

3.102.2 *Compartmented switchgear and controlgear (with non-metallic partitions)*

Metal-enclosed switchgear and controlgear in which components are arranged in separate compartments as for metal-clad switchgear and controlgear, but with one or more non-metallic partitions providing the degree of protection included in table 1 (or higher).

NOTE — Metal-enclosed switchgear and controlgear in which the main circuit components are individually embedded in solid insulating material can be considered as an alternative, provided that the conditions specified in I E C 466 are met.

3.102.3 *Cubicle switchgear and controlgear*

Metal-enclosed switchgear and controlgear, other than metal-clad and compartmented switchgear and controlgear.

NOTE — This term applies to switchgear and controlgear having a metal enclosure and having either:

- a) a number of compartments less than that required for metal-clad or compartmented switchgear and controlgear;
- b) partitions having a degree of protection lower than those included in table 1;
- c) no partitions.

3.103 *Transport unit*

A part of metal-enclosed switchgear and controlgear suitable for shipment without being dismantled.

3.104 *Functional unit*

A part of metal-enclosed switchgear and controlgear comprising all the components of the main circuits and auxiliary circuits that contribute to the fulfilment of a single function (IEV 441-13-04).

NOTE — Functional units may be distinguished according to the function for which they are intended, for example: incoming unit, outgoing unit, etc.

3.105 *Enclosure*

A part of metal-enclosed switchgear and controlgear providing a specified degree of protection of equipment against external influences and a specified degree of protection against approach to or contact with live parts and against contact with moving parts (IEV 441-13-01).

3.106 *Compartment*

A part of metal-enclosed switchgear and controlgear enclosed except for openings necessary for interconnection, control or ventilation (IEV 441-13-05).

NOTES

- 1 A compartment may be designated by the main component contained therein, e.g. circuit-breaker compartment, busbar compartment, etc.
- 2 Openings necessary for interconnection between compartments are closed with bushings or other equivalent means.
- 3 Busbar compartments may extend through several functional units without the need for bushings or other equivalent means.

3.107 *Gas-filled compartment*

A compartment of metal-enclosed switchgear and controlgear in which the gas pressure is maintained by one of the following systems:

- a) controlled pressure system;
- b) closed pressure system;
- c) sealed pressure system.

(Refer to annex GG.)

NOTE — Several gas-filled compartments may be interconnected to a common gas-system (gas-tight assembly).

3.108 *Component*

An essential part of the main or earthing circuits of metal-enclosed switchgear and controlgear which serves a specific function (for example circuit-breaker, disconnector, switch, fuse, instrument transformer, bushing, busbar, etc.).

3.109 *Partition*

A part of metal-enclosed switchgear and controlgear separating one compartment from other compartments (IEV 441-13-06).

3.110 *Shutter*

A part of metal-enclosed switchgear and controlgear that can be moved from a position where it permits contacts of a removable part to engage fixed contacts, to a position where it becomes a part of the enclosure or partition shielding the fixed contacts (IEV 441-13-07).

3.111 *Bushing*

A structure carrying one or more conductors through an enclosure and insulating it therefrom, including the means of attachment.

3.112 *Removable part*

A part of metal-enclosed switchgear and controlgear that may be removed entirely from the metal-enclosed switchgear and controlgear and replaced, even though the main circuit is alive (IEV 441-13-08).

3.113 *Withdrawable part*

A removable part of metal-enclosed switchgear and controlgear that can be moved to positions in which an isolating distance or segregation between open contacts is established, while the part remains mechanically attached to the enclosure (IEV 441-13-09).

3.114 *Segregation (of conductors)*

An arrangement of conductors with earthed metal interposed between them in such a manner that disruptive discharges can only occur to earth (IEV 441-11-11).

NOTE — A segregation may be established between the conductors as well as between the open contacts of a switching device.

3.115 *Service position (connected position)*

The position of a removable part in which it is fully connected for its intended function (IEV 441-16-25).

3.116 *Earthing position*

The position of a removable part in which the closing of a mechanical switching device causes a main circuit to be short-circuited and earthed (IEV 441-16-26).

3.117 *Test position (of a withdrawable part)*

The position of a withdrawable part in which an isolating distance or segregation is established in the main circuit and in which the control circuits are connected (IEV 441-16-27).

3.118 *Disconnected position (of a withdrawable part)*

The position of a withdrawable part in which an isolating distance or segregation is established in the circuits of the withdrawable part, that part remaining mechanically attached to the enclosure (IEV 441-16-28).

NOTE — In high-voltage metal-enclosed switchgear and controlgear, the auxiliary circuits may not be disconnected.

3.119 *Removed position (of a removable part)*

The position of a removable part when it is outside and mechanically and electrically separated from the enclosure (IEV 441-16-29).

3.120 *Main circuit*

All the conductive parts of metal-enclosed switchgear and controlgear included in a circuit which is intended to transmit electrical energy (IEV 441-13-02).

3.121 *Auxiliary circuit*

All the conductive parts of metal-enclosed switchgear and controlgear included in a circuit (other than the main circuit) intended to control, measure, signal and regulate (IEV 441-13-03).

NOTE — The auxiliary circuits of metal-enclosed switchgear and controlgear include the control and auxiliary circuits of the switching devices.

3.122 *Rated value*

A quantity value assigned, generally by a manufacturer, for a specified operating condition of the metal-enclosed switchgear and controlgear (IEV 151-04-03).

NOTE — See Section Four for individual rated values.

3.123 *Degree of protection*

The degree of protection provided by an enclosure to protect persons against contact with or approach to live parts and against contact with moving parts inside the enclosure and to protect the equipment against ingress of solid bodies.

3.124 *Ambient air temperature* (of metal-enclosed switchgear and controlgear)

The temperature, determined under prescribed conditions, of the air surrounding the enclosure of metal-enclosed switchgear and controlgear.

3.125 *Disruptive discharge*

Phenomena associated with the failure of insulation under electric stress, in which the discharge completely bridges the insulation under test, reducing the voltage between the electrodes to zero or nearly to zero.

NOTES

- 1 The term applies to discharges in solid, liquid and gaseous dielectrics and to combinations of these.
- 2 A disruptive discharge in a solid dielectric produces permanent loss of dielectric strength (non-self-restoring insulation); in a liquid or gaseous dielectric, the loss may be only temporary (self-restoring insulation).
- 3 The term "sparkover" is used when a disruptive discharge occurs in a gaseous or liquid dielectric.

The term "flashover" is used when a disruptive discharge occurs over the surface of a solid dielectric in gaseous or liquid medium.

The term "puncture" is used when a disruptive discharge occurs through a solid dielectric.

3.126 *Minimum functional pressure* (of gas-filled compartments)

The gas pressure in bars (gauge) referred to atmospheric air conditions of 20 °C and 1 013 hPa at and above which the rated values of the switchgear are maintained.

3.127 *Design pressure* (of gas-filled compartments)

The pressure in bars (gauge) used to determine the design of a gas-filled compartment.

3.128 *Design temperature* (of gas-filled compartments)

The highest temperature which can be reached by the gas under service conditions.

SECTION FOUR — RATED CHARACTERISTICS

4. Rating

The ratings of metal-enclosed switchgear and controlgear are the following:

- a) rated voltage and number of phases;
- b) rated insulation level;
- c) rated frequency;
- d) rated normal current (for main circuits);
- e) rated short-time withstand current (for main and earthing circuits);
- f) rated peak withstand current, if applicable (for main and earthing circuits);
- g) rated duration of short circuit;
- h) rated values of the components forming part of the metal-enclosed switchgear and controlgear including their operating devices and auxiliary equipment;
- i) rated filling pressure (of gas-filled compartments).

For the co-ordination of rated voltages, rated short-time withstand currents, rated peak withstand currents and rated normal currents of metal-enclosed switchgear and controlgear reference is made to I E C 56 and to I E C 129.

4.1 *Rated voltage*

Refer to Sub-clauses 4.1 and 4.1.1 of I E C 694.

NOTE — Components forming part of metal-enclosed switchgear and controlgear may have individual values of rated voltage in accordance with their relevant standards.

4.2 *Rated insulation level*

Refer to Sub-clauses 4.2 and 4.2.1 of I E C 694. For metal-enclosed switchgear and controlgear the rated withstand voltage values, based on current practice in Canada and the United States of America, are given in the table of annex EE.

4.3 *Rated frequency*

Refer to Sub-clause 4.3 of I E C 694 with the addition of the following rated values:

16⅔ Hz and 25 Hz

4.4 *Rated normal current and temperature rise*

4.4.1 *Rated normal current*

Refer to Sub-clause 4.4.1 of I E C 694 with the addition of the following paragraph:

Some main circuits of metal-enclosed switchgear and controlgear (e.g. busbars, feeder circuits, etc.) may not have the same value of rated normal current.

4.4.2 Temperature rise

Refer to Sub-clause 4.4.2 of I E C 694 with the addition of the following supplement:

The temperature rise of components contained in metal-enclosed switchgear and control-gear which are subject to individual specifications not covered by the scope of I E C 694 shall not exceed the temperature-rise limits permitted in the relevant standard for that component.

The maximum permissible temperatures and temperature rises to be taken into account for busbars are those specified for contacts, connections and metal parts in contact with insulation, as the case may be.

The temperature rise for accessible enclosures and covers shall not exceed 30 K. In the case of enclosures and covers which are accessible but need not be touched during normal operation, the temperature-rise limit may be increased by 10 K.

4.5 Rated short-time withstand current

Refer to Sub-clause 4.5 of I E C 694.

4.6 Rated peak withstand current

Refer to Sub-clause 4.6 of I E C 694.

NOTE — In principle, the rated short-time withstand current and the rated peak withstand current of a main circuit cannot exceed the corresponding rated values of the weakest of its series connected components. However, for each circuit or compartment, advantage may be taken of apparatus limiting the short-circuit current, such as current-limiting fuses, reactors, etc.

4.7 Rated duration of short circuit

Refer to Sub-clause 4.7 of I E C 694.

4.8 Rated supply voltage of closing and opening devices and auxiliary circuits

Refer to Sub-clause 4.8 of I E C 694.

4.9 Rated supply frequency of operating devices and auxiliary circuits

Refer to Sub-clause 4.9 of I E C 694.

4.10 Rated pressure of compressed gas supply for operation

Refer to Sub-clause 4.10 of I E C 694.

4.101 Rated filling pressure (of gas-filled compartments)

The pressure in bars (gauge) assigned by the manufacturer referred to atmospheric air conditions of 20 °C and 1 013 hPa at which the gas-filled compartment is filled before being put into service.

SECTION FIVE — RULES FOR DESIGN AND CONSTRUCTION**5. Design and construction**

Metal-enclosed switchgear and controlgear shall be designed so that normal service, inspection and maintenance operations, including the usual checking of phase sequence,

earthing of connected cables, locating of cable faults, voltage tests on connected cables or other apparatus and the elimination of dangerous electrostatic charges, can be carried out safely.

All components of the same rating and construction which may need to be replaced shall be interchangeable.

If there are removable parts with different ratings and if parts are interchangeable within the assembly of metal-enclosed switchgear and controlgear, any possible combination of removable and fixed parts shall withstand the rated insulation level specified for the fixed parts of the equipment concerned.

The various components contained within the enclosure are subject to the individual specifications applying to them.

For main circuits with current-limiting fuses, the manufacturer of the switchgear and controlgear may assign the fused short-circuit current.

5.1 *Requirements for liquids in switchgear and controlgear*

Refer to Sub-clause 5.1 of I E C 694.

5.2 *Requirements for gases in switchgear and controlgear*

Refer to Sub-clause 5.2 of I E C 694.

NOTE — For checking of sulphur hexafluoride in service, refer to I E C 480.

5.3 *Earthing*

5.3.1 *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 prior to becoming accessible. This does not apply to withdrawable and removable parts which become accessible after being separated from the switchgear.

5.3.2 *Earthing of the enclosure*

Refer to 5.3. of I E C 694 with the addition of the following supplement:

An earthing conductor shall be provided extending the whole length of the metal-enclosed switchgear and controlgear. The current density in the earthing conductor, if of copper, shall not exceed 200 A/mm² under the specified earth fault conditions; however, its cross-section area shall be not less than 30 mm². It shall be terminated by an adequate terminal intended for connection to the earth system of the installation.

NOTE — If the earthing conductor is not made of copper, equivalent thermal and mechanical requirements should be met.

In general, the continuity of the earth system shall be ensured taking into account the thermal and mechanical stresses caused by the current it may have to carry. The maximum value of earth fault currents depends upon the type of system neutral earthing employed and shall be indicated by the user.

Where earthing connections have to carry the full three-phase short-circuit current (as in the case of the short-circuiting connections used for earthing devices) these connections shall be dimensioned accordingly.

NOTE — As guidance, reference is made to a method of calculating cross-sectional areas of conductors given in annex BB.

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

For the interconnection within the functional unit, fastening by bolting or welding is acceptable for providing electrical continuity between the frame, covers, doors, partitions or other structural parts. Doors of the high-voltage compartments shall be connected to the frame by adequate means.

The metallic parts of a withdrawable part which are normally earthed shall also remain earth-connected in the test and disconnected positions under the prescribed conditions for the isolating distance (see I E C 129) and also in any intermediate position whilst the auxiliary circuits are not totally disconnected.

5.4 *Auxiliary equipment*

Refer to Sub-clause 5.4 of I E C 694.

5.5 *Dependent power closing*

Refer to Sub-clause 5.5 of I E C 694.

5.6 *Stored energy closing*

Refer to Sub-clause 5.6 of I E C 694.

5.7 *Operating of releases*

Refer to Sub-clause 5.7 of I E C 694.

5.8 *Low and high pressure interlocking devices*

Refer to Sub-clause 5.8 of I E C 694.

5.9 *Nameplates*

Refer to Sub-clause 5.9 of I E C 694 with the addition of the following supplement:

Metal-enclosed switchgear and controlgear, all their components and operating devices shall be provided with durable and clearly legible nameplates which shall contain the following information:

- manufacturer's name or trade mark;
- type designation or serial number;
- applicable rated values;
- number of the relevant standard.

The nameplates of each functional unit shall be legible during normal service. The removable parts, if any, shall have a separate nameplate with the data relating to the functional units they belong to, but this nameplate need only be legible when the removable part is in the removed position.

NOTE — The word "rated" need not appear on the nameplate.

5.101 *Degree of protection and internal fault*

5.101.1 *Protection of persons against approach to live parts and contact with moving parts*

For metal-clad and for compartmented switchgear and controlgear, the degree of protection shall be specified separately for the enclosure and for partitions.

For cubicle switchgear and controlgear, it is only necessary to specify the degree of protection for the enclosure.

For main circuits of gas-filled compartments, no degree of protection needs to be specified.

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.

The characteristic numeral indicates the degree of protection provided by the enclosure with respect to persons, also to the equipment inside the enclosure.

Table 1 gives details of objects which will be "excluded" from the enclosure for each of the degrees of protection.

The term "excluded" implies that a part of the body or an object held by a person either will not enter the enclosure or, if it enters, that adequate clearance will be maintained and no moving part will be touched.

TABLE 1

Degree of protection	Protection against approach to live parts and contact with moving parts
IP2X	By fingers or similar objects of diameter greater than 12 mm
IP3X	By tools, wires, etc., of diameter or thickness greater than 2,5 mm
IP4X	By wires of diameter or strips of thickness greater than 1,0 mm
NOTE — The designation of the degree of protection corresponds to I E C 529.	

5.101.2 *Protection of equipment against external effects*

- Protection against ingress of solid bodies: No additional provisions beyond those in Sub-clause 5.101.1 are to be taken.
- Protection against weather: Equipment for outdoor installation provided with appropriate protective features is to be indicated by the characteristic letter W placed immediately after the letters IP.
- Protection against ingress of water: No degree of protection is provided by indoor metal-enclosed switchgear and controlgear against harmful ingress of water.

5.101.3 *Protection of equipment against mechanical damage*

Under consideration. For the time being the manufacturer shall be consulted where enclosures may be subjected to mechanical impacts or similar effects.

5.101.4 *Internal fault*

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

There is little probability of such an event occurring in constructions which satisfy the requirements of this standard, but it cannot be completely disregarded.

Such an event may lead to the risk of injury, if persons are present, but with an even lower probability.

It is desirable that the highest possible degree of protection to persons should be provided. The principal objective should be to avoid such arcs or to limit their duration and consequences.

Experience has shown that faults are more likely to occur in some locations inside an enclosure than in others, so special attention should be paid to these.

For guidance, a list of such locations and of causes is given in table AA.1 of annex AA, columns (1) and (2). Measures to decrease the probability of internal faults or to reduce the risk are recommended in column (3). Examples of measures to limit the consequences of internal faults are given in table AA.2 of annex AA.

If such measures are considered to be insufficient then a test in accordance with annex AA may be agreed between the manufacturer and the user, to verify that the chosen criteria are fulfilled as agreed. This test covers only the case of an arc occurring entirely in air or in another insulating gas within the enclosure but not within components having a separate enclosure, for example switching devices and fuses, or within components like instrument transformers, etc.

Such a test should be unnecessary on those parts of circuits which are protected by current-limiting devices, for example fuses.

NOTE — The overpressure in the building caused by arcing due to an internal fault in the metal-enclosed switchgear and controlgear and the effects of the ejection of gases from pressure relief devices should be taken into consideration.

5.102 *Enclosure*

5.102.1 *General*

Enclosures shall be metallic. When the metal-enclosed switchgear and controlgear is installed, the enclosure shall provide at least the degree of protection specified in table 1. It shall also assure protection in accordance with the following conditions:

The floor surface, even if not metallic, may be considered as part of the 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 manufacturer and user.

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

Gas-filled compartments shall be capable of withstanding the normal and transient pressures to which they are subjected in service. While these compartments are permanently pressurized in service they are subjected to particular conditions of service which distinguish them from compressed air receivers and similar storage vessels. These conditions are:

- gas-filled compartments enclose the main circuit not only to prevent hazardous approach to live or moving parts but are so shaped that, when at or above the minimum functional pressure (see sub-clause 3.126), they ensure that the rated insulation level (see sub-clause 4.2) for the equipment is achieved (electrical rather than mechanical considerations predominate in determining the shape and materials employed);
- gas-filled compartments are normally filled with a non-corrosive gas, thoroughly dried, stable and inert; since measures to obtain the gas in this condition with only small

fluctuations in pressure are fundamental to the operation of the switchgear and since the compartments will not be subjected to internal corrosion, there is no need to make allowances for these factors in determining the design of the compartments;

— the service pressure is relatively low.

For outdoor installation, the manufacturer shall take into account the influence of climatic conditions.

5.102.2 *Design of gas-filled compartments*

The design of a gas-filled compartment shall be based on the design temperature and on the design pressure as defined in this standard.

The design temperature of the gas-filled compartment is generally the upper limit of ambient air temperature increased by the temperature rise of the gas due to the flow of rated normal current. Solar radiation should be taken into account if it has a significant effect.

The design pressure of the enclosure is at least the upper limit of the pressure reached within the enclosure at the design temperature.

Account shall be taken of the following:

- a) the full differential pressure possible across the compartment walls or partitions, including any evacuation process if used during filling;
- b) the resulting pressure in the event of an accidental leak between the compartments in the case of adjacent compartments having different service pressures;
- c) the possibility of the occurrence of an internal fault (see Sub-clause 5.101.4).

NOTE — For the purpose of establishing routine and type test pressures for the enclosure, the maximum value is given by the following expression:

Design pressure in bars (gauge) = $1,3 [\text{Rated filling pressure in bars (gauge)} + 1] - 1$

5.102.3 *Tightness of gas-filled compartments*

The manufacturer shall state the pressure system used and the permissible gas-leakage rate for the gas-filled compartments (refer to annex GG).

If requested by the user, in order to permit entry to a gas-filled compartment of closed or controlled pressure systems, the permissible gas leakage across partitions should also be stated by the manufacturer.

For gas-filled compartments where the minimum functional pressure exceeds 1 bar (gauge) it is recommended that an indication be provided when the pressure at 20 °C has fallen below the minimum functional pressure (see Sub-clause 3.126).

A partition separating a compartment filled with insulating gas from a neighbouring compartment filled with liquid, such as a cable box or a voltage transformer, shall not show any leakage affecting the dielectric properties of the two media.

5.102.4 *Covers and doors*

Covers and doors which are parts of the enclosure shall be 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 Sub-clause 5.102.6.

Two categories of covers or doors are recognized with regard to access to high-voltage compartments:

- a) those which need not 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;
- 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 provision for padlocks), unless the safety of persons is assured by a suitable interlocking device.

With metal-clad or compartmented switchgear and controlgear, covers or doors should only be opened when the part of the main circuit contained in the compartment being made accessible is dead.

5.102.5 *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. Precautions shall be taken to prevent the formation of dangerous electrostatic charges, either by clearance or by electrostatic shielding (for example a suitable earthed wire-mesh on the inside of the window).

The insulation between live parts of the main circuit and the inspection windows shall withstand the test voltages specified in Sub-clause 4.2.1 of I E C 694 for voltage tests to earth and between poles.

5.102.6 *Ventilating openings, vent outlets*

Ventilating openings and vent outlets 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.

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

5.103 *Partitions and shutters*

5.103.1 *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 Sub-clause 4.2.1 of I E C 694 for voltage tests to earth and between poles;
- b) apart from mechanical strength, the insulating material shall withstand likewise the test voltages specified in Item a). The appropriate test methods given in I E C 243-1 should be applied;
- c) the insulation between live parts of the main circuit and the inner surface of insulating partitions and shutters facing these shall withstand at least 150% of the rated voltage of the equipment;
- d) if a leakage current may reach the accessible side of the insulating partitions and shutters by a continuous path over insulating surfaces or by a path broken only by small gaps of gas or liquid, it shall be not greater than 0,5 mA under the specified test conditions (see Sub-clause 6.104).