BRITISH STANDARD

BS EN 50123-1:2003

Railway applications — Fixed installations — D.C. switchgear —

Part 1: General

The European Standard EN 50123-1:2003 has the status of a British Standard

ICS 29.120.60; 45.020

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British Standards

National foreword

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English version

Railway applications –
Fixed installations – D.C. switchgear
Part 1: General

Applications ferroviaires –
Installations fixes –
Appareillage à courant continu
Partie 1: Généralités

Bahnanwendungen –
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Gleichstrom-Schalteinrichtungen
Teil 1: Allgemeines

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Foreword

This European Standard was prepared by SC 9XC, Electric supply and earthing systems for public transport equipment and ancillary apparatus (fixed installations), of the Technical Committee CENELEC TC 9X, Electrical and electronic applications for railways.

The text of the draft was submitted to the formal vote and was approved by CENELEC as EN 50123-1 on 2002-09-01.

This European Standard supersedes EN 50123-1:1995. It has been prepared taking into account IEC document 9/578/FDIS (61992-1) in order to align technically as much as possible this EN 50123-1 and IEC 61992-1. These documents are to be considered as technically equivalent except for those references and peculiarities which are due to the European standardisation in the railway application field.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2003-09-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2005-09-01

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, Annexes A, B and C are normative and Annexes D and E are informative.

Contents

1 Scope

The EN 50123 series specifies requirements for d.c. switchgear and controlgear and is intended to be used in fixed electrical installations with nominal voltage not exceeding 3 000 V d.c., which supply electrical power to vehicles for public guided transport, i.e. railway vehicles, tramway vehicles, underground vehicles and trolley-buses.

Part 1 specifies general requirements.

The other parts are covering

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

2 Normative references

This European Standard series incorporates by dated or undated references, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard series only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 50119	2001	*Railway applications – Fixed installations – Electric traction overhead contact lines*
EN 50121	Series	*Railway applications – Electromagnetic compatibility*
EN 50122-1	1997	*Railway applications – Fixed installations – Part 1: Protective provisions relating to electrical safety and earthing*
EN 50124-1	2001	*Railway applications – Insulation coordination – Part 1: Basic requirements – Clearances and creepage distances for electrical and electronic equipment*
EN 50125-2	2002	Railway applications – Environmental conditions for equipment – Part 2: Fixed *electrical installations*
EN 50126	1999	*Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)*
EN 50163	1995	*Railway applications – Supply voltage of traction systems* (IEC 60850:2000)
EN 60099-1	1994	*Surge arresters – Part 1: Non-linear resistor type gapped surge arresters for a.c. systems* (IEC 60099-1:1991)

EN 60099-4	1993	*Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems* (IEC 60099-4:1991)
EN 60129 + A1 + A2	1994 1994 1996	*Alternating current disconnectors and earthing switches* (IEC 60129:1984 + A1:1992 + A2:1996)
EN 60243-1	1998	*Electrical strength of insulating materials – Test methods – Part 1: Tests at power frequencies* (IEC 60243-1:1998)
EN 60269	series	*Low-voltage fuses* (IEC 60269 series)
EN 60298	1996	*AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV* (IEC 60298:1990 + corr. April 1995 + A1:1994)
EN 60507	1993	*Artificial pollution tests on high-voltage insulators to be used on a.c. systems* (IEC 60507:1991)
EN 60529	1991	*Degrees of protection provided by enclosures (IP Code)* (IEC 60529:1989)
EN 60694	1996	*Common specifcations for high-voltage switchgear and controlgear standards* (IEC 60694:1996)
EN 60721	series	*Classification of environmental conditions* (IEC 60721 series)
EN 60947-1	1999	*Low-voltage switchgear and controlgear – Part 1: General rules* (IEC 60947-1:1999, mod.)
EN 60947-2 + A1	1996 1997	*Low-voltage switchgear and controlgear – Part 2: Circuit breakers* (IEC 60947-2:1995 + A1:1997)
HD 214 S2	1980	*Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions* (IEC 60112:1979)
HD 380 S2	1987	*Test methods for evaluating resistance to tracking and erosion of electrical insulating materials used under severe ambient conditions* (IEC 60587:1984)
HD 588.1 S1	1991	*High-voltage test techniques – Part 1: General definitions and test requirements* (IEC 60060-1:1989 + corr. March 1990)
IEC 60050-441	1984	*International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses*
IEC 60050-446	1983	*International Electrotechnical Vocabulary (IEV) – Chapter 446: Electrical relays*
IEC 60050-605	1983	*International Electrotechnical Vocabulary (IEV) – Chapter 605: Generation, transmission and distribution of electricity – Substations*
IEC 60050-811	1991	*International Electrotechnical Vocabulary (IEV) – Chapter 811: Electric traction*
IEC 60466	1987	*A.C. insulation-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 38 kV*
IEC 61245	1993	*Artificial pollution tests on high voltage insulators to be used in d.c. systems*

3 Definitions

For the purpose of this European Standard series, the definitions given in IEC 60050-441, IEC 60050-446, IEC 60050-605, IEC 60050-811, EN 50124-1, EN 60099-1, EN 60099-4, EN 60298 and EN 60947 apply together with the following:

3.1 General terms

3.1.1
switchgear
general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment; it covers also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures

NOTE For the sake of simplicity in this standard the term "switchgear" means "switchgear and controlgear".

3.1.1.1
d.c. switchgear and controlgear assembly
combination of one or more d.c. switching devices together with associated control, measuring, signalling, protective, regulating equipment, etc., completely assembled under the responsibility of the supplier, with all the internal electrical and mechanical interconnections and structural parts

NOTE 1 Throughout the Standard, the abbreviation switchgear assembly is used for a d.c. switchgear and controlgear assembly.

NOTE 2 The components of the switchgear assembly may be electromechanical or electronic.

NOTE 3 An enclosure, but not an integral enclosure, when housing a switching device and some associated controlgear, may be considered as a switchgear assembly.

3.1.2
switching device
device designed to make or break the current in one or more electric circuits
[IEV 441-14-01]

3.1.3
d.c. circuit breaker
switching device capable of making, carrying and breaking direct currents under normal circuit conditions and also making, carrying (up to a specified limit and for a specified time) and breaking currents under specified abnormal conditions, such as those of short-circuit

3.1.4
d.c. disconnector
mechanical switching device, which provides, in the open position, for safety reasons, an isolating distance in accordance with specified requirements

NOTE 1 The disconnector is capable of opening and closing a circuit when either negligible d.c. current is broken or made, or when no significant change in the voltage across the terminals of the disconnector occurs. It is also capable of carrying d.c. currents under normal circuit conditions and carrying, for a specified time, currents under abnormal conditions such as those of short-circuit.

NOTE 2 A disconnector is not suitable for making or breaking load current, fault current or other current arising from the effects of lightning or transient phenomena.

NOTE 3 A disconnector is only able to make or break current of very limited magnitude such as those arising from electrostatic charging or discharges across undamaged insulation. The ability to make or break minimum currents due to eventual marginal transient conditions of the network is subject to agreement between purchaser and supplier.

3.1.5
switch-disconnector
mechanical switching device capable of making, carrying and breaking currents in normal circuit conditions and, when specified, in given operating overload conditions. In addition, it is able to carry, for a specified time, currents under specified abnormal circuit conditions, such as short-circuit conditions. Moreover, it complies with the requirements for a disconnector (see 3.1.4)

When specified, a switch-disconnector may be designed for making short-circuit currents, but not for breaking the same.

NOTE Outdoor switch-disconnectors, in given special conditions, may be required to be suitable for breaking overload currents of specified amplitude.

3.1.6
earthing switch
mechanical switching device for earthing parts of the circuit, capable of withstanding for a specified time, currents under abnormal conditions such as those of short-circuit, but not required to carry currents under normal conditions of the circuit

NOTE An earthing switch may have a short-circuit making capacity (see 3.2.23).

[IEV 441-14-11]

3.1.7
low-voltage limiter
device intended to be in parallel in those parts of a traction system where overvoltages are expected having the function of limiting the voltage to predetermined values

3.1.8
d.c. sensor
device used for detecting a current or a voltage in d.c. main circuit, which produces an output signal, proportional to and linear (over a range) with the primary input, for connection to a secondary device which acts on the signal

3.1.9
d.c. shunt
device connected in the primary circuit, usually composed of metal grids, that provides a millivolt output proportional to the current following in the primary circuit

3.1.10
isolating transducer

device which is interposed between the output of a sensor in the main circuit and the input of a secondary device used for measurement or protection, and used to provide an output isolated from the main circuit and, usually, at lower voltage

3.1.11
hall effect sensor
type of sensor which fits around the main circuit current carrying conductor and uses a single or multiple Hall effect cells situated in the magnetic field of an iron circuit and which is energised by the current in the main conductor

3.1.12
divider
bank of resistors connected across the main supply with a footing resistor used as the output, which gives a voltage proportional to the main supply. This output is connected either directly or indirectly through an isolation transducer to the voltage terminals of the secondary device

3.1.13
operation
motion of the moving contact(s) from one position to another position, for example open to close or open to earth

NOTE 1 This may be a closing operation or an opening operation.

NOTE 2 If a distinction is necessary, the terms "electrical operation" (for example make and break) and "mechanical operation" (for example closing and opening) should be used.

NOTE 3 The position of a switching device where the continuity of the main circuit is assured is indicated as "close" position.

NOTE 4 The position of a switching device where the prescribed distance between the contacts of the switching device is assured is indicated as "open" position.

3.1.14
operating cycle (of a mechanical switching device)
succession of operations from one position to another and back to the first position through all other positions, if any [IEV 441-16-02]

3.1.15
dependent manual operation (of a mechanical switching device)
operation solely by means of directly applied manual energy, such that the speed and force of the operation are dependent upon the action of the operator [IEV 441-16-13]

3.1.16
stored energy operation (of a mechanical switching device)
operation by means of energy stored in the device itself prior to the completion of the operation and sufficient to complete it under predetermined conditions

NOTE This kind of operation may be subdivided according to
a) the energy storage mode (spring, weight, etc.);
b) the origin of energy (manual, electric, etc.);
c) the energy releasing mode (manual, electric, etc.).

[IEV 441-16-15]

3.1.17
independent manual operation (of a mechanical switching device)
stored-energy operation where the energy originates from manual power, stored and released in one continuous operation, in such a way that the speed and force of the operation are independent from the action of the operator [IEV 441-16-16]

3.1.18
independent power operation
operation by means of energy where the energy originates from an external power source and is released in a single continuous operation, in such a way that the speed and force of the operation are independent from the action of the operator

3.1.19
switching device with interlock preventing opening and/or closing operations
switching device in which an operation (closing and/or opening) is prevented by interlocking means reflecting given system conditions

3.1.20
utilisation category (of a switching device)
combination of specified requirements related to the condition in which the switching device fulfils its purpose, selected to represent a characteristic group of practical applications [IEV 441-17-19]

NOTE The specified requirements may concern, for example the values of the making capacities, if applicable, breaking capacities and other characteristics, the associated circuits and the relevant conditions of use and behaviour. The term "duty" used elsewhere in the standard corresponds to a particular aspect of the utilisation category.

3.1.21
unidirectional switching device
switching device (for example a circuit breaker), the purpose of which is to interrupt d.c. current which is flowing in a prescribed direction through that device, and which is identified accordingly

3.1.22
bidirectional switching device
switching device (for example a circuit breaker), the purpose of which is to interrupt d.c. current which flows in either direction through that device, and which is identified accordingly

NOTE Proof of bidirectional ability is included in the interrupting type tests.

3.2 Performance characteristics

3.2.1 Voltages

3.2.1.1
nominal voltage (U_n)
voltage by which an installation or part of an installation is designated

3.2.1.2 Limits of system voltages

3.2.1.2.1
highest system voltage (U_{max})
highest value given for the voltage in the continuous operating conditions U_{max1} specified in EN 50163

3.2.1.2.2
lowest system voltage (U_{min})
lowest value given for the voltage in the continuous operating conditions U_{min1} specified in EN 50163

3.2.2
rated insulation voltage (U_{Nm})
maximum value of the d.c. voltage for which the equipment is designed in respect to its insulation

3.2.3
rated voltage (U_{Ne})
voltage value, given by the manufacturer, which, combined with rated service current, determines the utilisation of the equipment and to which the corresponding tests and utilisation categories, if any, relate

NOTE The rated voltage may differ from the nominal voltage by a quantity within permitted tolerances.

3.2.3.1
rated auxiliary and control supply voltage
voltage measured at the circuit terminals of the apparatus during its operation, including, if necessary, the auxiliary resistors or accessories supplied or required by the manufacturer to be installed in series with it, but not including the conductors to the electrical supply

3.2.3.2
rated voltage of a gapped arrester (U_r)
maximum d.c. voltage value between terminals at which the surge arrester is designated to withstand continuously

3.2.3.3
rated voltage of a gapless arrester (U_r)
the maximum d.c. voltage value between terminals at which the surge arrester is designated to operate correctly under temporary overvoltage conditions as established in the operating duty tests (see 4.7.5 of EN 50123-5). The rated voltage is used as a reference parameter for the specification of the operating characteristics

3.2.3.4
rated voltage of a low-voltage limiter (U_r)
the maximum d.c. voltage value between terminals which the low-voltage limiter is designed to withstand continuously

3.2.3.5
maximum continuous operating voltage of a gapless arrester (U_c)
voltage which corresponds to U_{max} defined in 3.2.1.2.1

3.2.3.6
protective voltage level of a gapped arrester (U_p)
crest value, declared by the supplier, higher than the maximum of the three voltage values between the surge arrester terminals: residual voltage at I_n, maximum standard lightning impulse sparkover voltage, maximum front of wave impulse sparkover voltage, the latter divided by 1,15

3.2.3.7
protective voltage level for gapless arrester (U_p)
impulse protection level of the arrester covering the maximum residual voltage for the nominal discharge current I_n

3.2.3.8
maximum withstand voltage of a low-voltage limiter (U_w)
maximum peak voltage value between terminals at which the current in the voltage limiter is zero or limited to specified values (leakage current)

3.2.3.9
maximum sparkover voltage of a low-voltage limiter (U_s)
maximum voltage value between terminals at which a gapped voltage limiter is designated to make a connection between terminals such as to limit the difference of potential between the same to a safe value

3.2.3.10
rated supply voltage in a switchgear
voltage measured at the circuit terminals of the apparatus itself during its operation, including, if necessary, the auxiliary resistors or accessories supplied or required by the manufacturer to be installed in series with it, but not including the conductors from the connection to the electrical supply

3.2.4
rated impulse withstand voltage (U_{Ni})
the peak value of an impulse voltage of prescribed form and polarity which the equipment is capable of withstanding to, without failure, under the specified test conditions

3.2.5
power-frequency voltage withstand level (dry and wet) (U_a)
power-frequency test voltage level which, when withstood by the equipment, proves the integrity of its insulation in operating conditions

3.2.6
Transient voltages

3.2.6.1
recovery voltage
voltage which appears across the terminals of a switching device after the breaking of the current [IEV 441-17-25]

3.2.6.2
maximum arc voltage ($\hat{U}_{arc}$)
maximum voltage appearing across the switching device during arcing

3.2.7
prospective current
current that would flow in the circuit if the device was replaced by a conductor of negligible impedance [IEV 441-17-01]

NOTE The prospective current may be qualified in the same way as a real current: prospective broken current, peak value of the prospective current, etc.

3.2.8
conventional free-air thermal current (I_{th})
current which may be used for the temperature-rise test of an equipment in free-air (see notes 1 and 2). This value is equal to or greater than the maximum value of the rated service current I_{Ne} of the equipment

NOTE 1 Free-air is the indoor air existing in normal conditions, reasonably free from dust and external radiations.

NOTE 2 A free-air device is a device supplied by the manufacturer without an enclosure (see 3.3.16) or a device supplied by the manufacturer with an integral enclosure (see 3.3.17).

3.2.9
conventional enclosed thermal current (I_{the})
current stated by the manufacturer which may be used for the temperature-rise tests of the equipment when mounted in a specified enclosure
This value is equal to or greater than the maximum value of the rated service current I_{Ne} of the enclosed equipment

3.2.10
rated service current (I_{Ne})
value of current stated by the manufacturer taking into account the rated voltage (see 3.2.3), the continuous duty and the utilisation category (see 3.1.20) and the protective enclosure type, if any

NOTE 1 Any current, exceeding I_{Ne} is an overload condition.

NOTE 2 If a load cycle is specified by the purchaser, it should define the steady-state currents before and after the load cycle. If the temperature-rises resulting from the load cycle exceed the temperature-rise limits, then a higher rated service current needs to be used.

3.2.10.1
nominal discharge current of a gapped arrester (I_n)
peak value of discharge current, having an 8/20 waveshape, which is used to classify an arrester. It is also the discharge current which is used to initiate follow-through current in the operating duty test

3.2.10.2
nominal discharge current of a gapless arrester (I_n)
peak value of lightning current impulse (see EN 60099-4) which is used to classify an arrester

3.2.10.3
long term withstand current of a low-voltage limiter (I_w)
current that a low-voltage limiter is able to withstand for 1 800 s in specified conditions

3.2.10.4
leakage current of a low-voltage limiter
current which flows between terminals of a low-voltage limiter when U is applied under nominal service conditions

3.2.11
rated short-time withstand current (I_{Ncw})
current that a circuit or a switching device in the closed position can carry, during a specified short time under prescribed conditions of use and behaviour

3.2.11.1
rated earth fault current (of a switchgear assembly) (I_{Ncwe})
maximum short-time withstand current which can be carried in the earthing circuit

3.2.12
short-circuit current (I_{ss})
prospective sustained current resulting from a short circuit due to a fault or an incorrect connection in an electric circuit

3.2.12.1
rated short-circuit current (I_{Nss})
maximum value of the prospective sustained short-circuit current that the device will carry

3.2.13
peak of the short-circuit current ($\hat{I}_{ss}$)
peak prospective value of the short-circuit current under transient conditions

3.2.14
cut-off current
maximum instantaneous value of current attained during the breaking operation of a switching device
[IEV 441-17-12]

3.2.15
circuit time constant (t_c)
value of the ratio of inductance over resistance of the circuit

3.2.16 Time constants of the d.c. traction system

3.2.16.1
track time constant (of a line) (T_c)
time constant of the track itself plus all parts on the load side of a switching device, including the contact line (overhead contact line or third rail), the return circuit and any low-frequency or high-frequency impedance bonds

3.2.16.2
rated track time constant (of a switching device) (T_{Nc})
conventional value assigned to a switching device describing the capability of the device to break inductive short circuit currents under specified conditions

3.2.16.3
source time constant (T_s)
time constant of the d.c. source on the incoming supply side of a switching device, including the a.c. supply network, the rectifier conversion equipment, smoothing reactors, the d.c. connections in the substation and the feeder and return connections between substation and track

3.2.17
breaking current
current of a switching device at the instant of initiation of the contact separation during a breaking process

3.2.18
breaking capacity
value of the prospective breaking current that a switching device is capable of breaking at a stated voltage and under prescribed conditions of use and behaviour [IEV 441-17-08]

3.2.19
rated short-circuit breaking capacity
breaking capacity for which prescribed conditions include a short circuit at the load terminals of the switching device

3.2.20
critical current (I_c)
value of breaking current, less than rated short circuit breaking current, at which the arcing time is a maximum and is significantly longer than at the rated short circuit breaking current

NOTE It can be a current or a range of currents which produce this effect. See Annex C.

3.2.21
maximum circuit-energy short-circuit ($I_{max\ E}$)
short circuit having the maximum possible value of circuit energy, which normally occurs at a short distance along the track from the substation

3.2.22
making capacity
value of the prospective making current that a switching device is capable of making at a stated voltage, under prescribed conditions of use and behaviour [IEV 441-17-09]

3.2.23
rated short-circuit making capacity
making capacity for which the prescribed conditions include a short circuit at the load side terminals of the switching device

3.2.24
distant fault short-circuit
short circuit at a position remote from the switching device interrupting the fault

3.2.25
disruptive discharge
phenomenon associated with the failure of insulation, under electrical stress, in which the discharge completely bridges the insulation under test, reducing the voltage between the electrodes to zero or nearly to zero

NOTE 1 The term applies to discharges in solid, liquid and gaseous dielectrics and to combination of these.

NOTE 2 A disruptive discharge in a solid dielectric produces permanent loss of dielectric strength (non-self restoring insulation).

NOTE 3 The term “sparkover” is used when a discharge occurs in a gaseous or liquid dielectric.

NOTE 4 The term “flashover” is used when a disruptive discharge occurs over the surface of a solid dielectric in gaseous or liquid medium.

NOTE 5 The term “puncture” is used when a disruptive discharge occurs through a solid dielectric.

3.2.26
ambient air temperature (of a switchgear)
temperature, determined under prescribed conditions, of the air surrounding the enclosure or switchgear

3.3 Components

3.3.1
component
essential part of the switchgear which serves a specific function (for example, circuit-breaker, disconnector, switch, fuse, shunt, voltage and current transducers, bushing, busbar, etc)

3.3.2
conductive part
part capable of conducting current, although it may not necessarily be used for carrying service current [IEV 441-11-09]

3.3.3
exposed conductive part
conductive part which can be readily touched and which is not normally live, but which may become live under fault conditions [IEV 441-11-10]

NOTE 1 A conductive part of electrical equipment which can only become live under fault conditions through an exposed conductive part is not considered to be an exposed conductive part.

NOTE 2 Typical exposed conductive parts are enclosure walls, etc.

3.3.4
live part
conductor or conductive part intended to be energised in normal use, including, if applicable, the return conductor

NOTE The return circuit of the switchgear may be considered as either a live or an earthed part. The rated insulation voltage of the return circuit is stated by the purchaser.

3.3.5
clearance
distance between two conductive parts along a string stretched along the shortest distance between these conductive parts

3.3.6
clearance to earth
distance between any conductive part and any part earthed or intended to be earthed

3.3.7
clearance between open contacts
distance between the contacts, or any conductive part connected to the contacts, of a mechanical switching device in the open position

3.3.7.1
isolating distance
clearance between open contacts satisfying the safety requirements specified for switching devices

3.3.8
creepage distance
shortest distance along the surface of the insulating material between two conductive parts

NOTE A seal between two portions of insulating material is considered to be a part of the surface.

3.3.9 Circuits at main supply voltage

3.3.9.1
main circuit (of a switching device)
all conductive parts of a switching device included in the circuit which is designed to close and open

3.3.9.2
main circuit (of a switchgear assembly)
all conductive parts of a switchgear assembly which are at the main supply voltage, carrying power current, but excluding the busbars

3.3.9.3
busbars (of a switchgear assembly)
conductive parts of a switchgear assembly, at the main supply voltage, which are intended to distribute power current to one or more functional units

3.3.10 Main circuit contacts

3.3.10.1
main contact (of a mechanical switching device)
contact included in the main circuit of a mechanical switching device, intended to carry, in the close position, the current of the main circuit

3.3.10.2
arcing contact
contact on which the arc (if any) is intended to be established

NOTE An arcing contact may serve as a main contact: it may be a separate contact so designed that it opens after, and closes before, another contact which it is intended to protect from damage.

3.3.11
control circuit (of a switching device)
conductive parts of a switching device, other than those parts forming the main circuit, forming a circuit used to control and actuate the making and breaking operations of the switching device

3.3.12
auxiliary circuit (of a switching device)
conductive parts of a switching device forming a circuit differing from the main circuit and the control circuit

3.3.13
auxiliary circuit (of a switchgear assembly)
all conductive parts of switchgear included in a circuit (other than the main circuit) intended to control, measure, signal and regulate

NOTE The auxiliary circuits of a switchgear include the control and auxiliary circuits of the switching devices.

3.3.14
transport unit
part of a switchgear suitable for shipment without being dismantled

3.3.15
functional unit

part of a switchgear comprising all the components of the main circuits and auxiliary circuits that contribute to the fulfilment of a single function

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

3.3.16
enclosure
part providing a specified degree of protection of the equipment against certain external influences specified and a specified degree of protection against approach to or contact with live parts and against contact with moving parts

3.3.17
integral enclosure
enclosure which forms an integral part of the equipment

3.3.18
compartment
part of switchgear enclosed except for openings necessary for interconnections, control and/or ventilation

NOTE 1 A compartment may be designated by the main component contained therein, for example, circuit-breaker compartment, a busbar compartment, etc.

NOTE 2 Openings necessary for interconnections between compartments are closed with bushings or other equivalent means.

NOTE 3 Busbar compartments may extend through several functional units without the need for bushings or other equivalent means.

3.3.19
partition
part of switchgear separating one compartment from other compartments

3.3.20
shutter
part of switchgear that can be moved from a position where it is a part of the enclosure or partition shielding the live parts to a position where it permits contacts of a removable part to engage live parts

3.3.21
bushing
structure carrying one or more conductors through an enclosure and insulating it therefrom, including the means of attachment

3.3.22
removable part
part of switchgear that may be removed entirely from the metal-enclosed switchgear and replaced, even when the main circuit is alive

3.3.23
withdrawable part
removable part of a switchgear that can be moved to positions in which an isolating distance (see Table 1) or segregation between open contacts is established, while the part remains mechanically attached to the enclosure

3.3.24
service position (connected position) of a removable part
position of a removable part in which it is fully connected for its intended function

3.3.25
test position (of a withdrawable part)
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

3.3.26
disconnected position (of a withdrawable part)
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

NOTE In switchgear the auxiliary circuits may not be disconnected.

3.3.27
removed position (of a removable part)
position of a removable part when it is outside and mechanically and electrically separated from the enclosure

3.3.28
metal-enclosed switchgear
switchgear assemblies with an external metallic enclosure intended to be earthed and complete except for external connections

NOTE The metal-enclosed switchgear is subdivided into three types:
- metal-clad switchgear;
- compartmented switchgear (with one or more non-metallic partitions);
- cubicle switchgear.

3.3.28.1
metal-clad switchgear
metal-enclosed switchgear in which components are arranged in separate compartments with metal partitions intended to be earthed

NOTE 1 This term applies to metal-enclosed switchgear with metal partitions providing the degree of protection (or higher) included in EN 50123-6 and having separate compartments at least for the following components:
- each main switching device;
- components connected to one side of a main switching device, for example, feeder circuit;
- 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 is in a separate compartment.

NOTE 2 Metal-enclosed switchgear having metal partitions and meeting all the requirements of note 1 may utilise an insulating shutter barrier as a part of a shutter arrangement, the combination of which provides the degree of protection included in Table 1 of EN 50123-6 (or higher) and satisfies the requirements of the standard for partitions and shutters made of insulating material.

3.3.28.2
compartmented switchgear (with non-metallic partitions)
metal-enclosed switchgear in which components are arranged in separate compartments as for metal-clad switchgear, but with one or more non-metallic partitions providing the degree of protection (or higher) included in Table 1 of EN 50123-6

NOTE Metal-enclosed switchgear 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 IEC 60466 are met.

3.3.28.3
cubicle switchgear
switchgear, other than metal-clad and compartmented switchgear

NOTE This term applies to switchgear having a metal enclosure and having either
- a number of compartments fewer than required for metal-clad or compartmented switchgear,
- partitions having a degree of protection lower than those indicated in Table 1 of EN 50123-6,
- no partitions.

3.3.29
degree of protection
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 (see EN 60529)

3.4 Terms relating to d.c. circuit breakers, switch-disconnectors and associated relays

3.4.1
air d.c. circuit breaker
d.c. circuit breaker which exclusively operates by means of contacts which open and close in air at atmospheric pressure

3.4.2
gas circuit breaker
not in use for d.c. applications

3.4.3
semiconductor circuit breaker
circuit breaker designed to make and/or break the current in an electric circuit by means of the controlled conductivity of a semiconductor

NOTE There may be mechanical contacts associated with these semiconductor devices.

3.4.4
line circuit breaker (L)
circuit breaker used to connect or disconnect a power line circuit to a d.c. source of supply. The power line circuit is that circuit which transmits the electrical energy to the electrical machines and traction equipment on the vehicles. These circuit breakers are fitted with electrical protection and tripping devices. Line circuit breakers are used to disconnect the track line from the energised busbar

NOTE Line circuit breakers are always trip-free circuit breakers (see 3.4.11).

3.4.5
rectifier circuit breaker (R)
circuit breaker that connects the output of the rectifier to the energised busbar of the switchboard.

NOTE 1 Rectifier circuit breakers are fitted with a reverse series trip device to disconnect the rectifier from the d.c. busbar in the event of a rectifier fault. These circuit breakers are unidirectional in operation and they have a short-time rating in the forward direction.

NOTE 2 The terms "forward" and "reverse" relate to the normal flow of energy.

3.4.6
interconnecting circuit breaker (I)
circuit breaker used to couple or uncouple different portions of the contact line network

NOTE These circuit breakers are sometimes called bus-section or section circuit breakers.

3.4.7 Current limiting circuit breakers

3.4.7.1
high speed current limiting circuit breaker (H)
circuit breaker with a break time sufficiently short to prevent the short-circuit current reaching the peak value it would have attained without interruption

For this condition to apply, the H circuit breaker has an opening time not greater than 5 ms and a total break time not greater than 20 ms, when the current to be interrupted has a prospective sustained value of at least 7 times the circuit breaker setting and

$$\left[\frac{di}{dt}\right]_{t=0} \geq 5 \quad \text{kA/ms}$$

3.4.7.2
very high-speed current-limiting circuit breaker (V)
circuit breaker in which the total break time is not greater than 4 ms, irrespective of the other parameters of the circuit

3.4.8
semi-high speed circuit breaker (S)
circuit breaker in which interruption of the current is ensured, but no current limitation may take place

For this condition to apply, the S circuit breaker has an opening time not greater than 15 ms and a total break time not greater than 30 ms, when the current to be interrupted has a prospective sustained value of at least 3,5 times the circuit breaker setting and

$$\left[\frac{di}{dt}\right]_{t=0} \geq 1{,}7 \quad \text{kA/ms}$$

3.4.9
circuit breaker or switch-disconnector with lock-out preventing closing
switching device in which the closing of the main contacts in the main circuit is prevented when the closing command is given and/or maintained and at the same time conditions (for example, control signals from overload or short-circuit electrical protection) which require the circuit breaker to open are present

3.4.10
tripping (operation)
opening operation of a switching device initiated by a relay or release

3.4.11
trip-free circuit breaker
circuit breaker in which the moving contacts return to and remain in the open position when the tripping operation is initiated after the initiation of the closing operation, even if the closing command is maintained

NOTE To ensure proper breaking of the current which may have been established, it may be necessary that the contacts momentarily reach the closed position.

3.4.12
release (of a mechanical switching device)
device, mechanically connected to a mechanical switching device, which releases the holding means and permits the opening or closing of the switching device

NOTE 1 The term “release” refers here to any device, with mechanical action, used for a tripping operation, when the specified conditions are met in the input electrical circuits of the device.

NOTE 2 A circuit breaker can have several releases, each becoming operational according to specified conditions.

NOTE 3 A release can be made up of mechanical, electromagnetic or electronics parts.

3.4.13
relay (of a mechanical switching device)
device, electrically connected to a release fitted on the operating mechanism of a switching device, which permits the operation of the switching device

NOTE 1 The term “relay” refers here to any device, with electrical action, used for actuating a tripping operation, when the specified conditions are met in the input electrical circuits of the device.

NOTE 2 A circuit breaker can have several relays, each becoming operational according to specified conditions.

NOTE 3 A relay can be made up of electromagnetic or electronics parts.

3.4.14
overcurrent relay or overcurrent release
relay or release which causes a mechanical switching device to open with or without time-delay when the current in the relay or release exceeds a predetermined value

3.4.14.1
direct overcurrent relay or direct overcurrent release
overcurrent relay or release directly energised by the current in the main circuit of a switching device

3.4.14.2
indirect overcurrent relay or indirect overcurrent release
overcurrent relay or release energised by the current in the main circuit of a switching device through a shunt or a sensor

3.4.15
series overcurrent relay or series overcurrent release
relay or release designed as part of the main circuit of the circuit breaker

NOTE The opening operation of the circuit breaker can be otherwise caused by other relays or releases specific to the traction equipment (differential relays, thermal relays, etc.).

3.4.16
instantaneous relay or instantaneous release
relay or release which operates without an intentional delay

3.4.17
release auxiliary switch
auxiliary switch operated by the relay or release to indicate of their operation under fault conditions. Such an auxiliary switch may have a time delay reset

3.4.18
shunt relay or shunt release
relay or release fed by an independent voltage source

3.4.19
undervoltage relay or undervoltage release
relay or release which causes opening of the switching device when the voltage appearing at switching device terminals falls below a selected value

3.4.20
current setting (of a series overcurrent relay or release)
value of the current of the main circuit to which the operating characteristic of the relay or release relate and for which the relay and release is adjusted

NOTE A relay or release may have more than one current setting.

3.4.21
current setting range (of a series overcurrent relay or release)
range limited by minimum and maximum values between which the value of the current setting of the relay or release can be selected

3.4.22
anti pumping device
device which prevents reclosing after a close-open operation as long as the device initiating closing is maintained in the position of closing

3.4.23 Breaking characteristics

3.4.23.1
opening time (t_i)
interval of time between the specified instant of initiation of the opening operation and the instant when all contacts have separated in the main circuit

The opening of a circuit breaker may be caused by a series in-built overcurrent relay (or release) (see 3.4.23.3) or by a different device (see 3.4.23.4).

3.4.23.2
overcurrent opening time
opening time for an overcurrent relay or release

3.4.23.3
opening time with command from the series overcurrent relay (or series overcurrent release)
interval of time between the instant when the current in the main circuit reaches the value of the current setting (of the relay or of the release) and the instant of separation of all contacts

3.4.23.4
opening time controlled by a device other than an overcurrent relay (or overcurrent release)
interval of time between the instant of the initiation of the variation in the control energy (by emission or by loss of energy) causing initiation of the opening operation and the instant of separation of all contacts

3.4.23.5
arcing time (t_a)

interval of time between the instant of the initiation of the arc and the instant of final arc extinction

3.4.23.6
total break time (t_b)

interval of time between the beginning of the opening time and the current extinction

$$t_b = t_i + t_a$$

3.4.23.7
Joule integral (I^2t)
integral of the square of the current in a circuit breaker during the breaking process, over the total break time

$$I^2t = \int_{t_0}^{t_1} i^2 dt$$

where

t_0 is the beginning of the opening time,

t_1 is the final time of current extinction.

Joule integral may be considered also for the arcing time only.

3.4.23.8
characteristic I^2t of a circuit breaker
information (generally a curve) giving the values of I^2t (corresponding to the total break-time) as a function of the prospective current (at the corresponding voltage, for specified conditions of the current setting of the relay or release) and the time constant of the test circuit

3.4.23.9
total break time - current characteristic
curve giving the break time as a function of the prospective current for specified conditions as the current setting of the relay or release, and the time constant of the test circuit

3.4.23.10
cut off (current) characteristic
curve giving the cut off current as a function of the prospective current for specified conditions as the current setting of the release, and the time constant of the test circuit

4 Service conditions and requirements

4.1 Environmental conditions

Environmental conditions for indoor equipment are specified in Annex B.

Equipment suitable to be installed under normal conditions as specified in Annex B, do not require special prescriptions in the tendering or ordering stage.

Conditions of service where any or more of the normal conditions are exceeded are to be considered as abnormal conditions of service. In all such cases, additional requirements for the equipment shall be agreed between purchaser and supplier.

Where conditions of service are abnormal, particular tests or particular features in the tests either indicated in the standards or, if not indicated, agreed upon between purchaser and supplier may prove the suitability of the equipment to be used in the stated abnormal conditions.

4.2 Insulation levels

The enquiry and the order, as well as the nameplate, shall indicate (in the ways indicated in the appropriate parts of this standard) the applicable rated insulation voltage and the rated impulse level.

Insulation levels and clearances are given in Table 1.

Recommended values for creepage distances are given in Annex D.

Switching surges are taken into consideration for specific pieces of equipment, and are mentioned in the appropriate parts of this standard. Unless otherwise indicated, the voltage level to be considered for switching surges is the same as stated for the lightning impulse surges.

Inside the apparatus under consideration and between the apparatus itself and its earthed metallic enclosure or its enclosure made of suitable insulating material, lower distances than the minimum values prescribed in Table 1 are acceptable. Then suitable type tests shall show that no discharge occurs and that the given insulation and clearances are sufficient in the ambient conditions actually occurring or likely to occur during normal service operation.

Table 1 – Insulation levels

U_n	U_{Ne}	U_{Nm}	OV	U_{Ni}		U_a		Clearance Indoor		Clearance Outdoor	
				A	B	A	B	A	B	A’	B’
kV	kV	kV		kV	kV	kV	kV	mm	mm	mm	mm
0,6	0,72	0,9	3	6	7,2	2,8	3,4	10	12	18	22
			4	8	9,6	3,6	4,3	14	17	21	25
0,75	0,9	1,2	3	8	9,6	3,6	4,3	14	17	21	25
			4	12	14,4	5,5	6,6	22	26	27	32
0,75	0,9	1,8	3	10	12	4,6	5,5	18	22	23	28
			4	15	18	6,9	8,3	27	32	33	40
1,5	1,8	2,3	3	12	14,4	5,5	6,6	22	26	27	32
			4	18	21,6	8,3	10	32	38	39	47
1,5	1,8	3	3	15	18	6,9	8,3	27	32	33	40
			4	20	24	9,2	11	36	43	43	52
3	3,6	3,6	3	25	30	11,5	13,8	45	54	53	64
			4	30	36	14	16,8	54	65	63	76
3	3,6	4,8	3	30	36	14	16,8	54	65	63	76
			4	40	48	18,5	22,2	72	86	82	98
3	4,8	6,5	3	40	48	18,5	22,2	72	86	82	98
			4	50	60	23	27,6	91	109	101	121

Column	Origin of values	
U_n = nominal voltage	(EN 50163)	A : to earth and between phases – indoor
U_{Ne} = rated voltage		B : across an isolating distance if applicable – indoor
U_{Nm} = rated insulation voltage	(EN 50124-1 A.2)	A' and B' as A and B but outdoor
U_{Ni} = rated impulse voltage	A (EN 50124-1 A.2) B ≅ A x 1,2	
U_a = power frequency withstand voltage level	A (EN 50124-1 B.1) B ≅ A x 1,2	

Clearances for A and A’ conditions are taken from EN 50124-1 Table A.3 considering PD4 as recommended value for indoor equipment, and PD4A as recommended value for outdoor equipment. For B and B’ the values are obtained from A and A’ respectively, multiplied by 1,2.

NOTE 1 For values up to U_{Nm} = 2,3 kV, OV3 category is considered adequate and is internationally recognised. For outdoor situations with the equipment connected to contact line, differing from tunnels and urban transport systems, the use of OV4 may be advisable.

NOTE 2 For values of U_{Nm} above 2,3 kV, OV4 category is recommended in all cases except for protected situations, such as tunnels and urban transportation systems, where OV3 may be agreed between purchaser and supplier.

NOTE 3 When more than one line is shown for a given U_n, the lower levels are preferred particularly for third/fourth rail and light rail systems.

NOTE 4 The impulse voltages are given for reference only; the test is to be carried out only when specified in the appropriate equipment standard (for all equipment except that covered in EN 50123-5, the test is required for rated insulation voltages above 2 500 V).

5 Standard features and conventional assumptions

5.1 Standard features and conventional parameters for the main circuit

5.1.1 General assumptions for main parameters

5.1.1.1 Ripple factor

The maximum ripple factor of the d.c. current shall be that obtained by full-wave three-phase a.c. rectifier.

Where the peak ripple factor is higher, the supplier shall be informed in the tender documents.

NOTE Voltage values are mean values of the actual voltage, taking into account ripples in wave-shape.

5.1.1.2 Peak of the short-circuit current

The peak of the short-circuit current value is conventionally assumed to be 1,42 times the prospective sustained short-circuit current for a fault of negligible impedance at the input or output terminals of the switchboard, as specified. As the distance from the switchboard to any fault increases so this value decreases.

NOTE 1 The theoretical value of 1,66 times the steady-state value is never seen in practice, and the calculation factor 1,42 used in this standard is supported by test evidence.

NOTE 2 The value of I_{ss} may have to be adjusted to achieve the required peak value.

5.1.1.3 Maximum circuit-energy short-circuit

As the distance from the substation increases, the circuit time constant (ratio inductance over resistance) gradually changes from that of the source to that of the track. When the circuit gives a time constant approximately midway between the two values, it is then nearly at the position at which the maximum circuit energy occurs. A theoretical indication in this respect is given in Annex E.

For practical purposes, this is taken to be a position at which the short-circuit current I_{ss} and the circuit time constant t_c assume the values given in Table 2:

Table 2 – Test circuit parameters for maximum circuit energy

T_{Nc} ms	t_c	I_{ss}
≥ 63	0,5 T_{Nc}	0,5 I_{Nss}
31,5	0,65 T_{Nc}	0,65 I_{Nss}
16	0,8 T_{Nc}	0,8 I_{Nss}

If a high value smoothing reactor is used, the maximum energy fault may occur at the station outlet.

5.1.1.4 Distant fault short circuit

For simulating distant fault short circuit condition during tests, the value of current given to this circuit is conventionally twice the full load current of the line circuit breaker, i.e. 2 x I_{Ne}.

Since the circuit impedance is comprised mainly of the track itself, then the circuit time constant is taken to be the rated track time constant T_{Nc}.

5.1.1.5 Current values through a rectifier circuit breaker

As a guidance, the rated service current of the rectifier circuit breaker shall meet the overload requirements of the rectifier. The rated short time withstand current in the forward direction should be between 4 and 8 times the rectifier circuit breaker rated service current. The duration of the short-time withstand current should be between 0,1 s and 0,25 s and must allow sufficient time to give discrimination with the a.c. circuit breaker.

5.1.2 Standard short circuit stresses

5.1.2.1 General

The figures given in 5.1.2.2 and 5.1.2.3 for the rated short-circuit current and for the rated track time constant are given as preferred values in order to standardise the features of the equipment. Whenever possible, the values adopted should be the preferred values just greater than the calculated values for a given circuit.

5.1.2.2 Standard rated short-circuit currents (I_{Nss})

The following values are preferred values:

31,5	40	50	63	75 [1)]	80	100	125	kA

NOTE Up to 100 kA for U_n = 1,5 kV and up to 63 kA for U_n = 3 kV.

5.1.2.3 Standard rated track time constant (T_{Nc})

The following values are preferred values:

16	31,5	63	80	100	125	160	200	ms

5.1.3 Standard voltages for the main circuit

Standard values for the nominal voltage U_n are listed in EN 50163. The corresponding values of U_{Nm} in Table 1 shall be higher than U_{max1} of EN 50163.

The value of U_{max2} specified in EN 50163 is limited to 300 s, the value of U_{min2} specified in EN 50163 is limited to 600 s; both values shall be taken into consideration, when likely to occur so as not to cause damage in the insulation, flashover or dangerous temperature-rises.

5.1.4 Standard rated service currents for the main circuit (I_{Ne})

The following values are preferred values:

400	630	1 000	1 600	2 000	2 500	3 150	4 000	6 300	8 000	A

[1)] This value is already in use in some countries and can continue to be used. The preferred value for new installations elsewhere is the value 80.

5.2 Standard features for auxiliary and control circuits

For auxiliary and control circuits independent of the main circuits, the voltages given in Table 3 are preferred:

Table 3 – Preferred voltages for auxiliary and control circuits [V]

A.C.	24	48		110	127	230/400	
D.C.	24	48	60	110	125	220	440

The rated current of all contacts of supervisory and indication circuits shall be specified by the purchaser. All contacts of supervisory and indication circuits shall be capable of working at 20 % of their rated voltage, unless otherwise specified by the purchaser.

For the other equipment (for example, coils), the allowable range of the voltage shall be within 80 % and 110 % of their rated supply voltage, unless otherwise specified by the purchaser.

All auxiliary circuits operating at voltages above 500 V shall be protected by fuses according to EN 60269-1 or by other means giving equivalent performance.

NOTE It is recommended that all monitoring relays, manufactured in accordance with their specific standards, are of the plug-in type and are provided with a locking device to prevent accidental movement of the withdrawable portion, and, when applicable, with a transparent non-flammable cover, unless fitted with a position indicating device.

6 Temperature-rise limits

The temperature-rises of the various items of equipment measured during the tests performed in accordance with clause 7 and with the detailed prescriptions, if any, of the other parts of this standard shall not exceed the limits given in Tables 4 and 5.

In cases where the maximum ambient temperature is always below 40 °C, an increase in these limiting values may be accepted by agreement between purchaser and supplier. For abnormal site conditions, with a maximum ambient temperature exceeding 40 °C, the temperature-rises shall be reduced by the difference between the stipulated maximum ambient temperature and 40 °C. Moreover, care shall be taken that the heat released by an individual equipment does not influence the correct cooling of adjacent equipment or does not heat by conductivity such equipment.

Table 4 – Temperature-rise limits for insulated coils

Insulation class	**Temperature-rise limits measured by resistance variation** K [a]
105 (A)	65
120 (E)	80
130 (B)	90
155 (F)	115
180 (H)	140

[a] If measurement by resistance variation can not be applied then other methods are permissible. In this case the measurement of temperature shall be carried out by thermometer or other suitable methods.

Table 5 – Temperature-rise limits for various components

Component	Temperature-rise limits measured by thermometer K	
Bare wire coils	105	Note 1
Contacts in air:		
- pure Cu in spring form	35	
- brass or bronze in spring form	65	
- pure Cu or Cu-alloy not in spring form	75	
- plate of solid Ag	100	
- other metals or sintered metals		Note 2
Terminals for insulation to external connections	70	Note 3
Flexible connections in air	90	

NOTE 1 Provided that this value has no adverse effect on the satisfactory operation of adjacent parts.

NOTE 2 To be determined by the quality of the metals employed and limited by the obligation of not causing damage to themselves and to neighbouring parts.

NOTE 3 The 70 K temperature-rise limit is a value based upon a conventional test dealt with in other parts of the standard. A material used or tested in conditions corresponding to those of the actual installation may have connections, the type, nature and arrangement of which differ from those adopted for the test. The resulting terminal temperature-rise limit may be different and should be agreed upon between purchaser and supplier.

During tests on equipment, no correction shall be made to the temperature-rises observed if the ambient temperature during test is between 10 °C and 40 °C. Outside these limits, the correction to be applied to the temperature-rises observed shall be agreed between purchaser and supplier.

A temperature exceeding by more than 15 % the temperature-rises shown in Tables 4 and 5 is considered a hazardous temperature, unless otherwise agreed.

7 Tests

7.1 General

Type and routine (acceptance) tests applicable to a specific type of equipment, as well as details on testing procedures, are listed in the appropriate part of this standard.

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

The unit, unless otherwise required in the appropriate part of this standard, shall be tested as a complete assembly, either in its individual enclosure or in an enclosure simulating that enclosure or intended application.

The classification of the tests and the general procedures to be followed for carrying out the tests are covered by specific product standards.

NOTE 1 This standard sets out those test requirements which are common to most equipment listed in the scope.

NOTE 2 For procedural matters not covered in either this standard or in other parts of this series, reference may be made to EN or IEC publications covering similar equipment.

NOTE 3 Investigation tests are admitted and mentioned in other parts of this standard. They may be performed by initiative of the manufacturer or by agreement between purchaser and supplier to acquire experience either on test procedures or on possible new techniques, thus studying possible future applications of the equipment. It is understood that the results of investigation tests are not to be taken as influencing the acceptability of the material.

7.2 Test tolerances

Test tolerances shall be within the tolerances indicated in Table 6, unless otherwise indicated in the appropriate part of this standard.

Table 6 – Test tolerances

Quantity	Tolerance %	Quantity	Tolerance %
Current	+ 10 0	Frequency (if applicable)	+ 5 − 5
Voltage	+ 10 0	Time-constant	+ 30 0

7.3 Tests on movable devices

7.3.1 Mechanical operation test

The mechanical operation test applies to all equipment having moving parts. They are usually routine tests and are performed under normal conditions of the test laboratory. Equipment which is intended and designed for operation in ambient temperatures below -5 °C, will require additional tests that should be agreed between purchaser and supplier at the ordering stage.

This test shall be carried out without current in the main circuit.

The test consists of carrying out a limited number of operations (as strictly necessary for carrying out the checks mentioned in product standards), with the control circuits supplied at their rated voltage, as measured at the input terminals to that control circuit.

All resistances and impedances which are part of the control circuits shall be connected. However no additional impedances shall be connected between the supply source and the control circuit terminals.

This test is intended to prove the correct operation of the device and that it complies with the operating conditions specified within the maximum and minimum limits required for the opening and closing control devices.

The type test for abnormal environmental conditions, if required, shall be performed at both the lowest and the highest ambient temperatures for the service conditions specified. This test may be repeated immediately after the tests under 7.4.

This test ensures that the operation of the equipment is satisfactory when carried out under the most unfavourable combination of voltage and temperature obtainable within the specified limits.

The operating mechanism shall be actuated as far as possible as in normal operating conditions.

7.3.2 Electrical endurance test

The electrical endurance test is a type test carried out in laboratory conditions. It shall be carried out on switching devices and associated equipment.

The test shall consist of carrying out a set number of operating cycles, as specified in the appropriate product standard.

The test shall be made at the rated supply voltage of the control circuit. The unit shall be operated in such a way that it breaks its rated service current I_{Ne} (or, if agreed between purchaser and supplier, its conventional thermal current, I_{th} or I_{the}), at its rated service voltage U_{Ne} in a circuit having a time constant t_c equal to 0,01 s.

The operating mechanism shall be actuated as far as possible as in normal operating conditions.

The unit need only be closed for a sufficient time to ensure that it is fully closed mechanically and the transient currents from making have disappeared and that the breaking current value is established.

All resistances and impedances which are part of the control circuits shall be connected. However, no additional impedances shall be connected between the supply source and the input terminals of the control circuit on the switching device.

The unit shall be deemed to have passed the test, if, after the test, it is in a position to withstand

- its rated service current I_{Ne}, after any necessary adjustment and maintenance of the contacts, without exceeding the temperature-rises in clause 6, when tested in accordance with 7.4. The temperature-rise test is required only when the resistance of the main circuit (without maintenance) has increased by more than 50 % of the value before test. A small number of no-load operations are allowed in an endeavour to bring the resistance down below this figure; if the test has to be performed, then an additional 10 K temperature-rise is allowed on the contacts,
- an a.c. voltage equal to two times the rated voltage U_{Ne} applied
  - between its main circuit and earth,
  - between the main contacts in the open position.

The unit shall be deemed to have passed the test, if after the test, it can be operated normally and meets the withstand requirements specified above.

7.3.3 Mechanical endurance test

The mechanical endurance test is a type test and is carried out in laboratory conditions.

The test shall consist of operating the switching device and associated mechanical equipment for the number of operating cycles in succession, as specified in the appropriate product standard. The supply voltage to the control circuits shall be within the limits set out in 5.2.

All resistances and impedances which are part of the control circuits shall be connected. However no additional impedances shall be connected between the supply source and the input terminals of the control circuit on the switching device.

The operating mechanism shall be actuated as far as possible as in normal operating conditions.

The device under test shall be deemed to have passed this test if, after this test, it is capable of being operated normally as specified in the appropriate product standard.

7.4 Temperature-rise test

7.4.1 General

The temperature-rise test is a type test and is carried out with the test object installed in the laboratory to reproduce as far as possible the final installation conditions.

Coils and resistors shall be supplied at their rated maximum control voltage (see 5.2) or U_{max}, if applicable (see 3.2.1.2.1). AC circuits shall be supplied at rated frequency.

Contacts, leads and other conductive parts shall be able to carry their rated service current (see 3.2.10) (thermal current with or without enclosure for switching devices).

The temperature-rise above ambient temperature shall be taken when temperature readings have reached a steady state. Variations of less than 1 K/h, with a maximum test duration of 8 h, shall be considered conditions fulfilling the required steady-state conditions. For coils and resistors of auxiliary or control circuits which are normally energised for short periods, in the order of up to three times their time constant, followed by long periods of inactivity, need not be energised for this test.

7.4.2 Ambient temperature

The ambient air temperature shall be measured during the final quarter of the test period, by means of at least two thermometers or thermo-elements, placed regularly around the equipment, at half height and at a distance of about 1 m from the equipment. The thermometers or thermo-elements shall be protected from air currents and radiated heat, and care shall be taken to avoid indication errors due to rapid temperature changes.

7.4.3 Temperature-rise test of the main circuit

Equipment with an integral enclosure shall be tested in the enclosure.

The dimensions of the test conductors shall be recorded in the test report.

Where copper cables are used, the following current densities are recommended:

- for I_{Ne} up to 3 000 A: 1,5 A/mm²;
- for I_{Ne} from 3 000 A up to 6 500 A: 1,3 A/mm²;
- for I_{Ne} from 6 500 A up to 10 000 A: 1,1 A/mm².

Where copper bars are used, values should be as given in Table 7.

For tests on outdoor equipment, where temperature-rise limits are 30 K less than the values specified in clause 6, the current density of cables and dimensions of copper bars are different from those specified in Table 7. The recommended sizes are listed in EN 50123-4.

Table 7 – Recommended quantities and dimensions of copper bars

I_{Ne} A	Copper bars	
	Quantity	**Section** mm × mm
630 to 800	2	50 x 5
801 to 1 000	2	60 x 5
1 001 to 1 250	2	80 x 5
1 251 to 1 600	2	100 x 5
1 601 to 2 000	3	100 x 5
2 001 to 2 500	4	100 x 5
2 501 to 3 150	3	100 x 10
3 151 to 4 000	4	100 x 10
4 001 to 5 000	5	100 x 10
5 001 to 6 300	6	100 x 10
6 301 to 8 000	4	160 x 10

Copper bars should be preferably arranged in such a manner that the longer dimension of the cross-section is vertically oriented.

The temperature-rise test of the main circuit shall be carried out at its rated service current I_{Ne}, followed by the stipulated overloads or at its conventional thermal current I_{th} or I_{the}. The choice between these current values is left to agreement between purchaser and supplier.

Temporary connections to the main circuit shall be made so that no significant heat quantity is removed from or supplied to the main circuit during the test. The temperature-rise is measured across the main circuit terminals and across the temporary connections, 1 m away from the terminals. The temperature-rise difference shall not exceed 5 K.

7.4.4 Temperature-rise test for auxiliary and control circuits

The devices which are intended to operate continuously shall be tested as detailed in 7.4.3. Those circuits which are energised during closing and/or opening operations only shall be energised 10 times in sequence, each duration corresponding to that occurring during service, with a time interval between successive energisations not exceeding 5 s.

7.4.5 Measurement of the temperatures of all components

For live parts other than coils, the temperature of the different devices shall be measured by suitable means such as thermo-elements, located as near as possible of the accessible hottest spot for contacts; for conductors and joints, the thermo-elements shall be located as near as possible to adjacent insulation.

Good thermal conductivity shall be assured between the thermo-element and the surface of the tested part.

For coils connected in parallel, the resistance-variation method shall be applied. Other methods are admitted only when it is impossible to use such resistance-variation method. The coil temperature, as measured before the temperature test by means of a thermo-element, shall not differ from ambient temperature by more than 3 K.

7.5 Dielectric tests

7.5.1 Impulse withstand voltage test

The impulse withstand voltage test shall be carried out (as a type test or an investigation test) only when specified in the appropriate part of this standard for the particular product.

Unless otherwise specified in the appropriate part of this Standard, the test shall consist of the application between the live parts of the main circuit and all other conductive parts connected to earth, of three positive pulses with 1,2/50 waves, followed by three negative pulses with the same wave-shape. The peak value of the pulses U_{Ni} shall be chosen in accordance with Table 1.

Switching devices may have to be submitted (according to their duty, as specified for individual equipment type) to the same test for a second time, but in the open position by impulsing the line-side parts of the main circuit, connecting all the remaining conductive parts to earth.

The product is deemed to have passed the tests if no flashover occurs.

NOTE The test with surge (long) waves is considered to be an investigation test.

7.5.2 Power-frequency voltage withstand test

The power frequency voltage test is generally a routine test. It shall be carried out using a test voltage at a frequency of 50 Hz of approximately sinusoidal form (see HD 588.1 S1 and EN 50124-1, Annex B).

The test voltage U_a corresponding to the insulation voltage level is given in Table 1 and is applied for 60 s as follows:

- for switching devices both within the main circuit (in the closed position) and all the remaining conductive parts connected to earth, and (in the open position) between contacts, being one contact and all the remaining conductive parts being connected to earth.
- for all other equipment (except surge arresters, which have different requirements) between the live parts and earth.

Equipment intended to be installed indoors shall be tested in dry conditions; equipment intended to be installed outdoors shall be tested in wet conditions as a type test and in dry conditions as a routine test.

The power frequency voltage test value for auxiliary and control circuits shall be 2 000 V.

NOTE The test procedures are subject to agreement between purchaser and supplier, but EN 60507 may be used as guidance.

7.6 Short circuit and load switching conditions

7.6.1 Test circuit for short circuit and load switching conditions

A typical diagram of the test circuit is shown in Figure A.1 with typical calibration and characteristics shown in 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.

For test duties simulating substation faults, the test circuit shall produce a peak current with the characteristic illustrated as calibration 1 in Figure A.2.

Reactors L shall be core-less and shall be connected in series with resistors R and their value shall be obtained by adding in series elementary reactors; coupling in parallel is admissible only when these reactors have practically the same time-constant.

For test duties away from the substation or for load/overload current switching, the test circuit shall produce an exponential wave form with the characteristics illustrated as calibration 2 in Figure A.2, at the specified time constant. L and R should be added to the load side terminal of the switching device. This is not always possible in a testing station and usually some circuit adjustment is made on the a.c. side. This is acceptable provided that not less than 80 % of the impedance is on the load side.

Any test circuit differing from the above-mentioned arrangement shall be recorded in the report.

All those parts of the test object which are normally connected to earth, including the enclosure or the screens, shall be insulated from earth and connected through a device D to the conductor of the opposite polarity to that in which the test object is connected as illustrated in Figure A.1.

The device D shall include a fuse, which consists of a copper wire 50 mm in length and with a diameter of 0,8 mm or a similar fuse wire detecting the fault current. It shall include a resistor to limit the fault current to not less than 1,5 kA.

NOTE A copper wire with 0,8 mm diameter melts at a d.c. current of 1 500 A in a time of 0,01 s.

The prospective sustained fault current is the fault current to this value.

7.6.2 Details for the conduct of the test

The unit shall break the test current with no re-ignitions after current zero. There shall be no flashover between poles and no current shall operate device D.

The unit shall remain in a condition that allows its continued mechanical operation; any burning of the contacts shall not prevent the unit from opening normally

7.6.3 Conditions of the unit after the test

After the test has been performed no functional breakages shall occur.

Immediately after the test, check that the unit satisfactorily closes and opens during a no-load cycle.

After the test and before making any preliminary maintenance, the unit shall be capable of withstanding an a.c. r.m.s. voltage value equal to double the rated voltage U_{Ne} for 60 s. Alternatively, for switch-disconnectors only, the purchaser may require a check that the leakage currents are not higher than 2 mA, at 1,1 U_{Ne} by the application of a d.c. supply for 60 s. The leakage current shall be measured across each open contact and between each terminal and the frame.

The measurement of the resistance of the main circuit, taken after the test and compared with that taken before the test, shall show no great deviation (i.e. increase of not more than 50 %).

If the measurement of the resistance of the main circuit shows an increase of more than 50 % of the value before the test, a small number of no-load operations may be made in an endeavour to bring the resistance down below this figure; if not the temperature-rise test shall be repeated to prove that the unit passed the test; in such a case an additional 10 K temperature-rise is allowed on the contacts.

7.7 Verification of the behaviour during short-time withstand current test

7.7.1 Test and test values

The test shall be performed at the rated voltage U_{Ne} , with the circuit calibrated in accordance whith 7.6.1. These test values are then the values of the prospective current which shall be maintained for 0,25 s and shall show at least the sustained value of I_{Ncw} and a peak value of 1,42 I_{Ncw}. The test shall be repeated on the unit to be tested.

The test may be performed at a lower d.c. voltage value or as a two-part a.c. test. In these cases no prospective test is involved and the test values required are those actually seen during the test.

The a.c. test is split into two parts: the first is effected using an a.c. current having a asymmetrical peak value of 1,42 I_{Ncw}, applied for a loop time of not less than 15 ms; the second is with a reduced a.c. r.m.s. current applied for a longer time (not exceeding 3 s) to keep the Joule integral $I^2 \cdot t = I^2{}_{Ncw} \cdot 0{,}25$.

NOTE The value of I_{ss} may have to be adjusted to achieve the required peak value.

7.7.2 Test conditions

The test shall be performed with all switching devices in the test circuit in the closed position and at ambient temperature.

7.7.3 Details for the conduct of the test

The details for the conduct of the test shall be as specified in 7.6.2 (where applicable).

No break operation shall occur and all switching devices in the test circuit shall remain closed.

7.7.4 Conditions of the unit after the test

After the test, the mechanical parts and the insulation parts of the unit shall not show significant deterioration.

The unit shall conform to 7.6.3 (where applicable).

7.8 Verification of the manual control device for sturdiness and position indicator reliability

7.8.1 Condition of the tested devices

The devices shall be installed in the same manner as for normal operation. First of all the force *F* necessary to achieve opening is measured. For rotary actuating devices, the force is applied at the extreme point of the actuator.

If, for convenience of testing, the point of application of the force is closer to the rotation axis, the force value found at this point is selected as the opening force *F*.

7.8.2 Operating mode

The unit shall be closed. Those fixed and moving contact parts of the pole for which the test is deemed to be the most severe, shall be maintained in contact by appropriate means. Then the actuator shall be submitted to the appropriate limit value of stress specified in Table 8. This stress shall be applied without any impulse and maintained for 10 s.

7.8.3 Conditions of the unit after the above test

After the test and after the suppression of the stress on the actuating element, no part of the actuator or of the position indicator shall be damaged.

Table 8 – Values of forces or torques for the tests

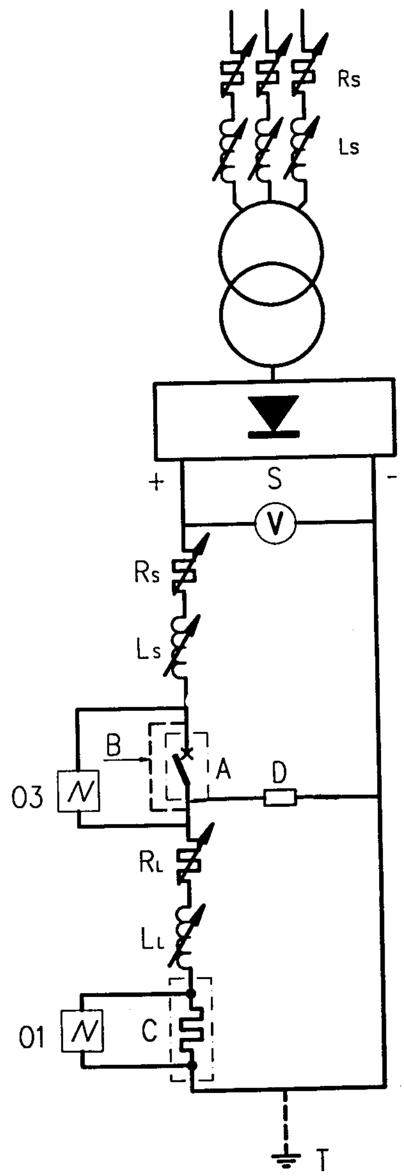
N°	Type of motion	Example	Specified stress		
			Normal value	Limit value	
				Min.	Max.
1	Translation with one or two fingers	push-button	3 *F*	50 N	
2	Full hand translation	side lever	3 *F*	100 N	500 N
3	Full hand traction	side lever	3 *C/D*	150 N	650 N
4	Rotation with fingers – Dia. < 25 mm – Dia. ≥ 25 mm	knurled knob	 3 *C/D* 3 *C/D*	 25 N 50 N	
5	Rotation with lateral hold	arrow knob	3 *C/L*	50 N	
6	Rotation with full hand hold	bascule	3 *C*	5 Nm	
7	Rotation with lever and one hand	latch	3 *F*	100 N	500 N
8	Rotation by symmetrical element with both hands	wheel or lever	3 *F*	150 N	650 N

Legend:
C = Torque necessary to achieve normal opening
D = Diameter of the actuator
F = Force necessary to achieve normal opening orthogonally applied to the axis of the control element
L = Length of the actuator

NOTE If 3 F (or 3 C) or 3 C/L is less than the minimum value in the table, the test is performed with this minimum value. If 3 F (or 3 C) or 3 C/D or 3 C/L is higher than the maximum value in the table, the test is performed with this maximum value.

Annex A
(normative)

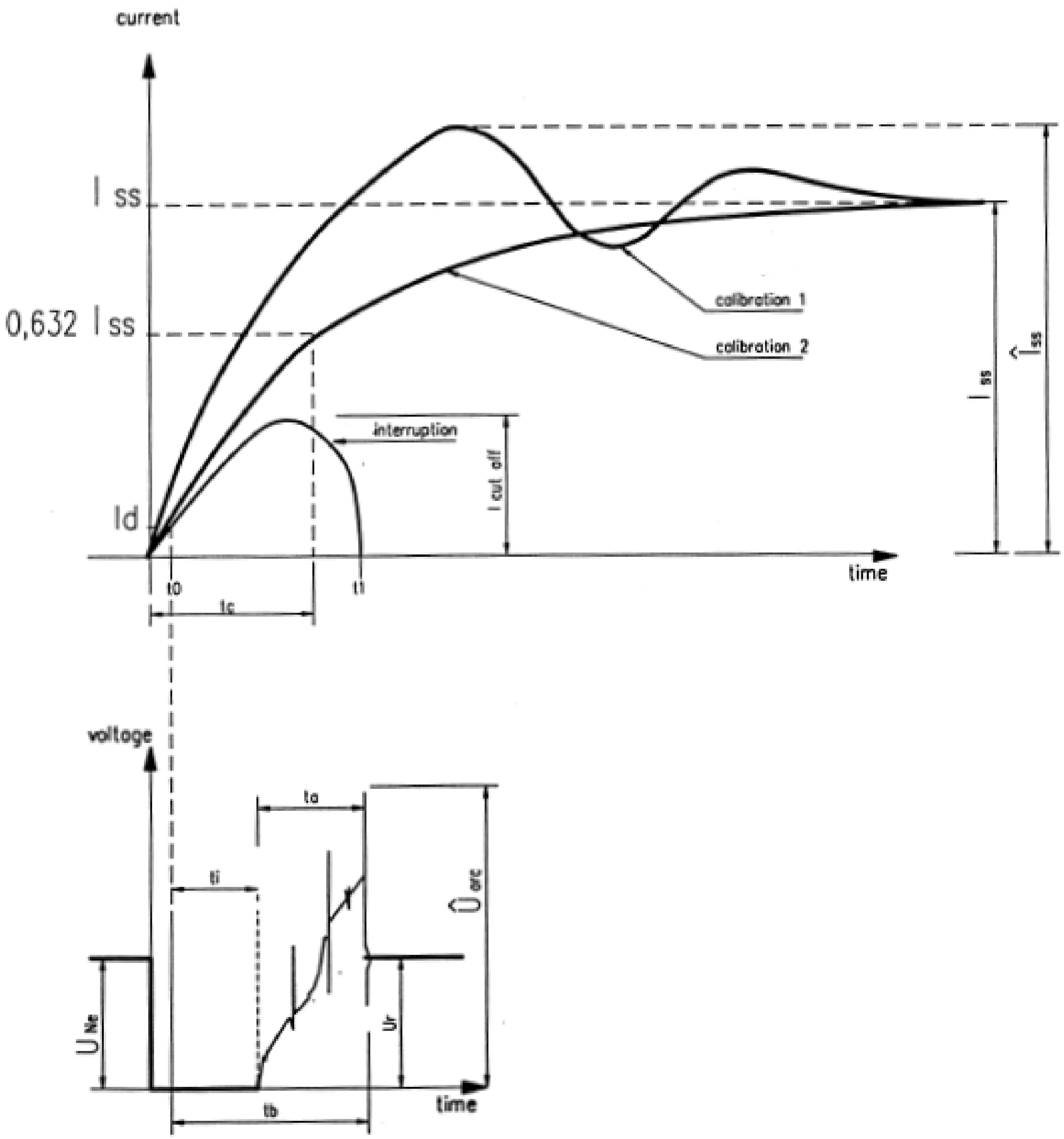
Diagrams for tests



Key

V	Supply voltage measurement	B	Provisional connection for calibration
S	Supply	01	Oscillograph for the current
R_S	Adjustable resistor supply	03	Oscillograph for the arc voltage and recovery voltage
L_S	Adjustable reactance supply	D	Frame fault current detection device
R_L	Adjustable resistor load	T	Earth connection, if made
L_L	Adjustable reactance load	C	Current sensor
A	Equipment under test		

Figure A.1 – Diagram of the test circuit for checking the making and breaking capacities in short-circuit and load/overload switching conditions



Key

$I_{cut\ off}$	Cut off current (3.2.14)	t_c	Time-constant of the circuit (3.2.15)
I_d	Setting of maximum current release (3.4.21)	U_r	Recovery voltage (3.2.6)
$\hat{I}_{SS}$	Peak of I_{SS} (3.2.13)	U_{Ne}	Rated voltage (3.2.3)
I_{SS}	Prospective sustained short circuit current (3.2.12)	$\hat{U}_{arc}$	Maximum arc voltage (3.2.6.1)
t_a	Arcing time (3.4.23.5)	t_0	Beginning of opening time (3.4.23.7)
t_b	Total break time (3.4.23.6)	t_1	Time of current extinction (3.4.23.7)
t_I	Opening time (3.4.23.1)		

Figure A.2 – Typical calibrations and interruption under short-circuit and load/overload switching conditions (two different cases of calibration are represented) (see 7.6)

Annex B
(normative)

Environmental conditions for indoor installations

B.1 General

These environmental conditions are based on EN 60721 series.

The environmental conditions considered as normal in service are indicated as well as possible abnormal conditions which are commonly met in given geographic or location conditions.

These conditions apply to indoor equipment, which represents the majority of the equipment concerned in this standard. For indoor conditions, the following conditions are intended: without pollution, with non-conductive dust, well protected without significant humidity and condensation.

However indications are given also for voltage levels and clearances in outdoor conditions which shall be specified by the purchaser. In any case, for outdoor switch-disconnectors and outdoor earthing switches, refer to EN 50119; for arresters and voltage limiters installed outdoors, refer to EN 60099-1 and EN 60099-4, except for installation in lines where EN 50119 applies.

B.2 Air pressure and altitude

The equipment shall be suitable for installation at an altitude (h) from - 120 m to 1 400 m above sea level.

For installation at higher altitudes, the temperature-rise tests and dielectric tests, carried out at laboratories at lower levels, shall take into account a correction in the temperature-rises and dielectric test values to be agreed between purchaser and supplier.

B.3 Temperature

The indoor equipment shall be suitable for the following ambient temperatures:

Θ_{min}	Minimum ambient temperature during operation	-5 °C
Θ_{ts}	Minimum ambient temperature during transport and storage	-25 °C
Θ_{mxts}	Maximum ambient temperature during transport and storage	55 °C
Θ_{d}	Maximum daily average ambient temperature	35 °C
Θ_{a}	Absolute maximum ambient temperature	40 °C

Any condition differing from the above shall be specified.

B.4 Atmospheric conditions

Indoors, air shall be clean and its relative humidity shall be not more than 50 % r.h. at the maximum temperature of +40 °C. Relative humidity may be higher if the temperatures are lower, for example, 90 % r.h. at +20 °C. Allowance shall be made for slight condensation that might occur during variations of temperature.

In the case where different situations are likely to occur, these, which represent abnormal situations in indoor installations, shall be brought to the attention of the supplier.

One hundred per cent humidity may occur during start-up. This is an abnormal operation to be specified, and suitable provisions to avoid failures or incorrect operations shall be agreed between purchaser and supplier.

Outdoors, a dust deposit of low conductivity is foreseen, and the humidity due to rain, snow, ice and fog.

B.5 Ventilation

Ventilation in the spaces intended for installation of the equipment shall be capable of maintaining the temperature of the ambient air below the limits in B.3.

B.6 Pollution

For indoor equipment, any pollution exceeding the statement in B.1 and level 1 given in EN 60721, shall be specified.

NOTE With reference to clearances, the appropriate pollution degree has been taken into account in the figures shown in Table 1. The same applies for the creepage distances shown in the Annex D.

Any deviation from these statements shall be specified and clearances /creepage distances shall be subject to agreement between purchaser and manufacturer.

B.7 Vibrations

The equipment shall be suitable for installation in the vicinity of a rail track on foundations designed so as to dampen the main effects of the passage of the trains. Nevertheless, a limited vibration may affect the equipment, which shall be capable of operating satisfactorily when subjected to conventional sinusoidal vibrations at 10 Hz, separately applied and having the following characteristics:

Table B.1 – Limits of sinusoidal vibrations

Orientation	Peak acceleration	Nominal duration
Vertical	5 m/s²	30 s
Horizontal	5 m/s²	30 s

Any condition differing from the above shall be specified.

B.8 Fire hazardous areas

The following classes are foreseen:

F0 No special fire hazard is envisaged. Except the characteristics inherent to the design of the equipment, no special measures are taken to limit flammability. This is considered normal service condition.

F1 Equipment subject to fire hazard. Restricted flammability is required. Self-extinction of fire (poor burning is permitted with negligible energy consumption) shall take place within a specified time period to be agreed between purchaser and supplier, unless specified by the standards. The emission of toxic substances and opaque smokes shall be minimised. Materials and products of combustion shall be practically halogen-free and shall contribute with a limited quantity of thermal energy to an external fire. This is considered an abnormal condition.

F2 By means of special provisions, the equipment shall be able to operate for a given time period if subject to an external fire. The requirement of class F1 shall also be met. This is considered an abnormal condition.

Annex C
(normative)

Search of critical currents for d.c. circuit breakers and switches

C.1 General

For air-break circuit breakers, critical currents are low currents which produce the longest arc durations. This is due to the weak magnetic field produced by the current in the arc, resulting in slow arc movement from the point of initiation to its extinction position within the arc chute.

C.2 Unidirectional circuit breakers and switches

This requirement applies to the switching devices which are required to break currents in one direction only. It applies to line circuit breakers L of the type U_1 and U_2.

Opening tests shall be performed at the following levels of current:

25 A 50 A 100 A 200 A 400 A,

at the rated voltage U_{Ne}, with a circuit time constant not less than 0,01 s. Lower time constants are accepted provided that the circuit load inductance has a minimum value of 50 mH. Inductances lower than 50 mH may be used with the agreement of the purchaser.

Ten opening operations are required at each value of the current, with a series starting at the lowest value first.

Before beginning the test, there should exist no residual magnetism at the arc chute.

The exact values of current are not important, provided that each current is approximately double the previous current.

The arcing times will have a wide scatter at each value of current.

The results should be plotted graphically to illustrate the scatter for arcing time versus current. The range of test currents may demonstrate a critical current existence, which may have a wide band in itself. The highest and lowest values of current tested shall demonstrate shorter arcing times than the critical value(s). If critical current is seen to exist it may be necessary to extend the test current range by using a halving or doubling factor.

C.3 Bidirectional circuit breakers and switches

This requirement applies to switching devices which are required at any time to break currents in both directions. It applies to interconnector I and rectifier R circuit breakers.

Opening tests shall first be performed as for unidirectional switching devices, to establish the critical current.

For circuit breakers, the next test is for the arc chute to clear a current in excess of 1 000 A, to leave a residual magnetism in the arc chute for that direction. For switches with a breaking duty, the next test is for the arc chute to clear a current in excess of 1 000 A or its rated breaking current, if less than 1 000 A.

Opening operations shall then be made at the critical current, with the current in the reverse direction to the previous high current.

Five operations shall be made and then the whole procedure repeated again. This ensures that the arc chute is kept magnetised in the reverse direction to the low current interruption, for 10 interruptions.

A further 10 operations shall be made at half and at double this value of current, carried out in the same manner as the critical current. If this produces longer arc durations, then further tests shall be performed until arc durations are shown to reduce. Each time, the current shall be halved or doubled.

Longer arc durations than the unidirectional critical currents may be found because of the adverse effects of the reversed residual magnetism.

Also lower currents than the critical current have fewer demagnetising effects on the residual magnetism and may produce longer arc durations.

Annex D
(informative)

Recommended creepage distances

For the purpose of this standard, only two groups of materials are considered according to their CTI values, as follows:

Table D.1 – Material group identification

Material Group I	600 ≤ CTI
Material Group II	400 ≤ CTI < 600

The CTI values above refer to values obtained, in accordance with HD 214 S2 and HD 380 S2, on samples specifically made for the purpose and tested with solution A.

Based on the above assumptions, the following Table D.2 gives recommended values:

Table D.2 – Recommended creepage distances, in mm/kV (base U_{Nm})

Material group	Indoor equipment	Outdoor equipment
I	25 mm/kV (U_{Nm})	30 mm/kV (U_{Nm})
II	30 mm/kV (U_{Nm})	40 mm/kV (U_{Nm})
The minimum creepage distance shall be at least equal to the minimum clearance given in Table 1.		

For measuring methods refer to EN 50124-1.

Annex E
(informative)

Determination of maximum energy fault location

A simple equivalent circuit of a d.c. traction system is shown in Figure E.1.

NOTE the subscript *c* used in this annex refers to the complete circuit

Therefore

$$T_s = \frac{L_s}{R_s} = \text{source time constant} \qquad (1)$$

$$T_c = \frac{L}{R} \qquad (2)$$

where

$L = (l \cdot x)$ and $R = (r \cdot x)$

$$t_c = \frac{L_s + (l \cdot x)}{R_s + (r \cdot x)} = \text{time constant of the whole circuit to a fault at point F} \qquad (3)$$

The energy stored in the circuit for a fault at point F is given by

E = 1/2 $l_c I^2$

where

l_c is the total circuit inductance and *I* is the prospective current of the short-circuit.

There is a value of distance x for which the energy is maximum.

If

$$l_c = L_s + (l \cdot x) \quad \text{and} \quad I = \frac{U}{R_s + (r \cdot x)} \qquad (4)$$

then

$$E = \frac{1}{2} \cdot \frac{\left(L_s + (l \cdot x)\right)U^2}{\left(R_s + (r \cdot x)\right)^2} \qquad (5)$$

For a maximum *dE/dx* = 0.

It can be shown that if *dE/dx* = 0 then the distance at which the maximum energy is stored in the circuit is

$$x = \frac{R_s}{R} - \frac{2L_s}{L} \qquad (6)$$

Obviously this equation has a meaning when x results positive.

Substituting this expression for t_c, the total circuit time constant at the position of maximum stored energy gives

$$t_c = \frac{T_c}{2} \tag{7}$$

which means that the maximum stored energy in the circuit occurs when the total circuit time constant is half that of the track time constant.

The prospective current I at the point where $t_c = T_c/2$ is given by $U/[R_s + (r \cdot x)]$

where

$$x = R_s/R - 2L_s/L. \tag{8}$$

If $I_{ss} = U/R_s$ then $I_{max\ E}$ (prospective current at the position of maximum stored energy at the maximum energy position) is, by substitution

$$I_{max\ E} = \frac{I_{SS}}{2\left(1 - T_s/T_c\right)} \tag{9}$$

which, when T_s is much smaller than T_c gives

$$I_{max\ E} = \frac{I_{ss}}{2} \quad \text{approximately} \tag{10}$$

at the maximum energy point.

Figure E.2 shows the relationship between the rates $I_{max\ E}/I_{ss}$ for values of T_s/T_c where T_s is not significantly less than T_c.

This indicates that when $T_s = 0{,}5T_c$ then the maximum energy position is at a current level of $I_{max\ E} = I_{ss}$, which is at the distance of x = 0.

This can also be shown by substituting the value of $R_s/R = 2L_s/L$ into (1) when $T_s = T_c/2$

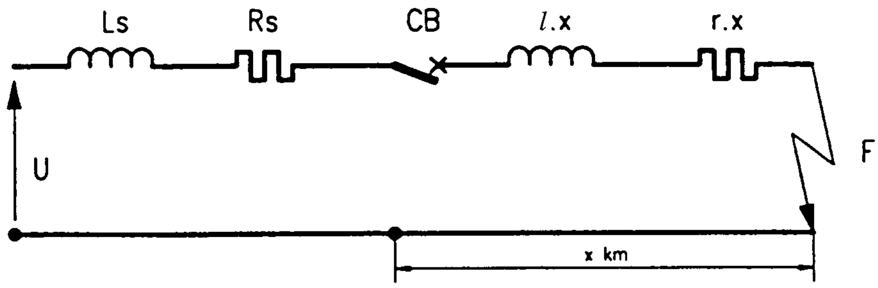
For type testing rated values (depicted by an $_N$, e.g. I_{Nss}) are used.

The value given in 5.1.1.3 is used for low values of T_{Nc} where the source time constant is unknown.

The values of t_c and I are adjusted to give test values that are likely to simulate unknown values of T_s.

These calculations only predict the stored energy of the circuit when the current reached through the circuit breaker is the prospective value.

The arc energy of the circuit-breaker is less than this value if current limiting is achieved by the circuit breaker.



Key

U	=	Supply voltage	F	=	Fault at distance x from the switching device
R_s	=	Source resistance	L_s	=	Source inductance
l	=	Track inductance per km	CB	=	Circuit breaker or switching device
r	=	Track resistance per km	X	=	Distance [km] between CB and F

Figure E.1 – Equivalent circuit of a d.c. traction system

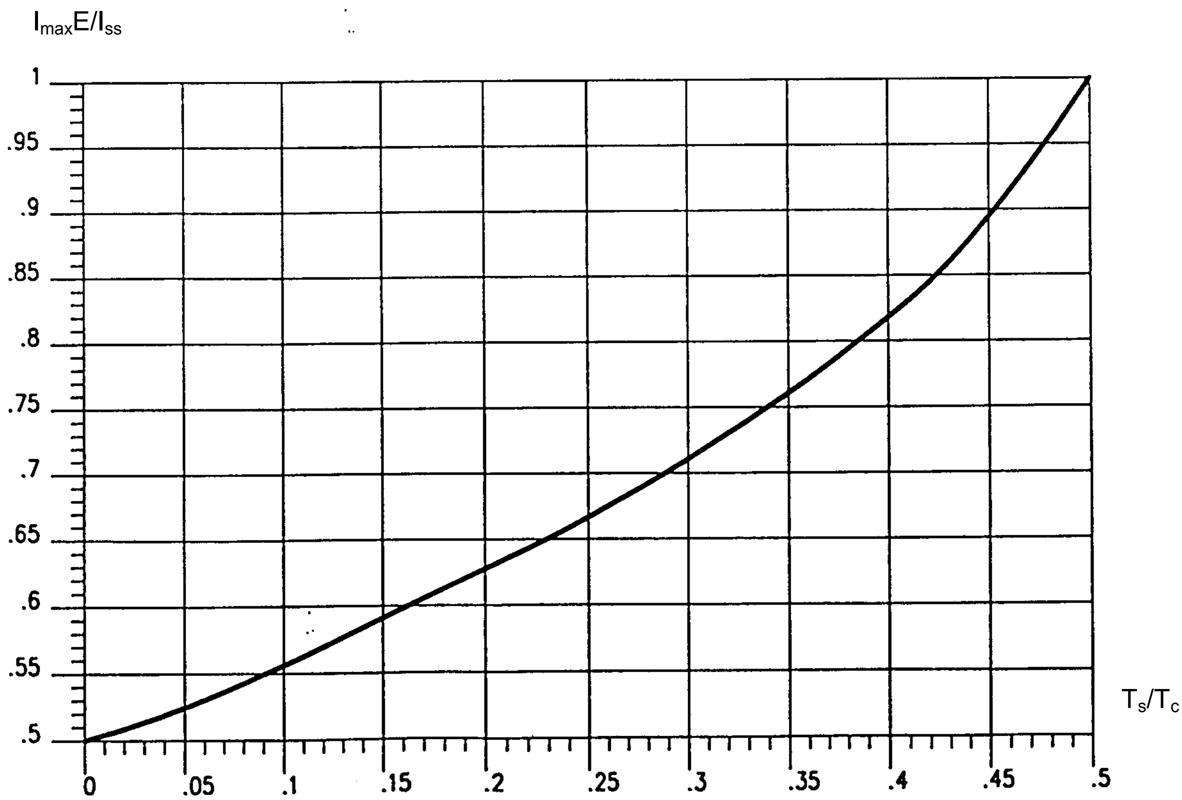


Figure E.2 – Ratio of I_{maxE}/I_{ss} to T_s/T_c

Bibliography

Additional useful information may be found in the following publications:

[1] EN 50122-2 *Railway applications – Fixed installations – Part 2: Protective provisions against the effects of stray currents caused by d.c. traction systems*

[2] EN 50124-2 *Railway applications – Insulation co-ordination – Part 2: Overvoltages and related protections*

[3] EN 50327 *Railway applications – Fixed installations – Harmonization of the rated values for converter groups and tests on converter groups*

[4] EN 50328 *Railway applications – Fixed installations – Electronic power converters for substations*

[5] EN 50329 *Railway applications – Fixed installations – Traction transformers*

[6] EN 60068-2 Series *Environmental testing – Part 2: Tests (IEC 60068-2 series)*

[7] HD 566 S1 *Thermal evaluation and classification of electric insulation (IEC 60085)*

[8] IEC 60815:1986 *Guide for the selection of insulators in respect of polluted conditions*

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