Technical Construction File

TCF No.: ZDE-22001007-13 / 07.October.2022

Certificat Holder	Zhejiang Dabo Electric Co., Ltd
Address	No. 79, Longhui Road, Houxi Village, Beibaixiang Town, Leqing City, Wenzhou City, Zhejiang Province
Manufacturer	Zhejiang Dabo Electric Co., Ltd
Address	No. 79, Longhui Road, Houxi Village, Beibaixiang Town, Leqing City, Wenzhou City, Zhejiang Province
Equipment Name	Transfer switch
Equipment All Model	SEE NEXT PAGE
Major Model	LW2R- 100II、YTQ2-63/2P、YTQ2-63/3P、 SF 219G, SF 419G
According To	Low Voltage Directive (2014/35/EU)
Reviewed By	LIQIan wang
Prepared By	Zhejiang Dabo Electric Co., Ltd
Controlled by	Beijing United-Standard Product Testing & Technical Service Co.,Ltd No.2109,Building 401,WangJingYuan,Chaoyang District,Beijing City,China

Equipment All Model:

LW2R- 100II、YTQ2-63/2P、YTQ2-63/3P、 SF 219G, SF 419G

Catalog Of The TCF

Part I: Description Of The Product

Equipment Name: Transfer switch

Equipment Major Model: LW2R- 100II、YTQ2-63/2P、YTQ2-63/3P、 SF 219G, SF 419G

1.1 EUT Photographs

Part II:LVD Measurement & Test Report

LVD MEASUREMENT AND TEST REPORT

Test Report No.: ZDE-22001007-13 / T

Certificat Holder	Zhejiang Dabo Electric Co., Ltd
Address	No. 79, Longhui Road, Houxi Village, Beibaixiang Town, Leqing City, Wenzhou City, Zhejiang Province
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According To	Low Voltage Directive (2014/35/EU)
Test Standards	EN 60947-6-1:2005+A1:2014
Test Engineer	
Verify Engineer	
Test Date	07.October.2022
Issuance Date	07.October.2022

Test item	
Description:	Transfer switch
Model and/or type reference:	LW2R- 100II、YTQ2-63/2P、YTQ2-63/3P、 SF 219G, SF 419G
Manufacturer :	Zhejiang Dabo Electric Co., Ltd

Clause	Requirement - Test	Result - Remark	Verdict
EN 60947-6-1:2005+A1:2014 Test Report			
1	General		
2	Definitions		
3	Classification		
4	Characteristics		

Alphabetical list of characteristics (whether rated or not) and symbols

Characteristic	Symbol	Subclause
Conventional enclosed thermal current	I_{the}	4.3.2.2
Conventional free air thermal current	I_{th}	4.3.2.1
Eight-hour duty	–	4.3.4.1
Intermittent duty	–	4.3.4.3
Periodic duty	–	4.3.4.5
Rated breaking capacity	–	4.3.5.3
Rated conditional short-circuit current	–	4.3.6.4
Rated control circuit voltage	U_c	4.5.1
Rated control supply voltage	U_s I_n	4.5.1
Rated current		a
Rated frequency	–	4.3.3
Rated impulse withstand voltage	U_{imp}	4.3.1.3
Rated insulation voltage	U_i	4.3.1.2
Rated making capacity	–	4.3.5.2
Rated operational current	I_e	4.3.2.3
Rated operational power	–	4.3.2.3
Rated operational voltage	U_e	4.3.1.1
Rated rotor insulation voltage	U_{ir}	a
Rated rotor operational current	I_{er}	a
Rated rotor operational voltage	U_{er}	a
Rated service short-circuit breaking capacity	I_{cs}	a
Rated short-circuit breaking capacity	I_{cn}	4.3.6.3
Rated short-circuit making capacity	I_{cm}	4.3.6.2
Rated short-time withstand current	I_{cw}	4.3.6.1
Rated starting voltage of an autotransformer starter	–	a
Rated stator insulation voltage	U_{is}	a
Rated stator operational current	I_{es}	a
Rated stator operational voltage	U_{es}	a
Rated ultimate short-circuit breaking capacity	I_{cu}	a
Rated uninterrupted current	I_u	4.3.2.4
Rotor thermal current	I_{thr}	a
Selectivity limit current	I_s	a
Stator thermal current	I_{ths}	a
Take-over current	I_B	2.5.25
Temporary duty	–	4.3.4.4
Uninterrupted duty	–	4.3.4.2
Utilization category	–	4.4

[a] This rating is defined in the relevant product standard.

	NOTE The above list is not exhaustive.		
4.1	General		
	The characteristics of an equipment shall be stated in the relevant product standard in respect of the following, where applicable: – type of equipment (4.2); – rated and limiting values for the main circuit (4.3);		P

Clause	Requirement - Test	Result - Remark	Verdict
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	– utilization category (4.4); – control circuits (4.5); – auxiliary circuits (4.6); – relay and releases (4.7); – co-ordination with short-circuit protective devices (4.8); – switching overvoltages (4.9).		
4.2	Type of equipment		
	The product standard shall state the following, where applicable: – kind of equipment: e.g. contactor, circuit-breaker, etc.; – number of poles; – kind of current; – interrupting medium; – operating conditions (method of operation, method of control, etc.). NOTE The above list is not exhaustive.		P
4.3	Rated and limiting values for the main circuit		
	Ratings are assigned by the manufacturer. They shall be stated in accordance with 4.3.1 to 4.3.6 as required by the relevant product standard, but it is not necessary to establish all the ratings listed.		P
4.3.1	Rated voltages		
	An equipment is defined by the following rated voltages: NOTE Certain types of equipment may have more than one rated voltage or may have a rated voltage range.		P
4.3.1.1	Rated operational voltage (Ue)		
	A rated operational voltage of an equipment is a value of voltage which, combined with a rated operational current, determines the application of the equipment and to which the relevant tests and the utilization categories are referred. For single-pole equipment, the rated operational voltage is generally stated as the voltage across the pole. For multipole equipment, it is generally stated as the voltage between phases. NOTE 1 For certain devices and particular applications a different method of stating Ue, may apply: this should be stated in the relevant product standard. NOTE 2 For multipole equipment for use on polyphase circuits a distinction may be made between a) equipment for use on systems where a single fault to earth will not cause the full phase-to-phase voltage to appear across a pole; – neutral earthed systems; – unearthed and impedance earthed systems.		P

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	b) equipment for use on systems where a single fault to earth will cause the full phase-to-phase voltage to appear across a pole (i.e. phase earthed systems). NOTE 3 An equipment may be assigned a number of combinations of rated operational voltages and rated operational currents or powers for different duties and utilization categories. NOTE 4 An equipment may be assigned a number of rated operational voltages and associated making and breaking capacities for different duties and utilization categories. NOTE 5 Attention is drawn to the fact that the operational voltage may differ from the working voltage (see 2.5.52) within an equipment.		
4.3.1.2	Rated insulation voltage (Ui)		
	The rated insulation voltage of an equipment is the value of voltage to which dielectric tests and creepage distances are referred. In no case shall the maximum value of the rated operational voltage exceed that of the rated insulation voltage. NOTE For equipment not having a specified rated insulation voltage, the highest value of the rated operational voltage is considered to be the rated insulation voltage.		P
4.3.1.3	Rated impulse withstand voltage (Uimp)		
	The peak value of an impulse voltage of prescribed form and polarity which the equipment is capable of withstanding without failure under specified conditions of test and to which the values of the clearances are referred. The rated impulse withstand voltage of an equipment shall be equal to or higher than the values stated for the transient overvoltages occurring in the circuit in which the equipment is fitted. NOTE Preferred values of rated impulse withstand voltage are given in Table 12.		P
4.3.2	Currents		
	An equipment is defined by the following currents:		P
4.3.2.1	Conventional free air thermal current (Ith)		
	The conventional free air thermal current is the maximum value of test current to be used for temperature-rise tests of unenclosed equipment in free air (see 8.3.3.3). The value of the conventional free air thermal current shall be at least equal to the maximum value of the rated operational current (see 4.3.2.3) of the unenclosed equipment in eight-hour duty (see 4.3.4.1). Free air is understood to be air under normal indoor conditions reasonably free from draughts and external radiation. NOTE 1 This current is not a rating and is not		P

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	mandatorily marked on the equipment. NOTE 2 An unenclosed equipment is an equipment supplied by the manufacturer without an enclosure or an equipment supplied by the manufacturer with an integral enclosure which is not normally intended to be the sole equipment protective enclosure.		
4.3.2.2	Conventional enclosed thermal current (Ithe)		
	The conventional enclosed thermal current is the value of current stated by the manufacturer to be used for the temperature-rise tests of the equipment when mounted in a specified enclosure. Such tests shall be in accordance with 8.3.3.3 and are mandatory if the equipment is described as enclosed equipment in the manufacturer's catalogues and normally intended for use with one or more enclosures of specified type and size (see Note 3). The value of the conventional enclosed thermal current shall be at least equal to the maximum value of the rated operational current (see 4.3.2.3) of the enclosed equipment in eight-hour duty (see 4.3.4.1). If the equipment is normally intended for use in unspecified enclosures, the test is not mandatory if the test for conventional free air thermal current (Ith) has been made. In this case, the manufacturer shall be prepared to give guidance on the value of enclosed thermal current or the derating factor (see Note 1). NOTE 1 Guidance may be in the form of a publication of the maximum rated current at a specified local ambient (surrounding, in the immediate vicinity of the device) air temperature (example 1: AC-1 Ie = 45 A at 40 °C local ambient air, AC-1 Ie = 40 A at 60 °C local ambient air example 2: Ith = 200 A at 40 °C local ambient air, Ith = 150 A at 60 °C local ambient air). By publishing such values, the manufacturer informs the user of the limits of application of the product independently of the size or the type of the enclosure. NOTE 2 This current is not a rating and is not mandatorily marked on the equipment. NOTE 3 The conventional enclosed thermal current value may be for unventilated equipment, in which case the enclosure used for the test should be of the size stated by the manufacturer, being the smallest that is applicable in service. Alternatively, the value may be for a ventilated equipment according to the manufacturer's data. NOTE 4 An enclosed equipment is an equipment normally intended for use with a specified type and size of enclosure or intended for use with more than one type of enclosure.		P
4.3.2.3	Rated operational current (Ie) or rated operational power		
	A rated operational current of an equipment is stated by the manufacturer and takes into account the rated operational voltage (see 4.3.1.1), the rated frequency		P

Clause	Requirement - Test	Result - Remark	Verdict
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	(see 4.3.3), the rated duty (see 4.3.4), the utilization category (see 4.4) and the type of protective enclosure, if appropriate. In the case of equipment for direct switching of individual motors, the indication of a rated operational current may be replaced or supplemented by an indication of the maximum rated power output, at the rated operational voltage considered, of the motor for which the equipment is intended. The manufacturer shall be prepared to state the relationship assumed between the operational current and the operational power, if any.		
4.3.2.4	Rated uninterrupted current (Iu)		
	The rated uninterrupted current of an equipment is a value of current, stated by the manufacturer, which the equipment can carry in uninterrupted duty (see 4.3.4.2).		
4.3.3	Rated frequency		
	The supply frequency for which an equipment is designed and to which the other characteristic values correspond. NOTE The same equipment may be assigned a number or a range of rated frequencies or be rated for both a.c. and d.c.		P
4.3.4	Rated duties		
	The rated duties considered as normal are:		P
4.3.4.1	Eight-hour duty		
	A duty in which the main contacts of an equipment remain closed, whilst carrying a steady current long enough for the equipment to reach thermal equilibrium but not for more than eight hours without interruption. NOTE 1 This is the basic duty on which the conventional thermal currents Ith and Ithe of the equipment are determined. NOTE 2 Interruption means breaking of the current by operation of the equipment.		P
4.3.4.2	Uninterrupted duty		
	A duty without any off-load period in which the main contacts of an equipment remain closed, whilst carrying a steady current without interruption for periods of more than eight hours (weeks, months, or even years). NOTE This kind of service is set apart from the eight-hour duty because oxides and dirt can accumulate on the contacts and lead to progressive heating. Uninterrupted duty can be taken account of either by a derating factor, or by special design considerations (e.g. silver contacts).		P
4.3.4.3	Intermittent periodic duty or intermittent duty		
	A duty with on-load periods, in which the main contacts of an equipment remain closed, having a definite relation to off-load periods, both periods being too short to allow the equipment to reach thermal equilibrium. Intermittent duty is characterized by the value of the current, the duration of the current flow and by the on-		P

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	load factor which is the ratio of the in-service period to the entire period, often expressed as a percentage. Standardized values of the on-load factor are 15 %, 25 %, 40 % and 60 %. According to the number of operating cycles which they shall be capable of carrying out per hour, equipments are divided into the following classes: - class 1: 1 operating cycle per hour; - class 3: 3 operating cycles per hour; - class 12: 12 operating cycles per hour; - class 30: 30 operating cycles per hour; - class 120: 120 operating cycles per hour; - class 300: 300 operating cycles per hour; - class 1 200: 1 200 operating cycles per hour; - class 3 000: 3 000 operating cycles per hour; - class 12 000: 12 000 operating cycles per hour; - class 30 000: 30 000 operating cycles per hour; - class 120 000: 120 000 operating cycles per hour; - class 300 000: 300 000 operating cycles per hour. For intermittent duty with a large number of operating cycles per hour, the manufacturer shall indicate, either in terms of the true cycle if this is known, or in terms of conventional cycles designated by him, the values of the rated operational currents which shall be such that: whichever is applicable The where T is the total operating cycle time. NOTE The above formula does not take account of the switching arc energy. A switching device intended for intermittent duty may be designated by the characteristics of the intermittent duty. Example: An intermittent duty comprising a current flow of 100 A for 2 min in every 5 min may be stated as 100 A, class 12, 40 %.		
4.3.4.4	Temporary duty		
	Duty in which the main contacts of an equipment remain closed for periods insufficient to allow the equipment to reach thermal equilibrium, the unload periods being separated by off-load periods of sufficient duration to restore equality of temperature with the cooling medium. Standardized values of temporary duty are 3 min, 10 min, 30 min, 60 min and 90 min, with contacts closed.		P
4.3.4.5	Periodic duty		
	A type of duty in which operation, whether at constant or variable load, is regularly repeated.		P

Clause	Requirement - Test	Result - Remark	Verdict
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4.3.5	Normal load and overload characteristics		
	This subclause gives general requirements concerning ratings under normal load and overload conditions. NOTE Where applicable, the utilization categories referred to in 4.4 may include requirements in respect of performance under overload conditions. Detailed requirements are given in 7.2.4.		P
4.3.5.1	Ability to withstand motor switching overload currents		
	An equipment intended for switching motors shall be capable of withstanding the thermal stresses due to starting and accelerating a motor to normal speed and due to operating overloads. The detailed requirements to meet these conditions are given in the relevant product standard.		P
4.3.5.2	Rated making capacity		
	The rated making capacity of an equipment is a value of current, stated by the manufacturer, which the equipment can satisfactorily make under specified making conditions. The making conditions which shall be specified are: – the applied voltage (see 2.5.32); – the characteristics of the test circuit. The rated making capacity is stated by reference to the rated operational voltage and rated operational current, according to the relevant product standard. NOTE 1 Where applicable, the relevant product standard states the relationship between rated making capacity and utilization category. For a.c., the rated making capacity is expressed by the r.m.s. value of the symmetrical component of the current, assumed to be constant. NOTE 2 For a.c., the peak value of the current during the first half-cycles following the closing of the main contacts of the equipment may be appreciably greater than the peak value of the current under steady-state conditions used in the determination of making capacity, depending on the power-factor of the circuit and the instant on the voltage wave when closing occurs. An equipment should be capable of closing on a current having the a.c. component equal to that which defines its rated making capacity, whatever the value of the inherent d.c. component, within the limits resulting from the power- factors indicated in the relevant product standard.		P
4.3.5.3	Rated breaking capacity		
	The rated breaking capacity of all equipment is a value of current, stated by the manufacturer, which the equipment can satisfactorily break, under specified breaking conditions. The breaking conditions which shall be specified are: – the characteristics of the test circuit;		P

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	- the power-frequency recovery voltage. The rated breaking capacity is stated by reference to the rated operational voltage and rated operational current, according to the relevant product standard. An equipment shall be capable of breaking any value of current up to and including its rated breaking capacity. NOTE 1 A switching device may have more than one rated breaking capacity, each corresponding to an operational voltage and a utilization category. For a.c., the rated breaking capacity is expressed by the r.m.s. value of the symmetrical component of the current. NOTE 2 Where applicable, the relevant product standard states the relationship between rated breaking capacity and utilization category.		
4.3.6	Short-circuit characteristics		
	This subclause gives general requirements concerning ratings under short-circuit conditions.		P
4.3.6.1	Rated short-time withstand current (Icw)		
	The rated short-time withstand current of an equipment is the value of short-time withstand current, assigned to the equipment by the manufacturer, that the equipment can carry without damage, under the test conditions specified in the relevant product standard.		P
4.3.6.2	Rated short-circuit making capacity (Icm)		
	The rated short-circuit making capacity of an equipment is the value of short-circuit making capacity assigned to that equipment by the manufacturer for the rated operational voltage, at rated frequency, and at a specified power-factor for a.c. or time constant for d.c. It is expressed as the maximum prospective peak current, under prescribed conditions.		P
4.3.6.3	Rated short-circuit breaking capacity (Icn)		
	The rated short-circuit breaking capacity of an equipment is the value of short-circuit breaking capacity assigned to that equipment by the manufacturer for the rated operational voltage, at rated frequency, and at a specified power-factor for a.c. or time constant for d.c. It is expressed as the value of the prospective breaking current (r.m.s. value of the a.c. component in the case of a.c.), under prescribed conditions.		P
4.3.6.4	Rated conditional short-circuit current		
	The rated conditional short-circuit current of an equipment is the value of prospective current, stated by the manufacturer, which the equipment, protected by a short-circuit protective device specified by the manufacturer, can withstand satisfactorily for the operating time of this device under the test conditions specified in the relevant product standard. The details of the specified short-circuit protective device shall be stated by the manufacturer. NOTE 1 For a.c., the rated conditional short-circuit current is expressed by the r.m.s. value of the a.c. component.		P

Clause	Requirement - Test	Result - Remark	Verdict
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	NOTE 2 The short-circuit protective device may either form an integral part of the equipment or be a separate unit.		
4.4	Utilization category		
	The utilization category of an equipment defines the intended application and shall be specified in the relevant product standard; it is characterized by one or more of the following service conditions: - current(s), expressed as multiple(s) of the rated operational current; - voltage(s), expressed as multiple(s) of the rated operational voltage; - power-factor or time-constant; - short-circuit performance; - selectivity; - other service conditions, as applicable. Examples of utilization categories for low-voltage switchgear and controlgear are given in Annex A.		P
4.5	Control circuits		
4.5.1	Electrically or electronically controlled circuits		
	Characteristics of electrical and electronic control circuits: - type of current; - rated frequency or d.c.; - rated control circuit voltage Uc (a.c., d.c.); - rated control supply voltage Us (a.c., d.c.), where applicable; - nature of external control circuit devices (contacts, sensors, optocouplers, electronic active components, etc); - power consumption. NOTE 1 In case of an electrical control circuit a distinction has been made above between the control circuit voltage Uc, which is the voltage which would appear across the "a" contacts (see 2.3.12) in the control circuit, and the control supply voltage Us, which is the voltage applied to the input terminals of the control circuit of the equipment and may be different f rom the control circuit voltage, due to the presence of built-in transformers, rectified, resistors, etc. NOTE 2 In case of an electronically control circuit a distinction is made between the control circuit voltage Uc, which is the controlling input signal, and the control supply voltage Us, which is the voltage applied to energize the power supply terminals of the control circuit equipment and may be different from Uc due to the presence of built-in transformers, rectifiers, resistors, electronic circuitry, etc."		P

Clause	Requirement - Test	Result - Remark	Verdict
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	!The rated control circuit voltage and rated frequency, if any, are the values on which the operating and temperature-rise characteristics of the control circuit are based. The correct operating conditions are based upon a value of the control supply voltage not less than 85 % of its rated value, with the highest value of control circuit current flowing, nor more than 110 % of its rated value. The electronic part of an electronically controlled electromagnet may form an integral part or a separate part provided it is an intrinsic function of the device. In both cases, the device shall be tested with this electronic part mounted as in normal use. Annex U gives examples and illustrations of different circuit configurations. The ratings and characteristics of control circuit devices shall comply with the requirements of IEC 60947-5 (see the note of Clause 1)."		
4.5.2	Air-supply control circuits (pneumatic or electro-pneumatic)		
	The characteristics of air-supply control circuits are: – rated pressure and its limits; – volumes of air, at atmospheric pressure, required for each closing and each opening operation. The rated supply pressure of a pneumatic or electro-pneumatic equipment is the air pressure on which the operating characteristics of the pneumatic control system are based.		P
4.6	Auxiliary circuits		
	The characteristics of auxiliary circuits are the number and kind of contacts (a-contact, b-contact, etc.) in each of these circuits and their ratings according to IEC 60947-5 (see note of Clause 1). The characteristics of auxiliary contacts and switches shall comply with the requirements of the above standard.		P
4.7	Relays and releases		
	The following characteristics of relays and releases shall be stated in the relevant product standard, where applicable: – type of relay or release; – rated values; – current setting or current setting range; – time/current characteristics (for presentation of time/current characteristics, see 4.8); – influence of ambient air temperature. ! extended functions as given in Annex T."		P
4.8	Co-ordination with short-circuit protective devices (SCPD)		
	The manufacturer shall state the type or the characteristics of the SCPD to be used with or within the		P

Clause	Requirement - Test	Result - Remark	Verdict
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	equipment, as the case may be, and the maximum prospective short-circuit current for which the equipment, including the SCPD, is suitable, at the stated operational voltage(s). !NOTE IEC/TR 61912-1 gives guidance on co-ordination with SCPDs."		
4.9	Switching overvoltages		
	The manufacturer shall specify the maximum value of switching overvoltages caused by the operation of the switching device, when required by the product standard. This value shall not exceed that of the rated impulse withstand voltage (see 4.3.1.3).		P
5	Product information		
5.1	Nature of information		
	The following information shall be given by the manufacturer, when required by the relevant product standard: Identification: - manufacturer's name or trademark; - type designation or serial number; - number of the relevant product standard, if the manufacturer claims compliance. Characteristics: - rated operational voltages (see 4.3.1.1 and note to 5.2); - utilization category and rated operational currents (or rated powers or rated uninterrupted currents), at the rated operational voltages of the equipment (see 4.3.1.1, 4.3.2.3, 4.3.2.4 and 4.4). In certain cases, this information may have to be completed by the value of the reference ambient air temperature at which the equipment has been calibrated; - the value of the rated frequency/frequencies, e.g.: 50 Hz, 50 Hz/60 Hz, and/or the indication "d.c." or the symbol ; - rated duty, with the indication of the class of intermittent duty, if any (see 4.3.4); - rated making and/or breaking capacities. These indications may be replaced, where applicable, by the indication of the utilization category; - rated insulation voltage (see 4.3.1.2); - rated impulse withstand voltage (see 4.3.1.3); !– relay or release characteristics (see 4.7);" - switching overvoltage (see 4.9); - rated short-time withstand current together with its duration, where applicable (see 4.3.6.1); - rated short-circuit making and/or breaking capacities, where applicable (see 4.3.6.2 and 4.3.6.3);		P

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	– rated conditional short-circuit current, where applicable (see 4.3.6.4); – IP code, in case of enclosed equipment (see Annex C); – pollution degree (see 6.1.3.2); – type and maximum ratings of short-circuit protective device, where applicable; – class of protection against electric shock (see IEC 61140), where applicable; – rated control circuit voltage, kind of current and frequency; – rated control supply voltage, kind of current and frequency, if different from those of the control coil; – rated supply pressure of the air-pressure and limits of pressure variations (for air-pressure controlled equipment); – suitability for isolation. !– length of insulation to be removed before insertion of the conductor into the terminal; – maximum number of conductors which may be clamped. For non-universal screwless terminals: – “s” or "sol" for terminals declared for rigid-solid conductors; – "r" for terminals declared for rigid (solid and stranded) conductors; – "f" for terminals declared for flexible conductors. In the case of electronically controlled electromagnets, other information may also be necessary, for example control circuit configuration (see 4.5 and Annex U)." NOTE This list is not exhaustive.		
5.2	Marking		
	All relevant information, as detailed in 5.1, which is to be marked on the equipment, shall be specified in the relevant product standard. Markings shall be indelible and easily legible. Marking of the manufacturer's name or trademark and type designation or serial number is mandatory on the equipment and preferably on the nameplate, if any, in order to permit the complete data to be obtained from the manufacturer. NOTE In the USA and Canada, the rated operational voltage Ue, may be marked as follows: a) on equipment for use on three-phase – four-wire systems, by both the value of phase-to-earth voltage and that of phase-to-phase voltage, e.g. 277/480 V; b) on equipment for use on three-phase – three-wire systems, by the value of phase-to-phase voltage, e.g. 480 V. The following information shall also be marked and visible after mounting:		P

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	– direction of movement of the actuator (see 7.1.5.2), if applicable; – indication of the position of the actuator (see also 7.1.6.1 and 7.1.6.2); – approval or certification mark, if applicable; – for miniaturized equipment, symbol, colour code or letter code; – terminal identification and marking (see 7.1.8.4); – IP code and class of protection against electric shock, when applicable (marked preferably on the equipment as far as possible); – suitability for isolation, where applicable, with the isolation function symbol according to IEC 60617-7, reference 07-01-03, combined with the appropriate function symbol for the equipment, e.g.: for a circuit-breaker suitable for isolation; for a switch-disconnector. This symbol shall be: • clearly and unmistakably marked; • visible when the equipment is installed as in service and the actuator is accessible. This requirement applies whether the equipment is unenclosed, or enclosed according to 7.1.11. This requirement also applies if the symbol is integrated into a wiring diagram and this diagram is the only marking indicating suitability for isolation. !In the case of electronically controlled electromagnets, information other than that given in 5.1 may also be necessary (see also 4.5 and Annex U). The indication "s", "sol", "r" or "f" for non-universal screwless terminals shall be marked on the device or, if the space available is not sufficient, on the smallest package unit or in technical information provided with the product. In the case of a group of terminals located together, a single marking on the device is acceptable."		
5.3	Instructions for installation, operation and maintenance		
	The manufacturer shall specify in his documents or catalogues the conditions for installation, operation and maintenance, if any, of the equipment during operation and after a fault. The manufacturer shall also specify the measures to be taken with regard to EMC, if any. For equipment only suitable in environment A (see 7.3.1) the manufacturer shall provide in the documentation the following notice: NOTICE This product has been designed for environment A. Use of this product in environment B may cause unwanted electromagnetic disturbances in which case the user may be required to take adequate mitigation measures.		P

Clause	Requirement - Test	Result - Remark	Verdict
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	If necessary, the instructions for the transport, installation and operation of the equipment shall indicate the measures that are of particular importance for the proper and correct installation, commissioning and operation of the equipment. These documents shall indicate the recommended extent and frequency of maintenance, if any. NOTE All equipment covered by this standard is not necessarily designed to be maintained.		
6	Normal service, mounting and transport conditions		
6.1	Normal service conditions		
	Equipment complying with this standard shall be capable of operating under the following standard conditions: NOTE For non-standard conditions in service, see Annex B. These may require agreement between manufacturer and user.		P
6.1.1	Ambient air temperature		
	The ambient air temperature does not exceed +40 °C and its average over a period of 24 h does not exceed +35 °C. The lower limit of the ambient air temperature is –5 °C. Ambient air temperature is that existing in the vicinity of the equipment if supplied without enclosure, or in the vicinity of the enclosure if supplied with an enclosure. NOTE 1 Equipment intended to be used in ambient air temperature above +40 °C (e.g. in forges, boiler rooms, tropical countries) or below –5 °C (e.g. –25 °C, as required by IEC 60439-1 for outdoor installed low-voltage switchgear and controlgear assemblies) should be designed or used according to the relevant product standard, where applicable, or according to agreement between manufacturer and user. Information given in the manufacturer's catalogue may take the place of such an agreement. NOTE 2 Ambient air temperature(s) for certain types of equipment, e.g. circuit-breakers or overload relays for starters, is indicated in the relevant product standard.		P
6.1.2	Altitude		
	The altitude of the site of installation does not exceed 2 000 m. NOTE For equipment to be used at higher altitudes, it is necessary to take into account the reduction of the dielectric strength and the cooling effect of the air. Electrical equipment intended to operate under these conditions shall be designed or used in accordance with an agreement between manufacturer and user.		P
6.1.3	Atmospheric conditions		
6.1.3.1	Humidity		
	The relative humidity of the air does not exceed 50 % at a maximum temperature of +40 °C. Higher relative		P

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	humidities may be permitted at lower temperatures, e.g. 90 % at +20 °C. Special measures may be necessary in cases of occasional condensation due to variations in temperature. NOTE Pollution degrees, as stated in 6.1.3.2, define the environmental conditions more precisely.		
6.1.3.2	Pollution degree		
	The pollution degree (see 2.5.58) refers to the environmental conditions for which the equipment is intended. NOTE 1 The micro-environment of the creepage distance or clearance and not the environment of the equipment determines the effect on the insulation. The micro-environment might be better or worse than the environment of the equipment. It includes all factors influencing the insulation, such as climatic and electromagnetic conditions, generation of pollution, etc. For equipment intended for use within an enclosure or provided with an integral enclosure, the pollution degree of the environment in the enclosure is applicable. For the purpose of evaluating clearances and creepage distances, the following four degrees of pollution of the micro-environment are established (clearances and creepage distances according to the different pollution degrees are given in Tables 13 and 15): Pollution degree 1: No pollution or only dry, non-conductive pollution occurs. Pollution degree 2: Normally, only non-conductive pollution occurs. Occasionally, however, a temporary conduc- tivity caused by condensation may be expected. Pollution degree 3: Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation. Pollution degree 4: The pollution generates persistent conductivity caused, for instance, by conductive dust or by rain or snow. Standard pollution degree of industrial applications: Unless otherwise stated by the relevant product standard, equipment for industrial applications is generally for use in pollution degree 3 environment. However, other pollution degrees may be considered to apply depending upon particular applications or the micro-environment. NOTE 2 The pollution degree of the micro-environment for the equipment may be influenced by installation in an enclosure. Standard pollution degree of household and similar applications: Unless otherwise stated by the relevant product standard, equipment for household and similar		P

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	applications is generally for use in pollution degree 2 environment. Unless otherwise stated by the manufacturer, a control circuit device is intended for installation under environmental conditions of pollution degree 3. However, other pollution degrees may apply, depending upon the micro-environment		
6.1.4	Shock and vibration		
	Standard conditions of shock and vibration to which the equipment can be submitted are under consideration.		P
6.2	Conditions during transport and storage		
	A special agreement shall be made between user and manufacturer if the conditions during transport and storage, e.g. temperature and humidity, differ from those defined in 6.1, except that, unless otherwise specified, the following temperature range applies during transport and storage: between –25 °C and +55 °C and, for short periods not exceeding 24 h, up to +70 °C. Equipment subjected to these extreme temperatures without being operated shall not undergo any irreversible damage and shall then operate normally under the specified conditions.		P
6.3	Mounting		
	The equipment shall be mounted in accordance with the manufacturer's instructions.		P
6.3.1	Mounting of single hole mounted devices		
	The single hole mounted push-buttons and indicator lights are located in a circular hole of the panel, which may have a rectangular recess for a key.		P
7.1	Constructional requirements		
7.1.1	General		
	The equipment with its enclosure, if any, whether integral or not, shall be designed and constructed to withstand the stresses occurring during installation and normal use and, in addition, shall provide a specified degree of resistance to abnormal heat and fire. Glow-wire requirements for non integral enclosure materials are given in relevant standards, e.g. IEC 62208. NOTE The need to reduce the impact on the natural environment of a product during all phases of its life is recognized. Assistance in the consideration of environmental aspects relating to products according to the IEC 60947 series is given in Annex O.		P
7.1.2	Materials		N/A
7.1.2.1	General materials requirements		
	Parts of insulating materials which might be exposed to thermal stresses due to electrical effects within the equipment shall not be adversely affected by abnormal heat and by fire." The manufacturer shall specify which test method,		

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	7.1.2.2 or 7.1.2.3, is to be used. !Text deleted"		
7.1.2.2	Glow wire testing		
	The suitability of materials used is verified by: a) making tests on the equipment; or b) making tests on sections taken from the equipment; or c) making tests on any parts of identical material having representative thickness; or d) providing data from the insulating material supplier fulfilling the requirements according to IEC 60695-2-12. The suitability shall be determined with respect to resistance to abnormal heat and fire. The manufacturer shall indicate which methods, amongst a), b), c) and d) shall be used." If an identical material having representative cross-sections has already satisfied the requirements of any of the tests of 8.2.1, then those tests need not be repeated. Tests on equipment shall be made by the glow-wire end-product test of IEC 60695-2-10 and IEC 60695-2-11. Parts of insulating materials necessary to retain current-carrying parts in position shall conform to the glow-wire tests of 8.2.1.1.1 at a test temperature of 850 °C or 960 °C according to the expected fire hazard. Product standards shall specify the value appropriate to the product, taking into account the Annex A of IEC 60695-2-11. Parts of insulating materials other than those specified in the previous paragraph shall conform to the requirements of the glow-wire test of 8.2.1.1.1 at a temperature of 650 °C. NOTE For small parts, as specified in IEC 60695-2-11, the relevant product standard may specify another test (for example needle flame test, according to IEC 60695-2-2). The same procedure may be applicable for other practical reasons when the metal part is large compared to the insulating material (such as terminal blocks).		
7.1.2.3	Test based on flammability category		
	For parts of insulating materials, hot wire ignition and, where applicable, arc ignition tests as specified in 8.2.1.1.2, shall be made based on flammability category. Tests on materials shall be made in accordance with Annex M. The hot wire ignition (HWI) and arc ignition (AI) test value requirements related to the material flammability category shall conform to Table M.1 or M.2. !Alternatively, the manufacturer may provide data from the insulating material supplier fulfilling the requirements given in Annex M."		
7.1.3	Current-carrying parts and their connections		N/A

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	Current-carrying parts shall have the necessary mechanical strength and current-carrying capacity for their intended use. For electrical connections, no contact pressure shall be transmitted through insulating material other than ceramic or other material with characteristics not less suitable, unless there is sufficient resiliency in the metallic parts to compensate for any possible shrinkage or yielding of the insulation material. Compliance shall be verified by inspection and by conducting the test sequences according to the relevant product standard. NOTE In the USA, the use of clamping units in which pressure is transmitted through insulating materials other than ceramic is permitted only in the following circumstances: 1 where the clamping unit is part of a terminal block; 2 where a temperature test demonstrates that the temperature limitations of the insulation material and of the terminals in accordance with the product standard are not exceeded; and 3 resilient metal is used in the clamping unit construction to compensate for loss of clamping pressure due to insulating material deformation.		
7.1.4	Clearances and creepage distances		
	For equipment tested according to 8.3.3.4 of this standard, minimum values are given in Tables 13 and 15. Electrical requirements are given in 7.2.3. In the other cases, guidance for minimum values is given in the relevant product standard.		P
7.1.5	Actuator		
7.1.5.1	Insulation		
	The actuator of the equipment shall be insulated from the live parts for the rated insulation voltage and, if applicable, the rated impulse withstand voltage. Moreover: - if it is made of metal, it shall be capable of being satisfactorily connected to a protective conductor unless it is provided with additional reliable insulation; - if it is made of or covered by insulating material, any internal metal part, which might become accessible in the event of insulation failure, shall also be insulated from live parts for the rated insulation voltage.		P
7.1.5.2	Direction of movement		
	The direction of operation for actuators of devices shall normally conform to IEC 60447. Where devices cannot conform to these requirements, e.g. due to special applications or alternative mounting positions, they shall be clearly marked such that there is no doubt as to the "I" and "O" positions and the direction of operation.		P
7.1.6	Indication of the contact position		

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7.1.6.1	Indicating means		
	When an equipment is provided with means for indicating the closed and open positions, these positions shall be unambiguous and clearly indicated. This is done by means of a position indicating device (see 2.3.18). NOTE In the case of enclosed equipment, the indication may or may not be visible from the outside. The relevant product standard may specify whether the equipment is to be provided with such an indicating device. If symbols are used, they shall indicate the closed and open positions respectively, in accordance with IEC 60417-2: 60417-2-IEC-5007 | On (power) 60417-2-IEC-5008 O Off (power) For equipment operated by means of two push-buttons, only the push-button designated for the opening operation shall be red or marked with the symbol "O". Red colour shall not be used for any other push-button. The colours of other push-buttons, illuminated push-buttons and indicator lights shall be in accordance with IEC 60073.		P
7.1.6.2	Indication by the actuator		
	When the actuator is used to indicate the position of the contacts, it shall automatically take up or stay, when released, in the position corresponding to that of the moving contacts; in this case, the actuator shall have two distinct rest positions corresponding to those of the moving contacts, but for automatic opening a third distinct position of the actuator may be provided.		P
7.1.7	Additional requirements for equipment suitable for isolation		N/A
7.1.7.1	Additional constructional requirements		
	NOTE 1 In the USA, devices meeting these additional requirements are not accepted as assuring isolation by themselves. Isolation requirements and procedures are covered in the relevant Federal regulations and maintenance standards. Equipment suitable for isolation shall provide in the open position (see 2.4.21) an isolation distance in accordance with the requirements necessary to satisfy the isolating function (see 7.2.3.1 and 7.2.7). Indication of the position of the main contacts shall be provided by one or more of the following means: - the position of the actuator; - a separate mechanical indicator; – visibility of all moving main contacts." The effectiveness of each of the means of indication provided on the equipment and its mechanical strength shall be verified in accordance with 8.2.5.		

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	When means are provided or specified by the manufacturer to lock the equipment in the open position, locking in that position shall only be possible when the main contacts are in the open position. This shall be verified in accordance with 8.2.5. Equipment shall be designed so that the actuator, front plate or cover are fitted to the equipment in a manner which ensures correct contact position indication and locking, if provided. NOTE 2 Locking in the closed position is permitted for particular applications. NOTE 3 If auxiliary contacts are provided for interlocking purposes, the operating time of the auxiliary and main contacts should be declared by the manufacturer. More specific requirements may be given in the relevant product standard. The indicated open position is the only position in which the specified isolation distance between the contacts is ensured. For equipment provided with positions such as “tripped position” or “standby position”, which are not the indicated open position, those positions shall be clearly identified. The marking of such positions shall not include the symbols “I” or “O”. An actuator having only one position of rest shall not be considered as appropriate to indicate the position of the main contact.		
7.1.7.2	Supplementary requirements for equipment with provision for electrical interlocking with contactors or circuit-breakers		
	If equipment suitable for isolation is provided with an auxiliary switch for the purpose of electrical interlocking with contactor(s) or circuit-breaker(s) and intended to be used in motor circuits, the following requirements shall apply unless the equipment is rated for AC-23 utilization category. An auxiliary switch shall be rated according to IEC 60947-5-1 as stated by the manufacturer. The time interval between the opening of the contacts of the auxiliary switch and the contacts of the main poles shall be sufficient to ensure that the associated contactor or circuit-breaker interrupts the current before the main poles of the equipment open. Unless otherwise stated in the manufacturer's technical literature, the time interval shall be not less than 20 ms when the equipment is operated according to the manufacturer's instructions. Compliance shall be verified by measuring the time interval between the instant of opening of the auxiliary switch and the instant of opening of the main poles under no-load conditions when the equipment is operated according to the manufacturer's instructions. During the closing operation the contacts of the auxiliary switch shall close after or simultaneously with the		

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	contacts of the main poles. A suitable opening time interval may also be provided by an intermediate position (between the ON an OFF positions) at which the interlocking contact(s) is (are) open and the main poles remain closed.		
7.1.7.3	Supplementary requirements for equipment provided with means for padlocking the open position		
	The locking means shall be designed in such a way that it cannot be removed with the appropriate padlock(s) installed. When the equipment is locked by even of a single padlock, it shall not be possible by operating the actuator, to reduce the clearance between open contacts to the extent that it no longer complies with the requirements of 7.2.3.1b). Alternatively, the design may provide padlockable means to prevent access to the actuator. Compliance with the requirements to padlock the actuator shall be verified using a padlock specified by the manufacturer or an equivalent gauge, giving the most adverse conditions, to simulate locking. The force F specified in 8.2.5.2.1 shall be applied to the actuator in an attempt to operate the equipment from the open position to the closed position. Whilst the force F is applied the equipment shall be subjected to a test voltage across open contacts. The equipment shall be capable of withstanding the test voltage required according to Table 14 appropriate to the rated impulse withstand voltage.		
7.1.8	Terminals		
7.1.8.1	Constructional requirements		
	All parts of terminals which maintain contact and carry current shall be of metal having adequate mechanical strength. !Terminal connections shall be such that the force to connect the conductors may be applied by screws, screwless-type or other equivalent means so as to ensure that the necessary contact pressure is maintained." Terminals shall be so constructed that the conductors can be clamped between suitable surfaces without any significant damage either to conductors or terminals. Terminals shall not allow the conductors to be displaced or be displaced themselves in a manner detrimental to the operation of equipment and the insulation voltage shall not be reduced below the rated values. If required by the application, terminals and conductors may be connected by means of cable lugs for copper conductors only. NOTE 1 Examples of overall dimensions of terminal lugs suitable to be directly connected to the stud terminals of equipment are given in Annex P. !Screwless-type clamping units, unless otherwise specified by the manufacturer, shall accept rigid and flexible conductors as indicated in Table 1.		P

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	On screwless-type clamping unit, the connection or disconnection of conductors shall be made as follows: – on universal clamping units by the use of a general purpose tool or a convenient device, integral with the clamping unit to open it for the insertion or withdrawal of the conductors; – on push-wire clamping units by simple insertion. For the disconnection of the conductors an operation other than a pull only on the conductor shall be necessary. The use of a general purpose tool or of a convenient device, integral with the clamping unit is allowed in order to "open" it and to assist the insertion or the withdrawal of the conductor." Examples of terminals are given in Annex D. The requirements of this subclause shall be verified by the tests of 8.2.4.2, 8.2.4.3 and 8.2.4.4, as applicable. NOTE 2 North American countries have particular requirements for terminals suitable for aluminium conductors and marking to identify the use of aluminium conductors.		
7.1.8.2	Connecting capacity		
	The manufacturer shall state the type (rigid – solid or stranded – or flexible), the minimum and the maximum cross-sections of conductors for which the terminal is suitable and, if applicable, the number of conductors simultaneously connectable to the terminal. However, the maximum cross-section shall not be smaller than that stated in 8.3.3.3 for the temperature-rise test and the terminal shall be suitable for conductors of the same type (rigid – solid or stranded – or flexible) at least two sizes smaller, as given in the appropriate column of Table 1. NOTE 1 Conductor cross-sections smaller than the minimum may be required in different product standards. NOTE 2 Because of voltage drop and other considerations, the product standards may require the terminals to be suitable for conductors of cross-sections larger than those specified for the temperature-rise test. The relationship between conductor cross-sections and rated currents may be given in the relevant product standards. Standard values of cross-section of round copper conductors (both metric and AWG/kcmil sizes) are shown in Table 1 which also gives the approximate relationship between ISO metric and AWG/kcmil sizes.		P
7.1.8.3	Connection		
	Terminals for connection to external conductors shall be readily accessible during installation. Clamping screws and nuts shall not serve to fix any other component although they may hold the terminals in place or prevent them from turning.		P

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7.1.8.4	Terminal identification and marking		
	Terminals shall be clearly and permanently identified in accordance with IEC 60445 and Annex L, unless superseded by the requirements of the relevant product standard. Terminals intended exclusively for the neutral conductor shall be identified by the letter "N", in accordance with IEC 60445. The protective earth terminal shall be identified in accordance with 7.1.10.3.		P
7.1.9	Additional requirements for equipment provided with a neutral pole		N/A
	When an equipment is provided with a pole intended only for connecting the neutral, this pole shall be clearly identified to that effect by the letter N (see 7.1.8.4). A switched neutral pole shall break not before and shall make not after the other poles. If a pole having an appropriate short-circuit breaking and making capacity (see 2.5.14 and 2.5.15) is used as a neutral pole, then all poles, including the neutral pole, may operate substantially together. NOTE The neutral pole may be fitted with an over-current release. For equipment having a value of conventional thermal current (free air or enclosed, see 4.3.2.1 and 4.3.2.2) not exceeding 63 A, this value shall be identical for all poles. For higher conventional thermal current values, the neutral pole may have a value of conventional thermal current different from that of the other poles, but not less than half that value or 63 A, whichever is the higher.		
7.1.10	Provisions for protective earthing		
7.1.10.1	Constructional requirements		
	The exposed conductive parts (e.g. chassis, framework and fixed parts of metal enclosures) other than those which cannot constitute a danger shall be electrically interconnected and connected to a protective earth terminal for connection to an earth electrode or to an external protective conductor. This requirement can be met by the normal structural parts providing adequate electrical continuity and applies whether the equipment is used on its own or incorporated in an assembly. NOTE If needed, requirements and tests may be specified in the relevant product standard. Exposed conductive parts are considered not to constitute a danger if they cannot be touched on large areas or grasped with the hand or if they are of small size (approximately 50 mm 50 mm) or are so located as to exclude any contact with live parts. Examples of these are screws, rivets, nameplates, transformer cores, electromagnets of switching devices and certain parts of releases, irrespective of their size.		

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7.1.10.2	Protective earth terminal		
	The protective earth terminal shall be readily accessible and so placed that the connection of the equipment to the earth electrode or to the protective conductor is maintained when the cover or any other removable part is removed. The protective earth terminal shall be suitably protected against corrosion. In the case of equipment with conductive structures, enclosures, etc., means shall be provided, if necessary, to ensure electrical continuity between the exposed conductive parts of the equipment and the metal sheathing of connecting conductors. The protective earth terminal shall have no other function, except when it is intended to be connected to a PEN conductor (see !2.1.15" – Note). In this case, it shall also have the function of a neutral terminal in addition to meeting the requirements applicable to the protective earth terminal.		
7.1.10.3	Protective earth terminal marking and identification		
	The protective earth terminal shall be clearly and permanently identified by its marking. The identification shall be achieved by colour (green-yellow mark) or by the notation PE, or PEN, as applicable, in accordance with IEC 60445, subclause 5.3, or by a graphical symbol for use on equipment. The graphical symbol to be used is the symbol: 60417-2-IEC-5019 Protective earth (ground) in accordance with IEC 60417-2. NOTE The symbol (60417-2-IEC-5017), previously recommended, shall be progressively superseded by the preferred symbol 60417-2-IEC-5019 given above.		
7.1.11	Enclosures for equipment		
	The following requirements are only applicable to enclosures supplied or intended to be used with the equipment.		P
7.1.11.1	Design		
	The enclosure shall be so designed that, when it is opened and other protective means, if any, are removed, all parts requiring access for installation and maintenance, as prescribed by the manufacturer, are readily accessible. Sufficient space shall be provided inside the enclosure for the accommodation of external conductors from their point of entry into the enclosure to the terminals to ensure adequate connection. The fixed parts of a metal enclosure shall be electrically connected to the other exposed conductive parts of the equipment and connected to a terminal which enables them to be earthed or connected to a protective conductor.		P

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	Under no circumstances shall a removable metal part of the enclosure be insulated from the part carrying the earth terminal when the removable part is in place. The removable parts of the enclosure shall be firmly secured to the fixed parts by a device so that they cannot be accidentally loosened or detached owing to the effects of operation of the equipment or vibrations. When an enclosure is so designed as to allow the covers to be opened without the use of tools, means shall be provided to prevent loss of the fastening devices. An integral enclosure is considered to be a non-removable part. If the enclosure is used for mounting push-buttons, removal of buttons should be from the inside of the enclosure. Removal from the outside shall only be by use of a tool intended for this purpose.		
7.1.11.2	Insulation		
	If, in order to prevent accidental contact between a metallic enclosure and live parts, the enclosure is partly or completely lined with insulating material, then this lining shall be securely fixed to the enclosure.		P
7.1.12	Degrees of protection of enclosed equipment		
	Degrees of protection of enclosed equipment and relevant tests are given in Annex C.		P
7.1.13	Conduit pull-out, torque and bending with metallic conduits		N/A
	Polymeric enclosures of equipment, whether integral or not, provided with threaded conduit entries, intended for the connection of extra heavy duty, rigid threaded metal conduits complying with IEC 60981, shall withstand the stresses occurring during its installation such as pull-out, torque, bending. Compliance shall be verified by the test of 8.2.7.		
7.2	Performance requirements		
	The following requirements apply to clean new equipment unless otherwise stated in the relevant product standard.		P
7.2.1	Operating conditions		
7.2.1.1	General		
	The equipment shall be operated in accordance with the manufacturer's instructions or the relevant product standard, especially for equipment with dependent manual operation where the making and breaking capacities may depend on the skill of the operator.		P
7.2.1.2	Limits of operation of power operated equipment		
	Unless otherwise stated in the relevant product standard, electromagnetic and electro- pneumatic equipment shall close with any control supply voltage between 85 % and 110 % of its rated value Us and an ambient air temperature between –5 °C and +40 °C. These limits apply to d.c. or a.c. as appropriate.		P

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	For pneumatic and electro-pneumatic equipment, unless otherwise stated, the limits of the air supply pressure are 85 % and 110 % of the rated pressure. Where a range of operation is given, the value of 85 % shall apply to the lower limit of the range, and the value of 110 % to the upper limit of the range. NOTE For latched equipment, operating limits should be agreed upon between manufacturer and user. For electromagnetic and electro-pneumatic equipment, the drop-out voltage shall not be higher than 75 % of the rated control supply voltage Us nor lower than 20 % of Us in the case of a.c. at rated frequency, or 10 % of Us in the case of d.c. !The limits between which an equipment, with an electronically controlled electromagnet, shall drop out and open fully are for d.c.: 75 % to 10 % of their rated control supply voltage Us, for a.c.: 75 % to 20 % of their rated control supply voltage Us, or 75 % to 10 % of their rated control supply voltage Us if specified by the manufacturer." For pneumatic and electro-pneumatic equipment, unless otherwise stated, opening shall occur at a pressure between 75 % and 10 % of the rated pressure. Where a range of operation is given, the value of 20 % or 10 %, as the case may be, shall apply to the upper limit of the range, and the value of 75 % to the lower limit of the range. In the case of coils, the limiting drop-out values apply when the coil circuit resistance is equal to that obtained at –5 °C. This may be verified by a calculation based on the values obtained at normal ambient temperature. !The drop out time may need to be specified for particular applications. In this case the drop out time shall be measured during the test associated with the verification of this subclause."		
7.2.1.3	Limits of operation of under-voltage relays and releases		
	a) Operating voltage An under-voltage relay or release, when associated with a switching device, shall operate to open the equipment even on a slowly falling voltage within the range between 70 % and 35 % of its rated voltage. NOTE A no-voltage release is a special form of under-voltage release in which the operating voltage is between 35 % and 10 % of the rated supply voltage. An under-voltage relay or release shall prevent the closing of the equipment when the supply voltage is below 35 % of the rated voltage of the relay or release; it shall permit closing of the equipment at supply voltages equal to or above 85 % of its rated value. Unless otherwise stated in the relevant product		P

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	standard, the upper limit of the supply voltage shall be 110 % of its rated value. The figures given above apply equally to d.c. and to a.c. at rated frequency. b) Operating time For a time-delay under-voltage relay or release, the time-lag shall be measured from the instant when the voltage reaches the operating value until the instant when the relay or release actuates the tripping device of the equipment.		
7.2.1.4	Limits of operation of shunt releases		
	A shunt release for opening shall cause tripping under all operating conditions of an equipment when the supply voltage of the shunt release measured during the tripping operation remains between 70 % and 110 % of the rated control supply voltage and, if a.c., at the rated frequency.		P
7.2.1.5	Limits of operation of current operated relays and releases		
	Limits of operation of current operated relays and releases shall be stated in the relevant product standard. NOTE The term "current operated relays and releases" covers over-current relays or releases, overload relays or releases, reverse current relays or releases, etc.		P
7.2.2	Temperature-rise		
	The temperature-rises of the parts of an equipment, measured during a test carried out under the conditions specified in 8.3.3.3, shall not exceed the values stated in this subclause. NOTE 1 Temperature-rise in normal service may differ from the test values, depending on the installation conditions and size of connected conductors. NOTE 2 The temperature-rise limits given in Tables 2 and 3 apply to equipment tested in new and clean condition. Different values may be prescribed by product standards for different test conditions and for devices of small dimensions but not exceeding the above values by more than 10 K.		P
7.2.2.1	Terminals		
	The temperature-rises of terminals shall not exceed the values stated in Table 2.		P
7.2.2.2	Accessible parts		
	The temperature-rises of accessible parts shall not exceed the values stated in Table 3. NOTE The temperature-rise limits of other parts are given in 7.2.2.8.		P
7.2.2.3	Ambient air temperature		
	The temperature-rise limits given in Tables 2 and 3 are applicable only if the ambient air temperature remains within the limits given in 6.1.1.		P
7.2.2.4	Main circuit		

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	The main circuit of an equipment shall be capable of carrying the conventional thermal current of the equipment without the temperature-rises exceeding the limits specified in Tables 2 and 3 when tested in accordance with 8.3.3.3.4.		P
7.2.2.5	Control circuits		
	The control circuits of an equipment, including control circuit devices to be used for the closing and operating operations of an equipment, shall permit the rated duty according to 4.3.4 and also the temperature-rises tests specified in 8.3.3.3.5 to be made without the temperature-rises exceeding the limits specified in Tables 2 and 3.		P
7.2.2.6	Windings of coils and electromagnets		
	With current flowing through the main circuit the windings of coils and electromagnets shall withstand their rated voltage without the temperature-rises exceeding the limits specified in 7.2.2.8 when tested in accordance with 8.3.3.3.6. NOTE This subclause does not apply to pulse-operated coils, whose operating conditions are defined by the manufacturer.		P
7.2.2.7	Auxiliary circuits		
	Auxiliary circuits of an equipment including auxiliary switches shall be capable of carrying their conventional thermal current without the temperature-rise exceeding the limits specified in Tables 2 and 3, when tested in accordance with 8.3.3.3.7. NOTE If an auxiliary circuit forms an integral part of the equipment, it suffices to test it at the same time as the main equipment, but at its actual service current.		P
7.2.2.8	Other parts		
	The temperature rises obtained during the test shall not impair the performance of the product. For plastics and insulating materials, the manufacturer shall demonstrate compliance by reference to the insulation temperature index (determined, for example, by the methods of IEC 60216) or by compliance with IEC 60085.		P
7.2.3	Dielectric properties		
	The dielectric properties are based on basic safety publications IEC 60664-1 and IEC 61140. !For reduced clearances and creepage distances through the use of coating see IEC 60664-3; for clearances and creepage distances equal to or less than 2 mm see IEC 60664-5." a) The following requirements provide the means of achieving co-ordination of insulation of equipment with the conditions within the installation. b) The equipment shall be capable of withstanding: – the rated impulse withstand voltage (see 4.3.1.3) in accordance with the overvoltage category given in Annex H;		P

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	– the impulse withstand voltage across the contact gaps of devices suitable for isolation as given in Table 14; – the power-frequency withstand voltage. NOTE The correlation between the nominal voltage of the supply system and the rated impulse withstand voltage of the equipment is given in Annex H. The rated impulse withstand voltage for a given rated operational voltage (see notes 1 and 2 to 4.3.1.1) shall be not less than that corresponding in Annex H to the nominal voltage of the supply system of the circuit at the point where the equipment is to be used, and the appropriate overvoltage category. c) The requirements of this subclause shall be verified by the tests of 8.3.3.4.		
7.2.3.1	Impulse withstand voltage		
	1) Main circuit a) Clearances from live parts to parts intended to be earthed and between poles shall withstand the test voltage given in Table 12 appropriate to the rated impulse withstand voltage. b) Clearances across the open contacts shall withstand: – the impulse withstand voltage specified, where applicable, in the relevant product standard; – for equipment designated as suitable for isolation, the test voltage given in Table 14 appropriate to the rated impulse withstand voltage. NOTE Solid insulation of equipment associated with clearances a) and/or b) above should be subjected to the impulse voltage specified in a) and/or b), as applicable. 2) Auxiliary and control circuits a) For auxiliary and control circuits which operate directly from the main circuit at their rated voltage, clearances from live parts to parts intended to be earthed and between poles shall withstand the test voltage given in Table 12 appropriate to the rated impulse withstand voltage of the auxiliary/control circuit and to the appropriate overvoltage category of the main circuit (see also the note of 7.2.3.1, item 1)). b) Auxiliary and control circuits which do not operate directly from the main circuit may have an overvoltage withstand capacity different from that of the main circuit. Clearances and associated solid insulation of such circuits, whether a.c. or d.c., shall withstand the appropriate voltage in accordance with Annex H.		P
7.2.3.2	Power-frequency withstand voltage of the main, auxiliary and control circuits		
	a) Power-frequency tests are used in the following cases: – dielectric tests as type tests for the verification of		P

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	solid insulation; – dielectric withstand verification, as a criterion of failure, after switching or short-circuit type tests; – routine tests. b) Type tests of dielectric properties The tests of dielectric properties, as type tests, shall be made in accordance with 8.3.3.4. For equipment suitable for isolation, the maximum leakage current shall be in accordance with 7.2.7 and shall be tested according to 8.3.3.4. c) Verification of dielectric withstand after switching or short-circuit tests The verification of dielectric withstand after switching and short-circuit tests as a criterion of failure, is always made at power-frequency voltage in accordance with item 4) of 8.3.3.4.1. For equipment suitable for isolation, the maximum leakage current shall be in accordance with 7.2.7, shall be tested according to 8.3.3.4 and shall not exceed the values specified in the relevant product standard. d) Vacant e) Verification of dielectric withstand during routine tests Tests to detect faults in materials and workmanship are made at power-frequency voltage, in accordance with item 2) of 8.3.3.4.2.		
7.2.3.3	Clearances		
	Clearances shall be sufficient to enable the equipment to withstand the rated impulse withstand voltage, according to 7.2.3.1. Clearances shall be higher than the values given in Table 13, for case B (homogeneous field) (see 2.5.62) and verified by a sampling test according to 8.3.3.4.3. This test is not required if the clearances, related to the rated impulse withstand voltage and pollution degree, are higher than the values given in Table 13 for case A (inhomogeneous field). The method of measuring clearances is given in Annex G.		P
7.2.3.4	Creepage distances		
	a) Dimensioning For pollution degrees 1 and 2, creepage distances shall be not less than the associated clearances selected according to 7.2.3.3. For pollution degrees 3 and 4, the creepage distances shall be not less than the case A clearances (Table 13) to reduce the risk of disruptive discharge due to overvoltages, even if the clearances are smaller than the values of case A as permitted in 7.2.3.3. The method of measuring creepage distances is given in Annex G. Creepage distances shall correspond to a pollution		P

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	degree as specified in 6.1.3.2 or to that defined in the relevant product standard and to the corresponding material group at the rated insulation or working voltage given in Table 15. Material groups are classified as follows, according to the range of values of the comparative tracking index (CTI) (see 2.5.65): - Material Group I 600 CTI - Material Group II 400 CTI 600 - Material Group IIIa 175 CTI 400 - Material Group IIIb 100 CTI 175 NOTE 1 The CTI values refer to the values obtained in accordance with IEC 60112, method A, for the insulating material used. NOTE 2 For inorganic insulating materials, for example glass or ceramics, which do not track, creepage distances need not be greater than their associated clearances. However, the risk of disruptive discharge should be considered. b) Use of ribs A creepage distance can be reduced to 0,8 of the relevant value of Table 15 by using ribs of 2 mm minimum height, irrespective of the number of ribs. The minimum base of the rib is determined by mechanical requirements (see G.2). c) Special applications Equipment intended for certain applications where severe consequences of an insulation fault have to be taken into account shall have one or more of the influencing factors of Table 15 (distances, insulating materials, pollution in the micro-environment) utilized in such a way as to achieve a higher insulation voltage than the rated insulation voltage given to the equipment according to Table 15.		
7.2.3.5	Solid insulation		
	Solid insulation shall be verified by either power-frequency tests, in accordance with item 3) of 8.3.3.4.1, or d.c. tests in the case of d.c. equipment. Dimensioning rules for solid insulation and d.c. test voltages are under consideration.		P
7.2.3.6	Spacing between separate circuits		
	For dimensioning clearances, creepage distances and solid insulation between separate circuits, the highest voltage ratings shall be used (rated impulse withstand voltage for clearances and associated solid insulation and rated insulation voltage or working voltage for creepage distances).		P
7.2.3.7	Requirements for equipment with protective separation		
	Requirements for equipment with protective separation are given in Annex N.		P
7.2.4	Ability to make, carry and break currents under no-load, normal load and overload conditions		

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7.2.4.1	Making and breaking capacities		
	The equipment shall be capable of making and breaking load and overload currents without failure under the conditions stated in the relevant product standard for the required utilization categories and the number of operations stated in the relevant product standard (see also general test conditions of 8.3.3.5).		P
7.2.4.2	Operational performance		
	Tests concerning the operational performance of equipment are intended to verify that the equipment is capable of making, carrying and breaking without failure the currents flowing in its main circuit under conditions corresponding to the specified utilization category, where relevant. Specific requirements and test conditions shall be stated in the relevant product standard and may concern – the operational performance off-load for which the tests are made with the control circuits energized and the main circuit not energized, in order to demonstrate that the equipment meets the operating conditions specified at the upper and lower limits of supply voltage and/or pressure specified for the control circuit during closing and opening operations; – the operational performance on-load during which the equipment shall make and break the specified current corresponding, where relevant, to its utilization category for the number of operations stated in the relevant product standard. The verification of operational performance off-load and on-load may be combined in one sequence of tests if so stated in the relevant product standard.		P
7.2.4.3	Durability		
	NOTE The term "durability" has been chosen, instead of "endurance" in order to express the expectancy of the number of operating cycles which can be performed by the equipment before repair or replacement of parts. Moreover the term "endurance" is also commonly used to cover operational performance as defined in 7.2.4.2 and it was deemed necessary not to use the term "endurance" in this standard in order to avoid confusion between the two concepts.		P
7.2.4.3.1	Mechanical durability		
	With respect to its resistance to mechanical wear, an equipment is characterized by the number, stated in the relevant product standard, of no-load operating cycles (i.e., without current at the main contacts) which can be effected before it becomes necessary to service or replace any mechanical parts; however, normal maintenance according to the manufacturer's instructions may be permitted for equipment designed to be maintained. Each operating cycle consists of one closing operation followed by one opening operation. The equipment shall		P

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	be mounted for the test according to the manufacturer's instructions. The preferred number of off-load operating cycles shall be specified in the relevant product standard.		
7.2.4.3.2	Electrical durability		
	With respect to its resistance to electrical wear, an equipment is characterized by the number of on-load operating cycles, corresponding to the service conditions given in the relevant product standard, which can be made without repair or replacement. The preferred number of on-load operating cycles shall be specified in the relevant product standard.		P
7.2.5	Ability to make, carry and break short-circuit currents		
	The equipment shall be so constructed as to be capable of withstanding, under conditions specified in the relevant product standard, the thermal, dynamic and electrical stresses resulting from short-circuit currents. In particular the equipment shall behave in such a manner that it complies with the requirements of 8.3.4.1.8. Short-circuit currents may be encountered - during current making; - during current carrying in the closed position; - during current interruption. The ability of the equipment to make, carry and break short-circuit currents is stated in terms of one or more of the following ratings: - rated short-circuit making capacity (see 4.3.6.2); - rated short-circuit breaking capacity (see 4.3.6.3); - rated short-time withstand current (see 4.3.6.1); - in the case of equipment co-ordinated with short-circuit protective devices (SCPDs): a) rated conditional short-circuit current (see 4.3.6.4), b) other types of co-ordination, specified solely in the relevant product standard. For ratings and limiting values according to items a) and b) above, the manufacturer shall indicate the type and the characteristics (e.g. current rating, breaking capacity, cut-off current, I 2t) of the SCPD necessary for the protection of the equipment.		P
7.2.6	Switching overvoltages		
	Product standards may specify switching overvoltage tests if applicable. In this case the test procedure and the requirements shall be defined in the product standard.		P
7.2.7	Leakage currents of equipment suitable for isolation		
	For equipment suitable for isolation and having a rated operational voltage Ue greater than 50 V, the leakage current shall be measured through each pole with the contacts in the open position.		P

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	The value of leakage current, with a test voltage equal to 1,1 times the rated operational voltage shall not exceed – 0,5 mA per pole for equipment in a new condition; – 2 mA per pole for equipment having been subjected to the making and breaking operations in accordance with the test requirements of the relevant product standard. A leakage current of 6 mA at 1,1 times the rated operational voltage is a limiting value for equipment suitable for isolation which value shall not be exceeded under any circumstances. Tests to verify this requirement may be specified in the relevant product standard.		
7.3	Electromagnetic compatibility (EMC)		
7.3.1	General		
	For products falling within the scope of this standard, two sets of environmental conditions are considered and are referred to as a) environment A; b) environment B. Environment A relates to low-voltage non-public or industrial networks/locations/installations including highly disturbing sources. NOTE 1 Environment A corresponds to equipment class A in CISPR 11. Environment B relates to low-voltage public networks such as domestic, commercial and light industrial locations/installations. Highly disturbing sources such as arc welders are not covered by this environment. NOTE 2 Environment B corresponds to equipment class B in CISPR 11. !For the purpose of this standard, the phrase “electronic circuit” excludes circuits in which all components are passive (including diodes, resistors, varistors, capacitors, surge suppressors, inductors)."		P
7.3.2	Immunity		
7.3.2.1	Equipment not incorporating electronic circuits		
	Equipment not incorporating electronic circuits is not sensitive to electromagnetic disturbances in normal service conditions, and therefore no immunity tests are required.		P
7.3.2.2	Equipment incorporating electronic circuits		
	Equipment incorporating electronic circuits shall have a satisfactory immunity to electro- magnetic disturbances. !Text deleted" For the appropriate tests to verify the compliance with these requirements, see 8.4. Specific performance criteria shall be given in the relevant product standard based on the acceptance criteria given in Table 24.		P

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7.3.3	Emission		
7.3.3.1	Equipment not incorporating electronic circuits		
	For equipment not incorporating electronic circuits, electromagnetic disturbances can only be generated by equipment during occasional switching operations. The duration of the disturbances is of the order of milliseconds. The frequency, the level and the consequences of these emissions are considered as part of the normal electromagnetic environment of low-voltage installations. Therefore, the requirements for electromagnetic emissions are deemed to be satisfied, and no verification is necessary.		P
7.3.3.2	Equipment incorporating electronic circuits		
7.3.3.2.1	Limits for high-frequency emissions		
	Equipment incorporating electronic circuits (such as switched mode power supply, circuits incorporating microprocessors with high-frequency clocks) may generate continuous electro- magnetic disturbances. For such emissions, these shall not exceed the limits specified in the relevant product standard, based on CISPR 11 for environment A and for environment B. These tests are only required when the control and/or auxiliary circuits contain components with fundamental switching frequencies greater than 9 kHz. The product standard shall detail the test methods.		P
7.3.3.2.2	Limits for low-frequency emissions		
	For equipment which generates low frequency harmonics, where applicable, the requirements of IEC 61000-3-2 apply. For equipment which generates low frequency voltage fluctuations, where applicable, the requirements of IEC 61000-3-3 apply.		P
8	Tests		
8.1	Kinds of test		
8.1.1	General		
	Tests shall be made to prove compliance with the requirements laid down in this standard, where applicable, and in the relevant product standard. Tests are as follows: – type tests (see 2.6.1) which shall be made on representative samples of each particular equipment; – routine tests (see 2.6.2) which shall be made on each individual piece of equipment manufactured to this standard, where applicable, and the relevant product standard; – sampling tests (see 2.6.3) which are made if called for in the relevant product standard. For sampling tests for clearance verification, see 8.3.3.4.3. The above tests may consist of test sequences,		P

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	according to the requirements of the relevant product standard. Where such test sequences are specified in a product standard, tests, the result of which are not influenced by preceding tests and have no significance for subsequent tests of a given test sequence may be omitted from that test sequence, and made on separate new samples, by agreement with the manufacturer. The product standard shall specify such tests, where applicable. The tests shall be carried out by the manufacturer, at his works or at any suitable laboratory of his choice. Where appropriate, subject to specification in the relevant product standard, and to agreement between manufacturer and user, special tests (see 2.6.4) may also be performed.		
8.1.2	Type tests		
	Type tests are intended to verify compliance of the designs of the control circuit devices with this standard. They comprise the verification of: a) temperature-rise (8.3.3.3); b) dielectric properties (8.3.3.4); c) making and breaking capacities of switching elements under normal conditions (8.3.3.5.2); d) making and breaking capacities of switching elements under abnormal conditions (8.3.3.5.3); e) performance under conditional short-circuit current (8.3.4); f) constructional requirements (8.2); g) degree of protection of enclosed control circuit devices (8.3.1).		P
8.1.3	Routine tests		
	Routine tests are the responsibility of the manufacturer and are usually limited to a mechanical inspection and a verification of the mechanical operation. In certain cases specified in Annexes J and K, the inspection is supplemented by a dielectric test. When performed, the dielectric test is carried out according to 8.3.3.4 with the following amendments: the required minimum duration of voltage application is reduced to about 1 s and the metal foil and external terminal connections are unnecessary. Additional routine tests for the control switch or the control circuit device may be specified as appropriate. A sampling plan may be accepted.		P
8.1.4	Sampling tests		
	Sampling tests shall be performed on time delay devices to verify the time delay or range of time delay as stated by the manufacturer.		P
8.2	Compliance with constructional requirements		

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	The verification of compliance with the constructional requirements stated in 7.1 concerns, for example – the materials; – the equipment; – the degrees of protection of enclosed equipment; – the mechanical properties of terminals; – the actuator; – the position indicating device (see 2.3.18).		P
8.2.1	Materials		
8.2.1.1	Test of resistance to abnormal heat and fire		
8.2.1.1.1	Glow-wire test (on equipment)		
	The glow-wire test shall be made according to IEC 60695-2-10 and IEC 60695-2-11 under the conditions specified in 7.1.2.2. For the purpose of this test, a protective conductor is not considered as a current-carrying part. NOTE If the test is to be made at more than one place on the same sample, care should be taken to ensure that any deterioration caused by previous tests does not affect the test to be made.		P
8.2.1.1.2	Flammability, hot wire ignition and arc ignition tests (on materials)		
	Suitable specimens of the material shall be subjected to the following tests: a) flammability test, in accordance with IEC 60695-11-10; b) hot wire ignition (HWI) test, as described in Annex M; c) arc ignition (AI) test, as described in Annex M. The test c) is required only if the material is located within the 13 mm of arcing parts or live parts which are subject to loosening of connections. Materials located within 13 mm of arcing parts are exempt from this test if the equipment is subjected to make/break testing.		P
8.2.2	Equipment		
	Covered by the various subclauses of 8.2.		P
8.2.3	Enclosures for equipment		
	For the degrees of protection of enclosed equipment, see Annex C.		P
8.2.4	Mechanical and electrical properties of terminals"		
	This subclause does not apply to aluminium terminals nor to terminals for connection of aluminium conductors.		P
8.2.4.1	General conditions for tests		
	Unless otherwise stated by the manufacturer, each test shall be made on terminals in a clean and new condition. When tests are made with round copper conductors, these shall be of copper according to IEC 60028. When tests are made with flat copper conductors, these		P

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	shall have the following charac- teristics: - minimum purity: 99,5 %; - ultimate tensile strength: 200-280 N/mm2; - Vickers hardness: 40 to 65.		
8.2.4.2	Tests of mechanical strength of terminals		
	Tests shall be made with the appropriate type of conductor having the maximum ! cross- section." !Screwless-type clamping unit according to 7.1.8.1 are tested with conductors of the maximum cross-section." The conductor shall be connected and disconnected five times. For screw-type terminals, the tightening torque shall be in accordance with Table 4 or 110 % of the torque specified by the manufacturer, whichever is the greater. The test shall be conducted on two separate clamping units. Where a screw has a hexagonal head with means for tightening with a screwdriver and the values in columns II and III are different, the test is made twice, first applying to the hexagonal head the torque specified in column III, and then, on another set of samples, applying the torque specified in column II by means of a screwdriver. If the values in columns II and III are the same, only the test with the screwdriver is made. Each time the clamping screw or nut is loosened, a new conductor shall be used for each tightening test. During the test, clamping units and terminals shall not work loose and there shall be no damage, such as breakage of screws or damage to the head slots, threads, washers or stirrups that will impair the further use of the screwed connections.		P
8.2.4.3	Testing for damage to and accidental loosening of conductors (flexion test)		
	The test applies to terminals for the connection of unprepared round copper conductors, of number, cross-section and type (flexible and/or rigid (stranded and/or solid)), specified by the manufacturer. NOTE An appropriate test for flat copper conductors may be made by agreement between manufacturer and user. The following tests shall be carried out using two new samples with a) the maximum number of conductors of the !minimum cross-section" connected to the terminal; b) the maximum number of conductors of the!maximum cross-section"connected to the terminal; c) the maximum number of conductors of the !minimum and maximum cross-sections"connected to the terminal.		P

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	Terminals intended for connection of either flexible or rigid (solid and/or stranded) conductors shall be tested with each type of conductor with different sets of samples. Terminals intended for connection of both flexible or rigid (solid and/or stranded) conductors simultaneously shall be tested as stated in c) above. The test is to be carried out with suitable test equipment. The specified number of conductors shall be connected to the terminal. The length of the test conductors should be 75 mm longer than the height H specified in Table 5. The clamping screws shall be tightened with a torque in accordance with Table 4 or with the torque specified by the manufacturer. The device tested shall be secured as shown in Figure 1. Each conductor is subjected to circular motions according to the following procedure: The end of the conductor under test shall be passed through an appropriate size bushing in a platen positioned at a height H below the equipment terminal, as given in Table 5. The other conductors shall be bent in order not to influence the result of the test. The bushing shall be positioned in the horizontal platen concentric with the conductor. The bushing shall be moved so that its centreline describes a circle of 75 mm diameter about its centre in the horizontal plane at 10 rpm 2 rpm. The distance between the mouth of the terminal and the upper surface of the bushing shall be within 15 mm of the height H in Table 5. The bushing is to be lubricated to prevent binding, twisting or rotation of the insulated conductor. A mass as specified in Table 5 is to be suspended from the end of the conductor. The test shall consist of 135 continuous revolutions. During the test, the conductor shall neither slip out of the terminal nor break near the clamping unit. Immediately after the flexion test, each conductor under test shall be submitted in the test equipment to the test of 8.2.4.4 (pull-out test).		
8.2.4.4	Pull-out test		
8.2.4.4.1	Round copper conductors		
	Following the test of 8.2.4.3, the pulling force given in Table 5 shall be applied to the conductor tested in accordance with 8.2.4.3. The clamping screws shall not be tightened again for this test. !The force shall be applied without jerks for 1 min, in the direction of the axis of the conductor." During the test, the conductor shall neither slip out of the terminal nor break near the clamping unit.		P
8.2.4.4.2	Flat copper conductors		
	A suitable length of conductor shall be secured in the terminal and the pulling force given in Table 6 applied without jerks for 1 min in a direction opposite to that of		P

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	the insertion of the conductor. During the test, the conductor shall neither slip out of the terminal nor break near the clamping unit.		
8.2.4.5	Test for insertability of unprepared round copper conductors having the !maximum cross-section"		P
8.2.4.5.1	Test procedure		
	The test shall be carried out using the appropriate gauge form A or form B specified in Table 7. The measuring section of the gauge shall be able to penetrate freely into the terminal aperture to the full depth of the terminal (see also note to Table 7). Alternatively, the test can be carried out by inserting the largest conductor of type and rated cross-section among those recommended by the manufacturer, the diameter of which corresponds to the theoretical diameter according to Table 7a, after the insulation has been removed and the end has been reshaped. The stripped end of the conductor shall be able to enter completely within the clamping unit aperture, without use of undue force. NOTE The manufacturer may specify the test method.		P
8.2.4.5.2	Construction of gauges		
	The construction of the gauges is shown in Figure 2. Details of dimensions a and b and their permissible deviations are shown in Table 7. The measuring section of the gauge shall be made from gauge steel.		P
8.2.4.6	Tests for insertability of flat conductors with rectangular cross-section		
	Under consideration.		P
8.2.4.7	Electrical performance of screwless-type clamping units		
	Subclauses 9.8 of IEC 60999-1 and 9.8 of IEC 60999-2 apply. NOTE 1 The terms “smallest cross-sectional area” and “largest cross-sectional area” of IEC 60999 series are respectively "minimum cross section" (2.3.30) and "maximum cross section" (2.3.31) defined in this standard. NOTE 2 The test current generally applied is Ith or Ithe declared for the product. The detailed test requirements may be adapted in the product standards. NOTE 3 The product standard should consider the practicality of the detailed test requirements.		P
8.2.4.8	Ageing test for screwless-type clamping units		
	Subclauses 9.10 of IEC 60999-1 and 9.10 of IEC 60999-2 apply. NOTE 1 The terms “smallest cross-sectional area” and “largest cross-sectional area” of IEC 60999 series are respectively "minimum cross section" (2.3.30) and "maximum cross section" (2.3.31) defined in this		P

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	standard. NOTE 2 The test current generally applied is Ith or Ithe declared for the product. The detailed test requirements may be adapted in the product standards. NOTE 3 The product standard should consider the practicality of the detailed test requirements."		
8.2.5	Verification of the effectiveness of indication of the main contact position of equipment suitable for isolation		
	When required in 7.1.4.3, the minimum actuating force or moment shall be tested during sequence V of 8.3.1. The performance shall be as stated in 7.1.4.3..		P
8.2.5.1	Condition of equipment for the tests		
	The condition of the equipment for the tests shall be stated in the relevant product standard.		
8.2.5.2	Method of test		
8.2.5.2.1	Dependent and independent manual operation		
	The force necessary to operate the device to the open position shall be measured at the extremity of the actuator. The measured force F shall be equal to the average value of maximum force obtained from three consecutive operations, with the device in a clean and new condition. This force F shall then be used for the establishment of the test force in Table 17. With the equipment in the closed position, the fixed and moving contacts of the pole for which the test is deemed to be the most severe shall be fixed together, for example, by welding. The actuator shall be submitted to a test force of 3F but which, however, shall not be less than the minimum nor more than the maximum values given in Table 17, corresponding to the type of actuator. !Where the device has more than one contact system in series, all contact systems that are in series shall be held in the closed position." In the case of multiple tip contact systems, the least number of parallel contact tips shall be fixed together as necessary to hold the contact system closed in order to allow the test force to be applied without the contacts separating. The appropriate means to keep the contact(s) closed and the number of contacts shall be specified by the manufacturer. The number of contacts and the method shall be stated in the report. The test force shall be applied without shock to the extremity of the actuator, for a period of 10 s, in the direction to open the contacts. The direction of the test force with respect to the actuator, as shown in Figure 16, shall be maintained throughout the test. !Verification shall be made according to 8.2.5.3.1."		P

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8.2.5.2.2	Dependent power operation		
	With the equipment in the closed position, the fixed and moving contacts of the pole for which the test is deemed to be the most severe shall be fixed together, e.g. by welding. !Where the device has more than one contact system in series, all contact systems that are in series shall be held in the closed position." In the case of multiple tip contact systems, the least number of parallel contact tips shall be fixed together as necessary to hold the contact system closed in order to allow the test force to be applied without the contacts separating. The appropriate means to keep the contact(s) closed and the number of contacts shall be specified by the manufacturer. The number of contacts and the method shall be stated in the report. The supply voltage to the power operator shall be applied at 110 % of its normal rated value to attempt to open the contact system of the equipment. Three attempts to operate the equipment at 5 min intervals by the power operator shall be made, each for a period of 5 s, unless an associated protective device of the power operator limits the time to a shorter period. Verification shall be made to 8.2.5.3.2. NOTE In Canada and the United States of America devices meeting these requirements are not accepted as assuring isolation by themselves.		P
8.2.5.2.3	Independent power operation		
	With the equipment in the closed position, the fixed and moving contacts of the pole for which the test is deemed to be the most severe shall be fixed together, e.g. by welding. !Where the device has more than one contact system in series, all contact systems that are in series shall be held in the closed position." In the case of multiple tip contact systems, the least number of parallel contact tips shall be fixed together as necessary to hold the contact system closed in order to allow the test force to be applied without the contacts separating. The appropriate means to keep the contact(s) closed and the number of contacts shall be specified by the manufacturer. The number of contacts and the method shall be stated in the report. The stored energy of the power operator shall be released to attempt to open the contact system of the equipment. Three attempts to operate the equipment by releasing the stored energy shall be made. Verification shall be made to 8.2.5.3.2. NOTE In Canada and the United States of America		P

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	devices meeting these requirements are not accepted as assuring isolation by themselves.		
8.2.5.3	Condition of equipment during and after test		
8.2.5.3.1	Dependent and independent manual operation		
	After the test, when the test force is no longer applied, the actuator being left free, the open position shall not be indicated by any of the means provided and the equipment shall not show any damage such as to impair its normal operation. When the equipment is provided with a means of locking in the open position, it shall not be possible to lock the equipment while the test force is applied.		P
8.2.5.3.2	Dependent and independent power operation		
	During and after the test, the open position shall not be indicated by any of the means provided and the equipment shall not show any damage such as to impair its normal operation. When the equipment is provided with means for locking in the open position, it shall not be possible to lock the equipment during the test.		P
8.2.6	Vacant		
8.2.7	Conduit pull-out test, torque test and bending test with metallic conduits		
	The test shall be made with an appropriate sized metal conduit (300 10) mm long. The polymeric enclosure shall be installed according to the manufacturer's instructions, in the most unfavourable position. The tests shall be made on the same conduit entry, this being the most unfavourable entry. The tests shall be made in the sequence 8.2.7.1, 8.2.7.2 and 8.2.7.3.		P
8.2.7.1	Pull-out test		
	The conduit shall be screwed without jerk into the entry with a torque equal to two-thirds of the values given in Table 22. A direct pull shall be applied, without jerk, to the conduit for 5 min. Unless otherwise specified in the relevant product standard, the pulling force shall be according to Table 20. After the test, the displacement of the conduit in relation with the entry shall be less than one thread depth and there shall be no evidence of damage impairing further use of the enclosure.		P
8.2.7.2	Bending test		
	A slowly increasing bending moment shall be applied without jerk to the free end of the conduit. When the bending moment results in a deflection of the conduit of 25 mm per 300 mm length, or the bending moment has reached the value given in Table 21, the moment is maintained for 1 min. The test is then repeated in a perpendicular direction. After the test there shall be no evidence of damage		P

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	impairing further use of the enclosure.		
8.2.7.3	Torque test		
	The conduit shall be tightened without jerk with a torque according to Table 22. The torque test does not apply to an enclosure that is not provided with a pre-assembled conduit entry, and that has instructions stating that the conduit entry is to be mechanically connected to the conduit before being connected to the enclosure. For enclosures provided with a single conduit connection up to and including 16 H, the tightening torque is reduced to 25 N m. After the test, it shall be possible to unscrew the conduit and there shall be no evidence of damage impairing further use of the enclosure.		P
8.3	Performance		
8.3.1	Test sequences		
	Where applicable, the relevant product standard shall specify the test sequences to which the equipment is to be submitted.		P
8.3.2	General test conditions		
	NOTE Tests according to the requirements of this standard do not preclude the need for additional tests concerning equipment incorporated in assemblies, for example tests in accordance with IEC 60439.		P
8.3.2.1	General requirements		
	The equipment to be tested shall agree in all its essential details with the design of the type which it represents. Unless otherwise stated in the relevant product standard, each test, whether individual or test sequence, shall be made on equipment in a clean and new condition. Unless otherwise stated, the tests shall be made with the same kind of current (and, in the case of a.c., at the same rated frequency and with the same number of phases) as in the intended service. The relevant product standard shall specify those values of test quantities not specified in this standard. If, for convenience of testing, it appears desirable to increase the severity of a test (e.g. to adopt a higher rate of operation in order to reduce the duration of the test), this may be done only with the consent of the manufacturer. Equipment under test shall be mounted complete on its own support or an equivalent support and connected as in normal service, in accordance with the manufacturer's instructions and under the ambient conditions stated in 6.1. The tightening torques to be applied to the terminal screws shall be in accordance with the manufacturer's instructions or, in the absence of such instructions, in		P

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	accordance with Table 4. Equipment having an integral enclosure (see 2.1.17) shall be mounted complete and any opening normally closed in service shall be closed for tests. Equipment intended for use only in an individual enclosure shall be tested in the smallest of such enclosures stated by the manufacturer. NOTE An individual enclosure is an enclosure designed and dimensioned to contain one equipment only. All other equipment shall be tested in free air. If such equipment may also be used in specified individual enclosures and has been tested in free air, it shall be additionally tested in the smallest of such enclosures stated by the manufacturer, for specific tests which shall be specified in the relevant product standard and stated in the test report. However, if such equipment may also be used in specified individual enclosures and is tested throughout in the smallest of such enclosures stated by the manufacturer, the tests in free air need not be made provided that such enclosure is bare metallic, without insulation. Details, including the dimensions of the enclosure, shall be stated in the test report. For the test in free air, unless otherwise specified in the relevant product standard, for the test concerning making and breaking capacities and performance under short-circuit conditions, a metallic screen shall be placed at all points of the equipment likely to be a source of external phenomena capable of producing a breakdown, in accordance with the arrangements and distances specified by the manufacturer. Details, including distance from the equipment under test to the metallic screen, shall be stated in the test report. The characteristics of the metallic screen shall be as follows: structure: woven wire mesh; or perforated metal; or expanded metal; material: steel; thickness or diameter of material: 1,5 mm minimum; ratio hole area/total area: 0,45 – 0,65; size of hole: not exceeding 30 mm2; coating: bare, or conductive plating; resistance: shall be included in the calculation for the prospective fault current in the fusible element circuit (see 8.3.3.5.2 g) and 8.3.4.1.2 d)), measured from the furthest point on the metallic screen likely to be reached by arc emissions. Maintenance or replacement of parts is not permitted, unless otherwise specified in the relevant product standard. The equipment may be operated without load prior to		

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	beginning a test. For the tests, the actuating system of mechanical switching devices shall be operated as for the intended use in service stated by the manufacturer and at the rated values of control quantities (such as voltage or pressure), unless otherwise specified in this standard or the relevant product standard.		
8.3.2.2	Test quantities		
8.3.2.2.1	Values of test quantities		
	All the tests shall be made with the values of test quantities corresponding to the ratings assigned by the manufacturer, in accordance with the relevant tables and data of the relevant product standard.		P
8.3.2.2.2	Tolerances on test quantities		
	The test recorded in the test report shall be within the tolerances given in Table 8, unless otherwise specified in the relevant subclauses. However, with the agreement of the manu- facturer, the tests may be made under more severe conditions than those specified.		P
8.3.2.2.3	Recovery voltage		
	a) Power-frequency recovery voltage For all breaking capacity and short-circuit breaking capacity tests, the value of the power- frequency recovery voltage shall be 1,05 times the value of the rated operational voltage as assigned by the manufacturer or as specified in the relevant product standard. NOTE 1 The value of 1,05 times the rated operational voltage for the power frequency recovery voltage, together with the test voltage tolerance according to Table 8, is deemed to cover the effects of variations of the system voltage under normal service conditions, according to IEC 60038. NOTE 2 This may require that the applied voltage be increased but the prospective peak making current should not be exceeded without the consent of the manufacturer. NOTE 3 The upper limit of the power-frequency recovery voltage may be increased with the approval of the manufacturer (see 8.3.2.2.2). b) Transient recovery voltage Transient recovery voltages, where required in the relevant product standard, are determined according to 8.3.3.5.2.		P
8.3.2.3	Evaluation of test results		
	Behaviour of the equipment during the tests and its condition after the tests shall be specified in the relevant product standard. For short-circuit tests, see also 8.3.4.1.7 and 8.3.4.1.9.		P
8.3.2.4	Test reports		
	Written reports on type tests proving compliance with the relevant product standard shall be made available		P

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	by the manufacturer. The details of test arrangements such as type and size of the enclosure, if any, size of conductors, distance from the live parts to the enclosure or to parts normally earthed in service, method of operation of the actuating system, etc., shall be given in the test report. Test values and parameters shall form part of the test report.		
8.3.3	Performance under no-load, normal load and overload conditions		
8.3.3.1	Operation		
	Tests shall be made to verify that the equipment operates correctly according to the requirements of 7.2.1.1.		P
8.3.3.2	Operating limits		
8.3.3.2.1	Power operated equipment		
	It shall be verified that the equipment opens and closes correctly within the limiting values of the control quantities, such as voltage, current, air pressure and temperatures, specified in the relevant product standard. Tests are made with no current flowing through the main circuit, unless otherwise specified. !In the case of a power operated equipment with electronically controlled electromagnet, supplied with a.c., where a drop out range is declared with limits between 75 % to 10 % of their rated control supply voltage Us, the equipment shall, in addition, be submitted to the capacitive drop out test as follows: A capacitor C shall be inserted in series in the supply circuit Us, the total length of the connecting conductors being 3 m. The capacitor is short-circuited by a switch of negligible impedance. The supply voltage shall then be adjusted to 110 % Us. It shall be verified that the equipment drops out when the switch is operated to the open position. The value of the capacitor shall be C (nF) = 30 + 200 000 / (f Us) where f is the minimum rated frequency (Hz); Us is the maximum rated supply voltage (V). For example for a coil rated 12…24 V – 50 Hz, the capacitor value is 196 nF (calculation made with Us max). The test voltage is the highest value of the declared rated supply voltage range Us. NOTE The value of the capacitor simulates a typical control wiring of 100 m long cable of 1,5 mm2 (0,3 nF/m that is 30 nF for 100 m) connected to a static output having a 1,3 mA leakage current (200 000 in the formula 10 E+9 *1,3 E-3/2*)."		P
8.3.3.2.2	Relays and releases		
	The operating limits of relays and releases shall		P

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	comply with the requirements of 7.2.1.3, 7.2.1.4 and 7.2.1.5 and shall be verified according to the test procedure defined in the relevant product standard. For undervoltage relays and releases, see 7.2.1.3. For shunt releases, see 7.2.1.4. For current operated relays and releases, see 7.2.1.5.		
8.3.3.3	Temperature-rise		
8.3.3.3.1	Ambient air temperature		
	The ambient air temperature shall be recorded during the last quarter of the test period by at least two temperature sensing means, e.g. thermometers or thermocouples, equally distributed around the equipment at about half its height and at a distance of about 1 m from the equipment. The temperature sensing means shall be protected against air currents, heat radiation and indicating errors due to rapid temperature changes. During the tests, the ambient air temperature shall be between +10 °C and +40 °C and shall not vary by more than 10 K. However, if the variation of the ambient air temperature exceeds 3 K, an appropriate correction factor should be applied to the measured temperature of the parts, depending on the thermal time-constant of the equipment.		P
8.3.3.3.2	Measurement of the temperature of parts		
	For parts other than coils, the temperature of the different parts shall be measured by suitable temperature sensing means at those points most likely to attain the maximum temperature; these points shall be stated in the test report. The oil temperature of oil-immersed equipment shall be measured at the upper part of the oil; this measurement may be made by means of a thermometer. The temperature sensing means shall not significantly affect the temperature-rise. Good thermal conductivity between the temperature sensing means and the surface of the part under test shall be ensured. !For electromagnet coils, the method of measuring the temperature by variation of resistance shall generally be used. Other methods are permitted only if it is impracticable to use the resistance method, for example for electronically controlled electromagnet. When measured by another method than the resistance method the limits of temperature rise permitted shall be adjusted accordingly. The product standard shall state the method and the limits. In the case of an electronically controlled electromagnet, coil temperature measuring by variation of resistance may be impracticable; in such a case, other methods are permitted, e.g. thermocouples or other suitable methods. When		P

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	measured by another method than the resistance method the limits of temperature rise permitted shall be adjusted accordingly. The product standard shall state the method and the limits." The temperature of the coils before beginning the test shall not differ from that of the surrounding medium by more than 3 K. For copper conductors, the value of the hot temperature T2, may be obtained from the value of the cold temperature T1, as a function of the ratio of the hot resistance R2 to the cold resistance R1 by the following formula: R2 R1 1 234,5 234,5 where T1 and T2 are expressed in degrees Celsius. The test shall be made for a time sufficient for the temperature-rise to reach a steady-state value, but not exceeding 8 h. It is assumed that a steady state is reached when the variation does not exceed 1 K per hour.		
8.3.3.3.3	Temperature-rise of a part		
	The temperature-rise of a part is the difference between the temperature of the part measured in accordance with 8.3.3.3.2, and the ambient air temperature measured in accordance with 8.3.3.3.1.		P
8.3.3.3.4	Temperature-rise of the main circuit		
	The equipment shall be mounted as specified in 8.3.2.1 and shall be protected against abnormal external heating or cooling. For the conventional thermal current test (free air or enclosed), equipment having an integral enclosure and equipment only intended for use with a specified type of enclosure shall be tested in its enclosure. No opening giving false ventilation shall be allowed. Equipment intended for use with more than one type of enclosure shall be tested either in the smallest enclosure stated by the manufacturer to be suitable or tested without an enclosure. If tested without an enclosure the manufacturer shall be prepared to state a value of conventional enclosed thermal current (see 4.3.2.2). For tests with multiphase currents, the current shall be balanced in each phase within ±5 %, and the average of these currents shall be not less than the appropriate test current. Unless otherwise specified in the relevant product standard, the temperature-rise test of the main circuit is made at one or both of the conventional thermal currents, as defined in 4.3.2.1 and 4.3.2.2 and may be made at any convenient voltage. When the heat exchange between the main circuit, the control circuit and the auxiliary circuits may be of		P

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	significance, the temperature-rise tests stated in 8.3.3.3.4, 8.3.3.3.5, 8.3.3.3.6 and 8.3.3.3.7 shall be made simultaneously, in so far as this is allowed by the relevant product standard. Tests on d.c. rated equipment may be made with an a.c. supply for convenience of testing, but only with the consent of the manufacturer. In the case of multipole equipment fitted with identical poles and tested with a.c. the test may be carried out, subject to the manufacturer's agreement, with single-phase current, with all poles connected in series provided that magnetic effects can be neglected. In the case of three-pole equipment provided with a neutral pole different from the phase poles, the test shall comprise – a three-phase test on the three identical poles; – a single-phase test on the neutral pole connected in series with the adjacent pole, the value of the test quantities being determined according to the value of the conventional thermal current (free air or enclosed) of the neutral pole (see 7.1.9). Equipment provided with short-circuit protective devices shall be tested according to the requirements given in the relevant product standard. At the end of the test, the temperature-rise of the different parts of the main circuit shall not exceed the values given in Tables 2 and 3, unless otherwise specified in the relevant product standard. Depending on the value of the conventional thermal current (free air or enclosed), one of the following test connection arrangements shall be used: i) For values of test current up to and including 400 A: a) The connections shall be single-core, PVC insulated, copper conductors with cross- sections as given in Table 9. b) The connections shall be in free air, and spaced at approximately the distance existing between the terminals. c) For single-phase or multi-phase tests the minimum length of any temporary connection from an equipment terminal to another terminal or to the test supply or to a star point shall be – 1 m for cross-sections up to and including 35 mm2 (or AWG 2); – 2 m for cross-sections larger than 35 mm2 (or AWG 2). ii) For values of test current higher than 400 A but not exceeding 800 A: a) The connections shall be single-core, PVC insulated, copper conductors with cross- sectional areas as given in Table 10, or the equivalent copper bars given in Table 11, as recommended by the manufacturer. b) The connections specified in a) shall be spaced at		

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	approximately the same distance as that between the terminals. Copper bars shall be painted matt black. Multiple parallel conductors per terminal shall be bunched together and arranged with approximately 10 mm air space between each other. Multiple copper bars per terminal shall be spaced at a distance approximately equal to the bar thickness. If the sizes stated for the bars are not suitable for the terminals, or are not available, other bars having approximately the same cross-sections and approximately the same or smaller cooling areas may be used. Copper conductors or bars shall not be laminated. c) For single-phase or multi-phase tests the minimum length of any temporary connection from the equipment terminal to another terminal or to the test supply shall be 2 m. The minimum length to a star point may be reduced to 1,2 m. iii) For values of test current higher than 800 A but not exceeding 3 150 A: a) The connections shall be copper bars of the sizes stated in Table 11 unless the equipment is designed only for cable connection. In this case, the size and arrangement of the cables shall be as specified by the manufacturer. b) Copper bars shall be spaced at approximately the same distance as that between the terminals. Copper bars shall be painted matt black. Multiple copper bars per terminal shall be spaced at a distance approximately equal to the bar thickness. If the sizes stated for the bars are not suitable for the terminals, or are not available, other bars having approximately the same or smaller cooling areas may be used. Copper bars shall not be laminated. c) For single-phase or multi-phase tests the minimum length of any temporary connection from an equipment terminal to another terminal or to the supply shall be 3 m, but this can be reduced to 2 m provided that the temperature-rise at the supply end of the connection is not more than 5 K below the temperature-rise in the middle of the connection length. The minimum length to a star point shall be 2 m. iv) For values of test current higher than 3 150 A: Agreement shall be reached between manufacturer and user on all relevant items of the test, such as: type of supply, number of phases and frequency (where applicable), cross- sections of test connections, etc. This information shall form part of the test report.		
8.3.3.3.5	Temperature-rise of control circuits		
	The temperature-rise tests of control circuits shall be made with the specified current and, in the case of a.c., at the rated frequency. Control circuits shall be tested at their rated voltage. Circuits intended for continuous operation shall be tested for a sufficient time for the temperature-rise to reach a steady-state value.		P

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	Circuits for intermittent duty shall be tested as prescribed in the relevant product standard. At the end of these tests the temperature-rise of the different parts of the control circuits shall not exceed the values specified in 7.2.2.5, unless otherwise specified in the relevant product standard.		
8.3.3.3.6	Temperature-rise of coils of electromagnets		
	Coils and electromagnets shall be tested according to the conditions given in 7.2.2.6. They shall be tested for a sufficient time for the temperature-rise to reach a steady-state value. The temperature shall be measured when thermal equilibrium is reached in both the main circuit and the coil of the electromagnet. Coils and electromagnets of equipment intended for intermittent duty shall be tested as prescribed in the relevant product standard. At the end of these tests the temperature-rise of the different parts shall not exceed the values specified in 7.2.2.6.		P
8.3.3.3.7	Temperature-rise of auxiliary circuits		
	The temperature-rise tests of auxiliary circuits shall be made under the same conditions as those specified in 8.3.3.3.5, but may be carried out at any convenient voltage. At the end of these tests the temperature-rise of the auxiliary circuits shall not exceed the values specified in 7.2.2.7.		P
8.3.3.4	Dielectric properties		
8.3.3.4.1	Type tests		
	1) General conditions for withstand voltage tests The equipment to be tested shall comply with the general requirements of 8.3.2.1. If the equipment is to be used without an enclosure, it shall be mounted on a metal plate and all exposed conductive parts (frame, etc.) intended to be connected to the protective earth in normal service shall be connected to that plate. When the base of the equipment is of insulating material, metallic parts shall be placed at all of the fixing points in accordance with the conditions of normal installation of the equipment and these parts shall be considered as part of the frame of the equipment. Any actuator of insulating material and any integral non-metallic enclosure of equipment intended to be used without an additional enclosure shall be covered by a metal foil and connected to the frame or the mounting plate. The foil shall only be applied to those parts of surface which can be touched with the standard test finger during operation or adjustment of the equipment. If the insulation part of an integral enclosure cannot be touched by the standard test finger due to the presence of an additional enclosure, no foil shall be		P

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	required. NOTE 1 This corresponds to accessible parts by the operator during operation or adjustment of the equipment (for example, actuator of a push-button). Annex R gives guidance for application of the metal foil on accessible parts during operation or adjustment. When the dielectric strength of the equipment is dependent upon the taping of leads or the use of special insulation, such taping or special insulation shall also be used during the tests. NOTE 2 Dielectric tests for semiconductor devices are under consideration. !For the dielectric test between phases, all circuits between these phases may be disconnected for the test. NOTE 3 The purpose of this test is to check the functional insulation only. When the circuits of equipment include devices such as motors, instruments, snap switches, capacitors and solid state devices which, according to their relevant specifications, have been subjected to dielectric test voltages lower than those specified in this standard, such devices shall be disconnected for the test. Where the control circuit normally connected to the main circuit is disconnected, the method used to maintain the main contacts closed shall be indicated in the test report. For the dielectric test between phase and earth, all circuits shall be connected. NOTE 4 The connection of all circuits for this test takes into account the function of protection against electric shock of the insulation between phase and earth. Printed circuit boards and modules with multi-point connectors may be disconnected or replaced by dummies during the insulation test. This does not apply, however, to auxiliaries for which, in case of an insulation fault, voltage may pass onto accessible parts not connected to the housing or from the side of higher voltage to the side of lower voltage, e.g. auxiliary transformers, measuring equipment, pulse transformers, the insulation stress of which is equal to that for the main circuit." 2) Verification of impulse withstand voltage a) General The equipment shall comply with the requirements stated in 7.2.3.1. The verification of the insulation is made by a test at the rated impulse withstand voltage. If equipment contains any part for which the dielectric properties are not sensitive to altitude (e.g. optocouplers, encapsulated parts), then the verification of the insulation may be alternatively performed by a test at the rated impulse withstand voltage without application of the altitude correction factor. These parts		

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	shall then be disconnected and the remainder of the equipment shall be tested with the rated impulse withstand voltage using the altitude correction factor. !Clearances equal to or larger than the values of class A of Table 13 may be verified by measurement, according to the method described in Annex G." b) Test voltage The test voltage shall be that specified in 7.2.3.1. For equipment incorporating overvoltage suppressing means, the energy content of the test current shall not exceed the energy rating of the overvoltage suppressing means. The latter shall be suitable for the application. NOTE 1 Such ratings are under consideration. The test equipment shall be calibrated to produce a 1,2/50 µs waveform as defined in IEC 61180. The output is then connected to the equipment to be tested and the impulse applied five times for each polarity at intervals of 1 s minimum. The influence of the equipment under test on the waveshape, if any, is ignored. If, in the course of a test procedure, repeated dielectric testing is required, the relevant product standard shall state the dielectric test conditions. NOTE 2 An example of test equipment is under consideration. c) Application of test voltage With the equipment mounted and prepared as specified in item a) above, the test voltage is applied as follows: i) between all the terminals of the main circuit connected together (including the control and auxiliary circuits connected to the main circuit) and the enclosure or mounting plate, with the contacts in all normal positions of operation; ii) between each pole of the main circuit and the other poles connected together and to the enclosure or mounting plate, with the contacts in all normal positions of operation; iii) between each control and auxiliary circuit not normally connected to the main circuit and: - the main circuit, - the other circuits, - the exposed conductive parts, - the enclosure or mounting plate, which, wherever appropriate, may be connected together; iv) for equipment suitable for isolation, across the poles of the main circuit, the line terminals being connected together and the load terminals connected together. The test voltage shall be applied between the line and load terminals of the equipment with the contacts in the open position and its value shall be as specified in item 1) b) of 7.2.3.1.		

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	For equipment not suitable for isolation, the requirements for testing with the contacts in the open position shall be stated in the relevant product standard. d) Acceptance criteria There shall be no unintentional disruptive discharge during the tests. NOTE 1 An exception is an intentional disruptive discharge, for example by transient overvoltage suppressing means. NOTE 2 The term "disruptive dicharge" related to phenomena 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 3 The term "sparkover" is used when a disruptive 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 dielectric in a gaseous or liquid medium. NOTE 5 The term "puncture" is used when a disruptive discharge occurs through a solid dielectric. NOTE 6 A disruptive discharge in a solid dielectric produces permanent loss of dielectric strength, in a liquid or gaseous dielectric, the loss may be only temporary. 3) Power-frequency withstand verification of solid insulation a) General This test applies to the verification of solid insulation and the ability to withstand temporary overvoltages. !The values of Table 12A are deemed to cover the ability to withstand temporary overvoltages (see the footnote b of Table 12A)." b) Test voltage The test voltage shall have a practically sinusoidal waveform and a frequency between 45 Hz and 65 Hz. !NOTE "practically sinusoidal" means that the ratio between the peak value and the r.m.s. value is 2 3 %." The high-voltage transformer used for the test shall be so designed that, when the output terminals are short-circuited after the output voltage has been adjusted to the appropriate test voltage, the output current shall be at least 200 mA. The overcurrent relay shall not trip when the output current is less than 100 mA. The value of the test voltage shall be as follows: i) for the main circuit, and for the control and auxiliary circuits, in accordance with Table 12A. The uncertainty of measurement of the test voltage shall		

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	not exceed 3 %. ii) if an alternating test voltage cannot be applied, for example due to EMC filter components, a direct test voltage may be used having the value of Table 12A, third column. The uncertainty of measurement of the test voltage shall not exceed 3 %. !Text deleted" c) Application of test voltage !The test voltage shall be applied to for 5 s in accordance with items i), ii) and iii) of 2) c) above. NOTE The product standard may increase the test duration to 60 s." d) Acceptance criteria During the test, no flashover, breakdown of insulation either internally (puncture) or externally (tracking) or any other manifestation of disruptive discharge shall occur. Any glow discharge shall be ignored. Components connected between phase and earth may be damaged during the tests but such failure shall not result in a condition that would lead to a hazardous situation. Product standards may give specific acceptance criteria. NOTE The voltage levels to earth are based on IEC 60664-1 under worst case conditions which generally do not occur in practice. 4) Power-frequency withstand verification after switching and short-circuit tests a) General The test should be performed on the equipment whilst it remains mounted for the switching or short-circuit tests. If this is not practicable, it may be disconnected and removed from the test circuit, although measures shall be taken to ensure that this does not influence the result of the test. b) Test voltage The requirements of 3) b) above shall apply except that the value of the test voltage shall be 2 Ue with a minimum of 1 000 V r.m.s. The requirements of 3) b) above shall apply except that the value of the test voltage shall be 2 Ue with a minimum of 1 000 V r.m.s. or 1 415 V d.c. if an a.c. voltage test cannot be applied. The value of Ue referred to is that at which switching and/or short- circuit tests have been performed. NOTE The product standards should be adapted to this decision when reprinted. c) Application of test voltage The requirements of 3) c) above shall apply. The application of the metal foil, according to 8.3.3.4.1 1), is not required.		

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	d) Acceptance criteria The requirements of 3) d) above shall apply. 5) Vacant 6) Verification of d.c. withstand voltage Under consideration. 7) Verification of creepage distances The shortest creepage distances between phases, between circuit conductors at different voltages and live and exposed conductive parts shall be measured. The measured creepage distance with respect to material group and pollution degree shall comply with the requirements of 7.2.3.4. 8) Verification of leakage current of equipment suitable for isolation Tests shall be specified in the relevant product standard.		
8.3.3.4.2	Routine tests		
	1) Impulse withstand voltage The tests shall be performed in accordance with item 2) of 8.3.3.4.1. The test voltage shall be not less than 30 % of the rated impulse withstand voltage (without altitude correction factor) or 2 Ui whichever is the higher. 2) Power-frequency withstand voltage a) Test voltage The test apparatus shall be the same as that stated in item 3) b) of 8.3.3.4.1 except that the overcurrent trip should be set at 25 mA. However, at the discretion of the manufacturer for safety reasons, test apparatus of a lower power or trip setting may be used, but the short-circuit current of the test apparatus shall be at least eight times the nominal trip setting of the overcurrent relay, for example for a transformer with a short-circuit current of 40 mA, the maximum trip setting of the overcurrent relay shall be 5 mA ± 1 mA. NOTE 1 The capacitance of the equipment may be taken into account. The value of the test voltage shall be 2 Ue with a minimum of 1 000 V r.m.s. NOTE 2 In the case of multiple values, Ue refers to the highest value marked on the equipment or given in the manufacturer's documentation. b) Application of test voltage The requirements of item 3) c) of 8.3.3.4.1 shall apply, except that the duration of the test voltage shall be 1 s only. However, as an alternative, a simplified test procedure may be used if it is considered to subject the insulation to an equivalent dielectric stress. c) Acceptance criteria The overcurrent relay shall not trip. 3) Combined impulse voltage and power-frequency		P

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	withstand voltage Product standards may specify if the tests of items 1) and 2) above may be replaced by a single power frequency withstand test where the peak value of the sinusoidal wave corresponds to the value stated in items 1) or 2), whichever is the higher. 4) In no case the application of the metal foil according to 8.3.3.4.1 1) is required.		
8.3.3.4.3	Sampling tests for verification of clearances		
	1) General These tests are intended to verify the maintaining of the design conformity regarding clearances and are only applicable to equipment with clearances smaller than those corresponding to Table 13, case A. 2) Test voltage The test voltage shall be that corresponding to the rated impulse withstand voltage. The relevant product standards shall state sampling plans and procedure. 3) Application of test voltage The requirements of item 2) c) of 8.3.3.4.1 shall apply, except that the metal foil need not be applied to the actuator or the enclosure. 4) Acceptance criteria No disruptive discharge shall occur.		P
8.3.3.4.4	Tests for equipment with protective separation		
	Tests for equipment with protective separation are given in Annex N.		P
8.3.3.5	Making and breaking capacities		
8.3.3.5.1	General test conditions		
	Tests for verification of making and breaking capacities shall be made according to the general test requirements stated in 8.3.2. The tolerances for individual phases shall be in accordance with Table 8, unless otherwise stated. Four-pole equipment shall be tested as three-pole equipment with the unused pole, which in the case of equipment provided with a neutral pole is the neutral pole, connected to the frame. If all poles are identical, one test on three adjacent poles is sufficient. If not, an additional test shall be made between the neutral pole and the adjacent pole, according to Figure 4, at the rated current of the neutral pole and at the phase-to-neutral voltage, with the other two unused poles connected to the frame. For transient recovery voltages, in the case of breaking capacity tests under normal load and overload conditions, values shall be specified in the relevant product standard.		P
8.3.3.5.2	Test circuit		
	a) Figures 3, 4, 5 and 6 give the diagrams of the circuits to be used for the tests concerning		P

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	– single-pole equipment on single-phase a.c. or d.c. (Figure 3); – two-pole equipment on single-phase a.c. or d.c. (Figure 4); – three-pole equipment or three single-phase equipment on three-phase a.c. (Figure 5); – four-pole equipment on three-phase four-wire a.c. (Figure 6); A detailed diagram of the circuit used for the test shall be given in the test report. b) The prospective current at the supply terminals of the equipment shall be not less than 10 times the test current or 50 kA, whichever is the lower. c) The test circuit comprises the supply source, the equipment D under test and the load circuit. d) The load circuit shall consist of resistors and air-cored reactors in series. Air-cored reactors in any phase shall be shunted by resistors taking approximately 0,6 % of the current through the reactor. However, where a transient recovery voltage is specified, instead of the 0,6 % shunt resistors, parallel resistors and capacitors shall be included across the load, the complete load circuit being as shown in Figure 8. NOTE For d.c. tests where L/R > 10 ms an iron-cored reactor may be used with series resistors, if necessary, verifying with an oscilloscope that the L/R value is as specified (15 %), and that the time required to obtain 95 % of the current made is equal to 3 L/R ± 20 %. Where a transient inrush current is specified (e.g. utilization categories AC-5b, AC-6 and DC-6), a different type of load may be specified in the relevant product standard. e) The loads shall be adjusted to obtain, at the specified voltage: – the value of current and power-factor or time-constant specified in the relevant product standard; – the value of the power-frequency recovery voltage; – where specified, the oscillatory frequency of the transient recovery voltage and the value of the factor . The factor is the ratio of the value U1 of the highest peak of the transient recovery voltage to the instantaneous value U2, at the instant of current zero, of the component of the recovery voltage at power frequency (see Figure 7). f) The test circuit shall be earthed at one point only. This could be either the load star-point or the supply star-point. The position of this point shall be stated in the test report. NOTE The sequence of connection of R and X (see		

Clause	Requirement - Test	Result - Remark	Verdict
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	Figures 8a and 8b) should not be changed between the adjustment and the test. g) All parts of the equipment normally earthed in service, including the enclosure or the screens, shall be insulated from earth and connected as indicated in Figures 3, 4, 5 or 6. This connection shall comprise a fusible element F consisting of a copper wire 0,8 mm in diameter and at least 50 mm long, or an equivalent fusible element, for the detection of the fault current. The prospective fault current in the fusible-element circuit shall be 1 500 A 10 %, except as stated in notes 2 and 3. If necessary, a resistor limiting the current to that value shall be used. NOTE 1 A copper wire of 0,8 mm in diameter will melt at 1 500 A in approximately half a cycle at a frequency between 45 Hz to 67 Hz (or 0,01 s for d.c.). NOTE 2 In the case of a supply having an artificial neutral, a lower prospective fault current may be accepted, subject to the manufacturer's agreement, with a smaller diameter wire according to the following table.		

Diameter of copper wire mm	Prospective fault current in the fusible element circuit A
0,1	50
0,2	150
0,3	300
0,4	500
0,5	800
0,8	1 500

NOTE 3 For the value of the resistance of the fusible element see 8.3.2.1.

8.3.3.5.3	Characteristics of transient recovery voltage		
	To simulate the conditions in circuits including individual motor loads (inductive loads), the oscillatory frequency of the load circuit shall be adjusted to the value f 2 000 I 0,2 U 0,8 10 % c e where f is the oscillatory frequency, in kilohertz; Ic is the breaking current, in amperes; Ue is the rated operational voltage of the equipment in volts. The factor shall be adjusted to the value = 1,1 0,05 The value of reactance necessary for the test may be obtained by coupling several reactors in parallel on condition that the transient recovery voltage can still be considered as having only one oscillatory frequency. This is generally the case when the reactors have practically the same time-constant. The load terminals of the equipment shall be connected as closely as possible to the terminals of the adjusted load circuit. The adjustment should be made with these		P

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	connections in place. Depending on the position of the earthing, two procedures for the adjustment of the load circuit are given in Annex E.		
8.3.3.5.4	Vacant		
8.3.3.5.5	Test procedure for making and breaking capacities		
	The number of operations, the "on" and "off" times and the ambient conditions shall be stated in the relevant product standard.		P
8.3.3.5.6	Behaviour of the equipment during and after making and breaking capacity tests		
	The criteria for acceptance during and after the tests shall be stated in the relevant product standard.		P
8.3.3.6	Operational performance capability		
	Tests shall be made to verify compliance with the requirements of 7.2.4.2. The test circuit shall be in accordance with 8.3.3.5.2 and 8.3.3.5.3. Detailed test conditions shall be stated in the relevant product standard.		P
8.3.3.7	Durability		
	Durability tests are intended to verify the number of operating cycles that an equipment is likely to be capable of performing without repair or replacement of parts. The durability tests form the basis of a statistical life estimate, where the manufactured quantities permit this.		P
8.3.3.7.1	Mechanical durability		
	During the test, there shall be no voltage or current in the main circuit. The equipment may be lubricated before the test, if lubrication is prescribed in normal service. The control circuit shall be supplied at its rated voltage and, where applicable, at its rated frequency. Pneumatic and electro-pneumatic equipment shall be supplied with compressed air at the rated pressure. Manually operated equipment shall be operated as in normal service. The number of operating cycles shall be not less than that prescribed in the relevant product standard. For equipment fitted with opening relays or releases, the total number of opening operations to be performed by such relays or releases shall be stated in the relevant product standard. Evaluation of test results shall be defined in the relevant product standard.		P
8.3.3.7.2	Electrical durability		
	The test conditions are those of 8.3.3.7.1 except that the main circuit is energized according to the requirements of the relevant product standard. Evaluation of test results shall be defined in the relevant product standard.		P

Clause	Requirement - Test	Result - Remark	Verdict
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8.3.4	Performance under short-circuit conditions		
	This subclause specifies the test conditions for verification of the ratings and limiting values of 7.2.5. Additional requirements regarding test procedure, operating and test sequences, condition of equipment after the tests and tests of co-ordination of the equipment with short- circuit protective devices (SCPD) are given in the relevant product standard.		P
8.3.4.1	General conditions for short-circuit tests		
8.3.4.1.1	General requirements		
	The general requirements of 8.3.2.1 apply. The control mechanism shall be operated under the conditions specified in the relevant product standard. If the mechanism is electrically or pneumatically controlled, it shall be supplied at the minimum voltage or the minimum pressure as specified in the relevant product standard. It shall be verified that the equipment operates correctly on no-load when it is operated under the above conditions. Additional test conditions may be specified in the relevant product standard.		P
8.3.4.1.2	Test circuit		
	a) Figures 9, 10, 11 and 12 give the diagrams of the circuits to be used for the tests concerning – single-pole equipment on single-phase a.c. or d.c. (Figure 9); – two-pole equipment on single-phase a.c. or d.c. (Figure 10); – three-pole equipment on three-phase a.c. (Figure 11); – four-pole equipment on three-phase four-wire a.c. (Figure 12). A detailed diagram of the circuit used shall be given in the test report. NOTE For combinations with SCPDs, the relevant product standard should specify the relative arrangement between the SCPD and the equipment under test. b) The supply S feeds a circuit including resistors R1, reactors X and the equipment D under test. In all cases the supply shall have sufficient power to permit the verification of the characteristics given by the manufacturer. The resistance and reactance of the test circuit shall be adjustable to satisfy the specified test conditions. The reactors X shall be air-cored. They shall be connected in series with the resistors R1, and their value shall be obtained by series coupling of individual reactors; parallel connecting of reactors is permitted when these reactors have practically the same time-constant. !c) Since the transient recovery voltage characteristics of		P

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	test circuits including large air-cored reactors are not representative of usual service conditions, the air-cored reactor in each phase shall be shunted by a resistor taking approximately 0,6 % of the current through the reactor, unless otherwise agreed between manufacturer and user. In each test circuit (Figures 9, 10, 11 and 12), the resistors and reactors are inserted between the supply source S and the equipment D under test. The positions of the closing device A and the current sensing devices (I1, I2, I3) may be different. The closing device A may be located on low voltage side or alternatively on the primary side. In the latter case the testing station has to demonstrate that the voltage wave is not distorted by the residual flux of the short-circuit transformer. The connections of the equipment under test to the test circuit shall be stated in the relevant product standard." When tests are made with current less than the rated value, the additional impedances required should be inserted on the load side of the equipment between it and the short circuit; they may, however, be inserted on the line side, in which case this shall be stated in the test report. This need not apply to short-time withstand current tests (see 8.3.4.3). Unless a special agreement has been drawn up between manufacturer and user and details noted in the test report, the diagram of the test circuit shall be in accordance with the figures. There shall be one and only one point of the test circuit which is earthed; this may be the short-circuit link of the test circuit or the neutral point of the supply or any other convenient point, but the method of earthing shall be stated in the test report. d) All parts of the equipment normally earthed in service, including the enclosure or the screens, shall be insulated from earth and connected to a point as indicated in Figures 9, 10, 11 or 12. This connection shall comprise a fusible element F consisting of a copper wire 0,8 mm in diameter and at least 50 mm long, or of an equivalent fusible element for the detection of the fault current. The prospective fault current in the fusible element circuit shall be 1 500 A 10 %, except as stated in notes 2 and 3. If necessary, a resistor limiting the current to that value shall be used. NOTE 1 A copper wire of 0,8 mm in diameter will melt at 1 500 A in approximately half a cycle at a frequency between 45 Hz and 67 Hz (or 0,01 s for d.c.). NOTE 2 In the case of a supply having an artificial neutral, a lower prospective fault current may be accepted, subject to the manufacturer's agreement, with a smaller diameter wire according to the following table.		

Clause	Requirement - Test	Result - Remark	Verdict
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	Diameter of copper wire mm / **Prospective fault current in the fusible element circuit** A 0,1 — 50 0,2 — 150 0,3 — 300 0,4 — 500 0,5 — 800 0,8 — 1 500 NOTE 3 For the value of the resistance of the fusible element see 8.3.2.1.		
8.3.4.1.3	For a.c., the power-factor of each phase of the test circuit should be determined according to an established method which shall be stated in the test report. Two examples are given in Annex F. The power-factor of a polyphase circuit is considered as the mean value of the power-factors of each phase. The power-factor shall be in accordance with Table 16. The difference between the mean value and the maximum and minimum values of the power- factors in the different phases shall remain within 0,05.		P
8.3.4.1.4	Time-constant of the test circuitPower-factor of the test circuit		
	For d.c., the time-constant of the test circuit may be determined according to the method given in Annex F, Clause F.2. The time-constant shall be in accordance with Table 16.		P
8.3.4.1.5	Calibration of the test circuit		
	The calibration of the test circuit is carried out by placing temporary connections B of negligible impedance as close as reasonably possible to the terminals provided for connecting the equipment under test. For a.c., resistors R1 and reactors X are adjusted so as to obtain, at the applied voltage, a current equal to the rated short-circuit breaking capacity as well as the power-factor specified in 8.3.4.1.3. In order to determine the short-circuit making capacity of the device under test from the calibration oscillogram, it is necessary to calibrate the circuit so as to ensure that the prospective making current is achieved in one of the phases. NOTE The applied voltage is the open-circuit voltage necessary to produce the specified power-frequency recovery voltage (but see also NOTE 1 of 8.3.2.2.3). For d.c., resistors R1 and reactors X are adjusted so as to obtain, at the test voltage, a current the maximum value of which is equal to the rated short-circuit breaking capacity as well as the time-constant specified in 8.3.4.1.4. The test circuit is energized simultaneously in all poles and the current curve is recorded for a duration of at least 0,1 s. For d.c. switching devices parting their contacts before		P

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	the peak value of the calibration curve is reached, it is sufficient to make a calibration record with additional pure resistance in the circuit to demonstrate that the rate of rise of the current expressed in amperes/second is the same as for the test current and the time-constant specified (see Figure 15). This additional resistance shall be such that the peak value of the calibration current curve is at least equal to the peak value of the breaking current. This resistance shall be removed for the actual test (see 8.3.4.1.8, item b)).		
8.3.4.1.6	Test procedure		
	After calibration of the test circuit in accordance with 8.3.4.1.5, the temporary connections are replaced by the equipment under test, and its connecting cables, if any. Tests for the performance under short-circuit conditions shall be made according to the requirements of the relevant product standard.		P
8.3.4.1.7	Behaviour of the equipment during short-circuit making and breaking tests		
	There shall be neither arcing nor flashover between poles, or between poles and frame, and no melting of the fusible element F in the leakage detection circuit (see 8.3.4.1.2). Additional requirements may be stated in the relevant product standard.		P
8.3.4.1.8	Interpretation of records		
	a) Determination of the applied voltage and power-frequency recovery voltage The applied voltage and the power-frequency recovery voltage are determined from the record corresponding to the break test made with the apparatus under test, and evaluated as indicated in Figure 13 for a.c. and in Figure 14 for d.c. The voltage on the supply side shall be measured during the first complete cycle after arc extinction in all poles and after high-frequency phenomena have subsided (see Figure 13). If additional information is required regarding, for example, the voltage across individual poles, arcing time, arcing energy, switching overvoltage, etc., this may be obtained by means of additional sensing devices across each pole, in which case the resistance of each of these measuring circuits shall be not less than 100 ohms per volts of the r.m.s. value of voltage across individual poles; this value shall be stated in the test report. b) Determination of the prospective breaking current This determination is made by comparing the current curves, recorded during the calibration of the circuit, with those recorded during the break test of the equipment (see Figure 13). For a.c., the a.c. component of the prospective breaking current is taken as being equal to the r.m.s. value of		P

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	the a.c. component of the calibration current at the instant which corresponds to the separation of the arcing contacts (value corresponding to A2 2 2 of Figure 13, item a)). The prospective breaking current shall be the average of the prospective currents in all phases with the tolerance according to Table 8; the prospective current in each phase shall be within 10 % of the rated value. NOTE With the agreement of the manufacturer, the current in each phase may be within 10 % of the average value. For d.c., the value of the prospective breaking current is taken as being equal to the maximum value A2 as determined from the calibration curve for equipment breaking before the current has reached its maximum value, and to the value A for equipment breaking after the current has passed its maximum value (see Figure 14, items a) and b)). For d.c. equipment tested according to the requirements of 8.3.4.1.5, when the calibration of the test circuit has been made at a current I1 lower than the rated breaking capacity, the test is considered void if the actual breaking current I2 is higher than I1, and it shall be carried out again after a calibration at a current I3 of a higher value than I2 (see Figure 15). The prospective breaking current A2 = U R shall be determined by calculating the resistance R of the test circuit from the resistors R1 of the corresponding calibration circuits. The time-constant of the test circuit is given by T A2 di / dt The tolerances shall be in accordance with Table 8. c) Determination of the prospective peak making current The prospective peak making current is determined from the calibration record and its value shall be taken as being that corresponding to A1 of Figure 13, item a) for a.c. and to A2 of Figure 14 for d.c. In the case of a three-phase test it shall be taken as the highest of the three A1 values obtained from the record. NOTE For tests on single-pole equipment, the prospective peak making current determined from the calibration record may differ from the value of the actual making current corresponding to the test, depending on the instant of making.		
8.3.4.1.9	Condition of the equipment after the tests		
	After the tests, the equipment shall comply with the requirements of the relevant product standard.		P
8.3.4.2	Short-circuit making and breaking capacities		
	The test procedure for verification of the rated short-circuit making and breaking capacities of the equipment shall be given in the relevant product standard.		P

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8.3.4.3	Verification of the ability to carry the rated short-time withstand current		
	The test shall be made with the equipment in the closed position, at a prospective current equal to the rated short-time withstand current and the corresponding operational voltage under the general conditions of 8.3.4.1. In the case of the testing station having difficulty in making this test at the operational voltage, it may be made at any convenient lower voltage, the actual test current being, in this case, equal to the rated short-time withstand current Icw. This shall be stated in the test report. If, however, momentary contact separation occurs during the test, the test shall be repeated at the rated operational voltage. For this test, over-current releases, if any, likely to operate during the test, shall be rendered inoperative. a) For a.c. The tests shall be made at the rated frequency of the equipment with a tolerance of 25 %, and at the power-factor appropriate to the rated short-time withstand current in accordance with Table 16. The value of the current during the calibration is the average of the r.m.s. values of the a.c. components in all phases (see 4.3.6.1). The average value shall be equal to the rated value within the tolerances specified in Table 8. In each phase the current shall be within ±5 % of the rated value. When making the test at the rated operational voltage, the calibration current is the prospective current. When making the test at any lower voltage, the calibration current is the actual test current. The current shall be applied for the specified time during which the r.m.s. value of its a.c. component shall remain constant. NOTE With the agreement of the manufacturer, the current in each phase may be within ±10 % of the average value in case of testing station difficulties. The highest peak value of the current during its first cycle shall be not less than n times the rated short-time withstand current, the value of n being that corresponding to this value of current according to Table 16. When, however, the characteristics of the testing station are such that the above requirements cannot be obtained, the following alternatives are permitted provided that where ttest is the duration of the test; tst is the short time; ttest 0 2		P

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	test dt I 2 t st itest is the calibration current if the a.c. component is not constant or Icw; I is the actual calibration current assumed to have a constant a.c. component. If the decrement of the short-circuit current of the testing station is such that the rated short-time withstand current cannot be obtained for the rated time without applying initially an excessively high current, the r.m.s. value of the current may be permitted to fall during the test below the specified value, the duration being increased appropriately, provided that the value of the highest peak current is not less than that specified. If, in order to obtain the required peak value, the r.m.s. value of the current has to be increased above the specified current, the duration of the test shall be reduced accordingly. b) For d.c. The current shall be applied for the specified time and its mean value determined from the record shall be at least equal to the specified value. When the characteristics of the testing station are such that the above requirements cannot be obtained for the rated time without applying initially an excessively high current, the value of the current may be permitted to fall during the test below the specified value, the duration being increased appropriately, provided that the maximum value of the current is not less than that specified. If the testing station is unable to make these tests on d.c., they may, if agreed between manufacturer and user, be made on a.c., provided suitable precautions are taken: for instance, the peak value of current shall not exceed the permissible current. c) Behaviour of the equipment during and after the test Behaviour of the equipment during the test shall be defined in the relevant product standard. After the test, it shall be possible to operate the equipment by its normal operating means.		
8.3.4.4	Co-ordination with short-circuit protective devices and rated conditional short-circuit current		
	Test conditions and procedures, where applicable, shall be stated in the relevant product standard.		P
8.4	Tests for EMC		
	Emission and immunity tests are type tests and shall be carried out under representative conditions, both operational and environmental, using the manufacturer's instructions for installation. The tests shall be carried out in accordance with the reference EMC standard; however, the product standard shall specify any particular test condition (e.g. use of an enclosure) and additional measures		P

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	necessary to verify the performance criteria of the product (e.g. application of dwell times).		
8.4.1	Immunity		
8.4.1.1	Equipment not incorporating electronic circuits		
	No tests are necessary. See 7.3.2.1.		P
8.4.1.2	Equipment incorporating electronic circuits		
8.4.1.2.1	General		
	Equipment utilizing circuits in which all components are passive (see 7.3.2.2) are not required to be tested. Performance criteria shall be given in the product standard based on the acceptance criteria given in Table 24.		P
8.4.1.2.2	Electrostatic discharges		
	The test shall be performed according to IEC 61000-4-2 with the values given in Table 23 except where a different test level is given and justified in the product standard and shall be repeated 10 times at each measuring point, with a minimum time interval of 1 s between pulses. The test set-up shall be in accordance with Figure 18.		P
8.4.1.2.3	Radiated radio-frequency electromagnetic fields		
	The test shall be performed according to IEC 61000-4-3 with the values given in Table 23 except where a different test level is given and justified in the product standard. The test set-up shall be in accordance with Figure 19. The test is performed in two steps: a first step (step 1) where the EUT is tested for resistance to unwanted operation on the whole range of frequencies, and a second step (step 2) where the EUT is tested for correct operation at discrete frequencies. For step 1, the frequency shall be swept over the ranges of 80 MHz to 1 000 MHz and 1 400 MHz to 2 000 MHz in accordance with Clause 8 of IEC 61000-4-3. The dwell time of the amplitude modulated carrier for each frequency shall be between 500 ms and 1 000 ms unless otherwise stated in the product standard, and the step size shall be 1 % of the previous frequency. The actual dwell time shall be stated in the test report. For step 2, to verify the functional characteristics at discrete frequencies, the test shall be performed in accordance with the relevant product standard.		P
8.4.1.2.4	Electrical fast transients/bursts (EFT/B)		
	The test shall be performed according to IEC 61000-4-4 with the values given in Table 23 with a repetition rate of 5 kHz, except where a different test level and/or repetition rate is given and justified in the product standard. The test set-up shall be in accordance with Figure 20 for all ports except signal ports. For the tests on signal ports, the connecting leads shall be placed in a capacitive coupling clamp, with a total		P

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	cable length between the EFT generator and the capacitive coupling clamp of maximum 1 m.		
8.4.1.2.5	Surges		
	The test shall be performed according to IEC 61000-4-5 with the values given in Table 23, taking into account the footnote d of Tables 2 and 3 of IEC 61000-6-2. Pulses with both positive and negative polarity shall be applied, the preferred phase angles being 0°, 90° and 270°. A series of five pulses is applied for each polarity and each phase angle, the interval between two pulses being approximately 1 min. Where three-phase equipment employs an identical circuit configuration for each phase then tests are required on only one phase.		P
8.4.1.2.6	Conducted disturbances induced by radio-frequency fields		
	The test shall be performed according to IEC 61000-4-6 with the values given in Table 23. The tests shall be carried out with the EUT in free air. The disturbances shall be injected, on power lines, by means of a coupling-decoupling network M1, M2 or M3 as applicable. On signal lines, disturbances shall be injected by means of coupling-decoupling network. If not feasible, an E.M. clamp may be used. The particular test set-up shall be in accordance with Figure 21 or Figure 22 and detailed in the test report. The test is performed in two steps: a first step (step 1) where the EUT is tested for resistance to unwanted operation on the whole range of frequencies, and a second step (step 2) where the EUT is tested for correct operation at discrete frequencies. For step 1, the frequency shall be swept over the range of 150 kHz to 80 MHz in accordance with Clause 8 of IEC 61000-4-6. The dwell time of the amplitude modulated carrier for each frequency shall be between 500 ms and 1 000 ms unless otherwise stated in the product standard and the step size shall be 1 % of the previous frequency. The actual dwell time shall be stated in the test report. For step 2, to verify the functional characteristics at discrete frequencies, the test shall be performed in accordance with the relevant product standard.		P
8.4.1.2.7	Power frequency magnetic fields		
	This test is applicable only to equipment containing devices susceptible to power frequency magnetic fields as defined by the relevant product standard. The test method shall be in accordance with IEC 61000-4-8 and the test shall be performed with the EUT in free air unless it is only used in a dedicated enclosure. The test levels are given in Table 23. The field shall be applied to the EUT in the three perpendicular axes (see		P

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	Figure 23).		
8.4.1.2.8	Voltage dips and interruptions		
	This test is applicable only to equipment susceptible to unwanted operation in case of voltage dips and interruptions as defined by the relevant product standard. The test shall be performed in accordance with IEC 61000-4-11. The EUT shall be connected to the test generator with the shortest power supply cable as specified by the EUT manufacturer. If no cable length is specified, it shall be the shortest possible length suitable to the application of the EUT. The test levels are given in Table 23, the given percentage means percentage of the rated operational voltage.		P
8.4.2	Emission		
8.4.2.1	Equipment not incorporating electronic circuits		
	No tests are necessary. See 7.3.3.1.		P
8.4.2.2	Equipment incorporating electronic circuits		
	The product standard shall specify the details of the test methods. See 7.3.3.2.		P

Table 1 – Standard cross-sections of round copper conductors and approximate relationship between mm2 and AWG/kcmil sizes

(see 7.1.8.2)

Rated cross-section mm^2	AWG/kcmil size	Equivalent metric area mm^2
0,2	24	0,205
0,34	22	0,324
0,5	20	0,519
0,75	18	0,82
1	–	–
1,5	16	1,3
2,5	14	2,1
4	12	3,3
6	10	5,3
10	8	8,4
16	6	13,3
25	4	21,2
35	2	33,6
–	1	42,4
50	0	53,5
70	00	67,4
95	000	85,0
–	0000	107,2
120	250 kcmil	127
150	300 kcmil	152
185	350 kcmil	177
–	400 kcmil	203
240	500 kcmil	253

Clause	Requirement - Test	Result - Remark	Verdict

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300	600 kcmil	304
NOTE The dash, when it appears, counts as a size when considering connecting capacity (see 7.1.8.2).		

Table 2 – Temperature-rise limits of terminals

(see 7.2.2.1 and 8.3.3.3.4)

Terminal material	Temperature-rise limits [a, c] K
Bare copper	60
Bare brass	65
Tin plated copper or brass	65
Silver plated or nickel plated copper or brass	70
Other metals	[b]

[a] The use in service of connected conductors significantly smaller than those listed in Tables 9 and 10 could result in higher terminals and internal part temperatures and such conductors should not be used without the manufacturer's consent since higher temperatures could lead to equipment failure.

[b] Temperature-rise limits to be based on service experience or life tests but not to exceed 65 K.

[c] Different values may be prescribed by product standards for different test conditions and for devices of small dimensions, but not exceeding by more than 10 K the values of this table.

Table 3 – Temperature-rise limits of accessible parts

(see 7.2.2.2 and 8.3.3.3.4)

Accessible parts	Temperature-rise limits [a] K
Manual operating means:	
Metallic	15
Non-metallic	25
Parts intended to be touched but not hand-held:	
Metallic	30
Non-metallic	40
Parts which need not be touched during normal operation [b]:	
Exteriors of enclosures adjacent to cable entries:	
Metallic	40
Non-metallic	50
Exterior of enclosures for resistors	200[b]
Air issuing from ventilation openings of enclosures for resistors	200[b]

[a] Different values may be prescribed by product standards for different test conditions and for devices of small dimensions but not exceeding by more than 10 K the values of this table.

[b] The equipment shall be protected against contact with combustible materials or accidental contact with personnel. The limit of 200 K may be exceeded if so stated by the manufacturer. Guarding and location to prevent danger is the responsibility of the installer. The manufacturer shall provide appropriate information, in accordance with 5.3.

Table 4 – Tightening torques for the verification of the mechanical strength of screw-type terminals

(see 8.3.2.1, 8.2.6 and 8.2.6.2)

Diameter of thread mm			Tightening torque N·m		
Metric standard values	Range of diameter		I	II	III
1,6	≤1,6		0,05	0,1	0,1
2,0	>1,6	up to and including 2,0	0,1	0,2	0,2
2,5	>2,0	up to and including 2,8	0,2	0,4	0,4
3,0	>2,8	up to and including 3,0	0,25	0,5	0,5
–	>3,0	up to and including 3,2	0,3	0,6	0,6
3,5	>3,2	up to and including 3,6	0,4	0,8	0,8
4,0	>3,6	up to and including 4,1	0,7	1,2	1,2

Clause	Requirement - Test	Result - Remark	Verdict

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4,5	>4,1 up to and including 4,7	0,8	1,8	1,8
5	>4,7 up to and including 5,3	0,8	2,0	2,0
6	>5,3 up to and including 6,0	1,2	2,5	3,0
8	>6,0 up to and including 8,0	2,5	3,5	6,0
10	>8,0 up to and including 10,0	–	4,0	10,0
12	>10 up to and including 12	–	–	14,0
14	>12 up to and including 15	–	–	19,0
16	>15 up to and including 20	–	–	25,0
20	>20 up to and including 24	–	–	36,0
24	>24	–	–	50,0

Column I Applies to screws without heads which, when tightened, do not protrude from the hole, and to other screws which cannot be tightened by means of a screwdriver with a blade wider than the root diameter of the screw.

Column II Applies to nuts and screws which are tightened by means of a screwdriver.

Column III Applies to nuts and screws which can be tightened by means other than a screwdriver.

Table 5 – Test values for flexion and pull-out tests for round copper conductors

(see 8.2.4.4.1)

Conductor cross-section		Diameter of bushing hole [a, b]	Height *H* [a]	Mass	Pulling force
mm^2	AWG/kcmil	mm	mm	kg	N
0,2	24	6,5	260	0,2	10
0,34	22	6,5	260	0,2	15
0,5	20	6,5	260	0,3	20
0,75	18	6,5	260	0,4	30
1,0	–	6,5	260	0,4	35
1,5	16	6,5	260	0,4	40
2,5	14	9,5	280	0,7	50
4,0	12	9,5	280	0,9	60
6,0	10	9,5	280	1,4	80
10	8	9,5	280	2,0	90
16	6	13,0	300	2,9	100
25	4	13,0	300	4,5	135
–	3	14,5	320	5,9	156
35	2	14,5	320	6,8	190
–	1	15,9	343	8,6	236
50	0	15,9	343	9,5	236
70	00	19,1	368	10,4	285
95	000	19,1	368	14	351
–	0000	19,1	368	14	427
120	250 kcmil	22,2	406	14	427
150	300 kcmil	22,2	406	15	427
185	350 kcmil	25,4	432	16,8	503
–	400 kcmil	25,4	432	16,8	503
240	500 kcmil	28,6	464	20	578
300	600 kcmil	28,6	464	22,7	578

[a] Tolerances: for height *H* ± 15 mm, for diameter of the bushing hole ± 2 mm.

[b] If the bushing hole diameter is not large enough to accommodate the conductor without binding, a bushing having the next larger hole size may be used.

Table 6 – Test values for pull-out test for flat copper conductors

(see 8.2.4.4.2)

Clause	Requirement - Test	Result - Remark	Verdict

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Maximum width of flat conductors mm	Pulling force N
12	100
14	120
16	160
20	180
25	220
30	280

Table 7 – Maximum conductor cross-sections and corresponding gauges (see 8.2.4.5.1)

Conductor cross-section		Gauge (see Figure 2)					
Flexible conductors mm²	Rigid conductors (solid or stranded) mm²	Form A Marking	Form A Diameter a mm	Form A Width b mm	Form B Marking	Form B Diameter a mm	Permissible deviation for a and b mm
1,5	1,5	A1	2,4	1,5	B1	1,9	
2,5	2,5	A2	2,8	2,0	B2	2,4	0 −0,05
2,5	4	A3	2,8	2,4	B3	2,7	
4	6	A4	3,6	3,1	B4	3,5	
6	10	A5	4,3	4,0	B5	4,4	0 −0,06
10	16	A6	5,4	5,1	B6	5,3	
16	25	A7	7,1	6,3	B7	6,9	
25	35	A8	8,3	7,8	B8	8,2	0 −0,07
35	50	A9	10,2	9,2	B9	10,0	
50	70	A10	12,3	11,0	B10	12,0	
70	95	A11	14,2	13,1	B11	14,0	0 −0,08
95	120	A12	16,2	15,1	B12	16,0	
120	150	A13	18,2	17,0	B13	18,0	
150	185	A14	20,2	19,0	B14	20,0	
185	240	A15	22,2	21,0	B15	22,0	
240	300	A16	26,5	24,0	B16	26,0	0 −0,09

NOTE For conductor cross-sections of differently shaped solid or stranded standard conductors other than those given in this table, an unprepared conductor of appropriate cross-section may be used as the gauge, the force of insertion being not greater than 5 N.

Table 7a – Relationship between conductor cross-section and diameter

Conductor cross-section	Theoretical diameter of the largest conductor					
	Metric			AWG/kcmil		
	Rigid		Flexible	Rigid b	b Class B	Flexible c Classes I.K.M.

Clause	Requirement - Test	Result - Remark	Verdict

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mm²	Solid mm	Stranded mm	mm	Gauge	Solid mm	Stranded mm	Stranded mm
0,2	0,51	0,53	0,61	24	0,54	0,61	0,64
0,34	0,63	0,66	0,8	22	0,68	0,71	0,80
0,5	0,9	1,1	1,1	20	0,85	0,97	1,02
0,75	1,0	1,2	1,3	18	1,07	1,23	1,28
1,0	1,2	1,4	1,5	–	–	–	–
1,5	1,5	1,7	1,8	16	1,35	1,55	1,60
2,5	1,9	2,2	2,3 [a]	14	1,71	1,95	2,08
4,0	2,4	2,7	2,9 [a]	12	2,15	2,45	2,70
6,0	2,9	3,3	3,9 [a]	10	2,72	3,09	3,36
10,0	3,7	4,2	5,1	8	3,43	3,89	4,32
16,0	4,6	5,3	6,3	6	4,32	4,91	5,73
25,0	–	6,6	7,8	4	5,45	6,18	7,26
35,0	–	7,9	9,2	2	6,87	7,78	9,02
50		9,1	11,0 [a]	0		9,64	12,08
70		11,0	13,1 [a]	00		11,17	13,54
95		12,9	15,1 [a]	000		12,54	15,33
–		–	–	0000		14,08	17,22
120		14,5	17,0 [a]	250		15,34	19,01
150		16,2	19,0 [a]	300		16,80	20,48
185		18,0	21,0 [a]	350		18,16	22,05
–		–	–	400		19,42	24,05
240		20,6	24,0 [a]	500		21,68	26,57
300		23,1	27,0 [a]	600		23,82	30,03

NOTE Diameters of the largest rigid and flexible conductors are based on Table 1 and Table 3 of IEC 60228A and on IEC 60344 and, for AWG conductors, on ASTM B172-71 [1], ICEA Publication S-19-81 [2], ICEA Publication S-66-524 [3] and ICEA Publication S-66-516 [4].

Figures in square brackets refer to the bibliography.

[a] Dimensions for class 5 flexible conductors only, according to IEC 60228A.

[b] Nominal diameter +5 %.

[c] Largest diameter for any of the three classes I, K, M +5 %.

Table 8 – Tolerances on test quantities

(see 8.3.4.3, item a))

All tests	Tests under no-load, normal load and overload conditions	Tests under short-circuit conditions
– Current $^{+5}_{0}$ %	– Power factor ± 0,05	– Power factor $^{0}_{-0,05}$
– Voltage $^{+5}_{0}$ % (including power frequency recovery voltage)	– Time-constant $^{+15}_{0}$ %	– Time-constant $^{+25}_{0}$ %
	– Frequency ±5 %	– Frequency ±5 %

NOTE 1 Where maximum and/or minimum operating limits are stated in the product standard, the above tolerances do not apply.

NOTE 2 By agreement between manufacturer and user, tests made at 50 Hz may be accepted for operation at 60 Hz and vice versa.

Table 9 – Test copper conductors for test currents up to 400 A inclusive

(see 8.3.3.3.4)

Range of test current [a]	Conductor size [b, c, d]

Clause	Requirement - Test	Result - Remark	Verdict

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A		mm^2	AWG/kcmil
0	8	1,0	18
8	12	1,5	16
12	15	2,5	14
15	20	2,5	12
20	25	4,0	10
25	32	6,0	10
32	50	10	8
50	65	16	6
65	85	25	4
85	100	35	3
100	115	35	2
115	130	50	1
130	150	50	0
150	175	70	00
175	200	95	000
200	225	95	0000
225	250	120	250 kcmil
250	275	150	300 kcmil
275	300	185	350 kcmil
300	350	185	400 kcmil
350	400	240	500 kcmil

[a] The value of test current shall be greater than the first value in the first column and less than or equal to the second value in that column.

[b] For convenience of testing and with the manufacturer's consent, smaller conductors than those given for a stated test current may be used.

[c] The tables give alternative sizes for conductors in the metric and AWG/kcmil system and for bars in millimetres and inches. Comparison between AWG/ kcmil and metric sizes is given in Table 1.

[d] Either of the two conductors specified for a given test current range may be used.

Table 10 – Test copper conductors for test currents above 400 A and up to 800 A inclusive (see 8.3.3.3.4)

Range of test current [a] A		**Conductors [b, c, d]**			
		Metric		**kcmil**	
		Number	**Size** mm^2	**Number**	**Size** kcmil
400	500	2	150	2	250
500	630	2	185	2	350
630	800	2	240	3	300

[a] The value of test current shall be greater than the first value in the first column and less than or equal to the second value in that column.

[b] For convenience of testing and with the manufacturer's consent, smaller conductors than those given for a stated test current may be used.

[c] The tables give alternative sizes for conductors in the metric and AWG/kcmil system and for bars in millimetres and inches. Comparison between AWG/ kcmil and metric sizes is given in Table 1.

[d] Either of the two conductors specified for a given test current range may be used.

Table 11 – Test copper bars for test currents above 400 A and up to 3 150 A inclusive (see 8.3.3.3.4)

Range of test current [a] A		**Copper bars [b, c, d, e, f]**		
		Number	**Dimensions** mm	**Dimensions** Inches
400	500	2	30 × 5	1 × 0,250

Clause	Requirement - Test	Result - Remark	Verdict

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500	630	2	40 × 5	1,25 × 0,250
630	800	2	50 × 5	1,5 × 0,250
800	1 000	2	60 × 5	2 × 0,250
1 000	1 250	2	80 × 5	2,5 × 0,250
1 250	1 600	2	100 × 5	3 × 0,250
1 600	2 000	3	100 × 5	3 × 0,250
2 000	2 500	4	100 × 5	3 × 0,250
2 500	3 150	3	100 × 10	6 × 0,250

[a] The value of test current shall be greater than the first value in the first column and less than or equal to the second value in that column.

[b] For convenience of testing and with the manufacturer's consent, smaller conductors than those given for a stated test current may be used.

[c] The tables give alternative sizes for conductors in the metric and AWG/kcmil system and for bars in millimetres and inches. Comparison between AWG/kcmil and metric sizes is given in Table 1.

[d] Either of the two conductors specified for a given test current range may be used.

[e] Bars are assumed to be arranged with their long faces vertical. Arrangements with long faces horizontal may be used if specified by the manufacturer.

F Where four bars are used they shall be in two sets of two bars with not more than 100 mm between pair centres.

Table 12 – Impulse withstand test voltages

Rated impulse withstand voltage U_{imp} kV	**Test voltages and corresponding altitudes** $U_{1,2/50}$ kV				
	Sea level	**200 m**	**500 m**	**1 000 m**	**2 000 m**
0,33	0,35	0,35	0,35	0,34	0,33
0,5	0,55	0,54	0,53	0,52	0,5
0,8	0,91	0,9	0,9	0,85	0,8
1,5	1,75	1,7	1,7	1,6	1,5
2,5	2,95	2,8	2,8	2,7	2,5
4,0	4,8	4,8	4,7	4,4	4,0
6,0	7,3	7,2	7,0	6,7	6,0
8,0	9,8	9,6	9,3	9,0	8,0
12	14,8	14,5	14	13,3	12

NOTE Table 12 uses the characteristics of a homogeneous field, case B (see 2.5.62).

Table 12A – Dielectric test voltage corresponding to the rated insulation voltage

Rated insulation voltage U_i V	**AC test voltage (r.m.s.)** V	**DC test voltage [b, c]** V
$U_i \leq 60$	1 000	1 415
$60 < U_i \leq 300$	1 500	2 120
$300 < U_i \leq 690$	1 890	2 670
$690 < U_i \leq 800$	2 000	2 830
$800 < U_i \leq 1\,000$	2 200	3 110
$1\,000 < U_i \leq 1\,500$ [a]	–	3 820

[a] For d.c. only.

[b] Test voltages based on 4.1.2.3.1, third paragraph of IEC 60664-1.

[c] A direct current test voltage may be used only if an alternating test voltage cannot be applied. See also 3) b) ii) of 8.3.3.4.1.

Table 13 – Minimum clearances in air

Clause	Requirement - Test	Result - Remark	Verdict

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Rated impulse withstand voltage U_{imp} kV	Minimum clearances mm							
	Case A Inhomogeneous field conditions (see 2.5.63)				Case B Homogeneous field ideal conditions (see 2.5.62)			
	Pollution degree				Pollution degree			
	1	2	3	4	1	2	3	4
0,33	0,01				0,01			
0,5	0,04	0,2			0,04	0,2		
0,8	0,1		0,8		0,1		0,8	1,6
1,5	0,5	0,5		1,6	0,3	0,3		
2,5	1,5	1,5	1,5		0,6	0,6		
4,0	3	3	3	3	1,2	1,2	1,2	
6,0	5,5	5,5	5,5	5,5	2	2	2	2
8,0	8	8	8	8	3	3	3	3
12	14	14	14	14	4,5	4,5	4,5	4,5

NOTE The values of minimum clearances in air are based on 1,2/50 µs impulse voltage, for barometric pressure of 80 kPa, equivalent to normal atmospheric pressure at 2 000 m above sea level.

Table 14 – Test voltages across the open contacts of equipment suitable for isolation

Rated impulse withstand voltage U_{imp} kV	Test voltages and corresponding altitudes $U_{1,2/50}$ kV				
	Sea level	200 m	500 m	1 000 m	2 000 m
0,33	1,8	1,7	1,7	1,6	1,5
0,5	1,8	1,7	1,7	1,6	1,5
0,8	1,8	1,7	1,7	1,6	1,5
1,5	2,3	2,3	2,2	2,2	2
2,5	3,5	3,5	3,4	3,2	3
4,0	6,2	6,0	5,8	5,6	5
6,0	9,8	9,6	9,3	9,0	8
8,0	12,3	12,1	11,7	11,1	10
12	18,5	18,1	17,5	16,7	15

!Table 15 – Minimum creepage distances

Rated insulation voltage of equipment or working voltage a.c. r.m.s. or d.c. [b, c]	Minimum creepage distances for equipment subject to long term stress													
	Printed wiring material													
	Pollution degree													
	1	2	1	2			3				4			
	Material groups													
	All	All except IIIb	All	I	II	III	I	II	IIIa	IIIb	I	II	IIIa	IIIb
V	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
10	0,025	0,04	0,08	0,4	0,4	0,4	1	1	1		1,6	1,6	1,6	
12,5	0,025	0,04	0,09	0,42	0,42	0,42	1,05	1,05	1,05		1,6	1,6	1,6	

Clause	Requirement - Test	Result - Remark	Verdict

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16	0,025	0,04	0,1	0,45	0,45	0,45	1,1	1,1	1,1	1,6	1,6	1,6	
20	0,025	0,04	0,11	0,48	0,48	0,48	1,2	1,2	1,2	1,6	1,6	1,6	
25	0,025	0,04	0,125	0,5	0,5	0,5	1,25	1,25	1,25	1,7	1,7	1,7	
32	0,025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3	1,8	1,8	1,8	
40	0,025	0,04	0,16	0,56	0,8	1,1	1,4	1,6	1,8	1,9	2,4	3	
50	0,025	0,04	0,18	0,6	0,85	1,2	1,5	1,7	1,9	2	2,5	3,2	
63	0,04	0,063	0,2	0,63	0,9	1,25	1,6	1,8	2	2,1	2,6	3,4	
80	0,063	0,1	0,22	0,67	0,95	1,3	1,7	1,9	2,1	2,2	2,8	3,6	
100	0,1	0,16	0,25	0,71	1	1,4	1,8	2	2,2	2,4	3	3,8	
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4	2,5	3,2	4	
160	0,25	0,4	0,32	0,8	1,1	1,6	2	2,2	2,5	3,2	4	5	
200	0,4	0,63	0,42	1	1,4	2	2,5	2,8	3,2	4	5	6,3	
250	0,56	1	0,56	1,25	1,8	2,5	3,2	3,6	4	5	6,3	8	
320	0,75	1,6	0,75	1,6	2,2	3,2	4	4,5	5	6,3	8	10	
400	1	2	1	2	2,8	4	5	5,6	6,3	8	10	12,5	
500	1,3	2,5	1,3	2,5	3,6	5	6,3	7,1	8	10	12,5	16	
630	1,8	3,2	1,8	3,2	4,5	6,3	8	9	10	12,5	16	20	a
800	2,4	4	2,4	4	5,6	8	10	11	12,5	16	20	25	
1 000	3,2	5	3,2	5	7,1	10	12,5	14	16	20	25	32	
1 250			4,2	6,3	9	12,5	16	18	20	25	32	40	
1 600			5,6	8	11	16	20	22	25	32	40	50	
2 000			7,5	10	14	20	25	28	32	40	50	63	
2 500			10	12,5	18	25	32	36	40	50	63	80	
3 200			12,5	16	22	32	40	45	50	63	80	100	
4 000			16	20	28	40	50	56	63	80	100	125	
5 000			20	25	36	50	63	71	80	100	125	160	
6 300			25	32	45	63	80	90	100	125	160	200	
8 000			32	40	56	80	100	110	125	160	200	250	
10 000			40	50	71	100	125	140	160	200	250	320	

a Values of creepage distances in this area have not been established. Material group IIIb is in general not recommended for application in pollution degree 3 above 630 V and in pollution degree 4.

b As an exception, for rated insulation voltages 127 V, 208 V, 415/440 V, 660/690 V and 830 V, creepage distances corresponding to the lower values 125 V, 200 V, 400 V, 630 V and 800 V respectively may be used.

c The values of creepage distances stated for 250 V can be used for 230 V (10 %) nominal voltage.

NOTE 1 It is appreciated that tracking or erosion will not occur on insulation subjected to working voltages of 32 V and below. However, the possibility of electrolytic corrosion has to be considered and for this reason minimum creepage distances have been specified.

NOTE 2 Voltage values are selected in accordance with the R_{10} series.

Table 16 – Values of power-factors and time-constants corresponding to test currents, and ratio n between peak and r.m.s. values of current

(see 8.3.4.3, item a))

Test current A	Power-factor	Time-constant ms	*n*

Clause	Requirement - Test	Result - Remark	Verdict
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$I \leq 1\,500$	0,95	5	1,41
$1\,500 < I \leq 3\,000$	0,9	5	1,42
$3\,000 < I \leq 4\,500$	0,8	5	1,47
$4\,500 < I \leq 6\,000$	0,7	5	1,53
$6\,000 < I \leq 10\,000$	0,5	5	1,7
$10\,000 < I \leq 20\,000$	0,3	10	2,0
$20\,000 < I \leq 50\,000$	0,25	15	2,1
$50\,000 < I$	0,2	15	2,2

Table 17 – Actuator test force
(see 8.2.5.2.1)

Type of actuator [a]	Test force [a]	Minimum test force N	Maximum test force N
Push-button (a)	3*F*	50	150
One-finger operated (b) Two-finger operated (c)	3*F*	50	150
	3*F*	100	200
One-hand operated (d) and (e) Two-hand operated (f) and (g)	3*F*	150	400
	3*F*	200	600

[a] *F* is the normal operating force in new condition. The test force shall be 3*F* with the stated minimum and maximum values and be applied as shown in Figure 16.

Table 18 – Vacant

Table 19 – Vacant

Table 20 – Test values for conduit pull-out test
(see 8.2.7.1)

Conduit designation according to IEC 60981	Conduit diameter Inside mm	Conduit diameter Outside mm	Pulling force N
12 H	12,5	17,1	900
16 H to 41 H	16,1 to 41,2	21,3 to 48,3	900
53 H to 155 H	52,9 to 154,8	60,3 to 168,3	900

Table 21 – Test values for conduit bending test
(see 8.2.7.2)

Conduit designation according to IEC 60981	Conduit diameter Inside mm	Conduit diameter Outside mm	Bending moment N·m
12 H	12,5	17,1	35 [a]
16 H to 41 H	16,1 to 41,2	21,3 to 48,3	70
53 H to 155 H	52,9 to 154,8	60,3 to 168,3	70

[a] This value is reduced to 17 Nm for enclosures which have only provision for an incoming conduit, but not for an outgoing conduit.

Table 22 – Test values for conduit torque test
(see 8.2.7.1 and 8.2.7.3)

Conduit designation according to IEC 60981	Conduit diameter Inside mm	Conduit diameter Outside mm	Torque N·m

Clause	Requirement - Test	Result - Remark	Verdict

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12 H	12,5	17, 1	90
16 H to 41 H	16,1 to 41,2	21,3 to 48,3	120
53 H to 155 H	52,9 to 154,8	60,3 to 168,3	180

!Table 23 – Tests for EMC – Immunity

(see 8.4.1.2)

Type of test	Test level required	
Electrostatic discharge immunity test IEC 61000-4-2	8 kV / air discharge or 4 kV / contact discharge	
Radiated radio-frequency electromagnetic field immunity test 80 MHz to 1 GHz IEC 61000-4-3	10 V/m	
Radiated radio-frequency electromagnetic field immunity test 1,4 GHz to 2 GHz IEC 61000-4-3	3 V/m	
Radiated radio-frequency electromagnetic field immunity test 2 GHz to 2,7 GHz IEC 61000-4-3	1 V/m	
Electrical fast transient/burst immunity test IEC 61000-4-4	2 kV/ 5 kHz on power ports 1 kV/ 5 kHz on signal ports	
1,2/50 s – 8/20 s surge immunity test [a] IEC 61000-4-5	2 kV (line to earth) 1 kV (line to line)	
Conducted radio-frequency immunity test (150 kHz to 80 MHz) IEC 61000-4-6	10 V	
Power frequency magnetic field immunity test [b] IEC 61000-4-8	30 A/m	
Voltage dips immunity test (50 Hz/ 60 Hz) IEC 61000-4-11 [e]	Class 2 [c, d, e] 0 % during 0,5 cycle and 1 cycle 70 % during 25 / 30 cycles	Class 3 [c, d, e] 0 % during 0,5 cycle and 1 cycle 40 % during 10/12 cycles 70 % during 25/30 cycles 80 % during 250/300 cycles
Short interruptions immunity test IEC 61000-4-11	Class 2 [c, d, e] 0 % during 250/300 cycles	Class 3 [c, d, e] 0 % during 250/300 cycles
Immunity to harmonics in the supply IEC 61000-4-13	No requirements [f]	
NOTE Performance criteria are given in the relevant product standard based on the acceptance criteria given in Table 24.		

[a] Regarding applicability see 7.2 and 8.2 of IEC 61000-4-5 (Not applicable for low voltage d.c. input/output ports (60 V), when the secondary circuits (isolated from the a.c. mains) are not subject to transient overvoltages).

[b] Applicable only to equipment containing devices susceptible to power frequency magnetic fields (see 8.4.1.2.7).

[c] The given percentage means percentage of the rated operating voltage, e.g. 0 % means 0 V.

[d] Class 2 applies to points of common coupling and in-plant points of common coupling in the industrial environment in general.

Class 3 applies to in-plant couplings in industrial environment only. This class should be considered when a major part of the load is fed through converters; welding machines are present; large motors are frequently started or loads vary rapidly.

The product standard shall state the applicable class.

[e] The value in front of the slash mark (/) is for 50 Hz and the value behind for 60 Hz tests.

[f] Requirements are under study for the future.

Table 24 – Acceptance criteria when EM disturbances are present

Clause	Requirement - Test	Result - Remark	Verdict

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Item	Acceptance criteria (performance criteria during tests)		
	A	B	C
Overall performance	No noticeable changes of the operating characteristic. Operating as intended	Temporary degradation or loss of performance which is self-recoverable	Temporary degradation or loss of performance which requires operator intervention or system reset [a]
Operation of power and control circuits	No unwanted operation	Temporary degradation or loss of performance which is self-recoverable [a]	Temporary degradation or loss of performance which requires operator intervention or system reset [a]
Operation of displays and control panels	No changes to visible display information. Only slight light intensity fluctuation of LEDs, or slight movement of characters	Temporary visible changes or loss of information. Undesired LED illumination	Shut down or permanent loss of display. Wrong information and/or unpermitted operating mode, which should be apparent or an indication should be provided. Not self-recoverable
Information processing and sensing functions	Undisturbed communication and data interchange to external devices	Temporarily disturbed communication, with possible error reports of the internal and external devices	Erroneous processing of information. Loss of data and/or information. Errors in communication. Not self-recoverable
[a] Specific requirements shall be detailed in the product standard.			

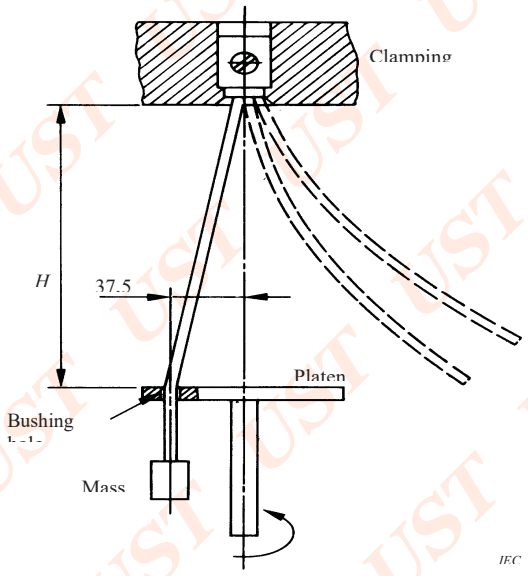

Figure 1 – Test equipment for flexion test
(see 8.2.4.3 and Table 5)

Dimensions in millimetres

Clause	Requirement - Test	Result - Remark	Verdict
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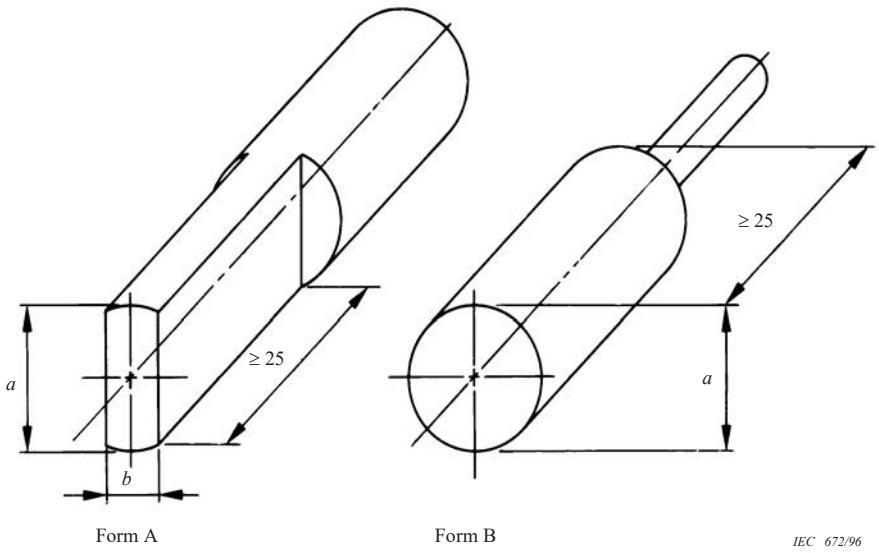

Figure 2 – Gauges of form A and form B
(see 8.2.4.5.2 and Table 7)

---------- End of this report ----------

EC DECLARATION OF CONFORMITY

COUNCIL DIRECTIVE 2014/35/EU ON Low Voltage Directive WE,

Zhejiang Dabo Electric Co., Ltd
No. 79, Longhui Road, Houxi Village, Beibaixiang Town, Leqing City, Wenzhou City, Zhejiang Province

THE PRODUCT DESCRIBED IS IN CONFORMITY WITH THE DIRECTIVE

2014/35/EU

PRODUCT TYPE: Transfer switch

PRODUCT MODEL: LW2R- 100II、YTQ2-63/2P、YTQ2-63/3P、 SF 219G, SF 419G

THE PRODUCT HAS BEEN ASSESSED BY THE APPLICATION OF THE FOLLOWING STANDARDS:

EN 60947-6-1:2005+A1:2014

ISSUE PLACE AND DATE

COMPANY STAMP AND SIGNATURE
OF AUTHORIZED PERSONNEL