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ASSOCIATION EUROPÉENNE DES CONSTRUCTEURS DE POMPES  
EUROPÄISCHE VEREINIGUNG DER PUMPENHERSTELLER



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## ***EUROPUMP* - Guideline**

# **Safety of Electrical, Submersible Motors**

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### 1 Foreword

This guideline is another one within a row of brochures published by EUROPUMP with the intention to give answers to questions coming up with use of pumps. It is the result of the work conducted by the Standards Commission of EUROPUMP. It was made to fill the gap between existing standards and to give a helping hand to users as well as to manufactures. It covers electrical safety of electrical submersible motors for use with pumps and mixers with a voltage lower than 250 V for single phase motors and lower than 650 V for other motors. It is reflecting on motors for industrial use only including sewage treatment plants, flood stations, irrigation and deep-well application.

The Standards Commission would like to express its particular gratitude to Frank Ennenbach who takes the chair and to all participants for their valuable contribution within this Working Group

For the EUROPUMP Standards Commission

Juergen Koether

(Commission Chairman)

Frank Ennenbach

(Chairman of the Working Group)

### 2 Introduction

It has been assumed in the drafting of this Europump Guideline that the execution of its provisions is entrusted to appropriately qualified and experienced personnel.

Moreover, when elaborating this guideline, the Standards Committee took into account as far as possible the requirements given in IEC 60335. However, special requirements or national rules, e.g. for wiring, may differ.

This standard recognises the internationally accepted level of protection against hazards such as electrical, mechanical, thermal, fire and radiation of electrical submersible motors when operated as in normal use taking into account the manufacturer's instructions; it also covers abnormal situations which can be expected in practice. Following this guideline should fulfil the requirements of the Directive 73/23/EC: "Low Voltage Directive". The Directive 98/37/EC: "Machinery Directive" is covered by EN 809, the Directive 89/336/EC: "Electromagnetic Compatibility" by EN 50081 and EN 61000.

A product which complies with the text of this standard will not necessarily be judged to comply with the safety principles of the standard if, when examined and tested, it is found to have other features which impair the level of safety covered by these requirements.

A product employing materials or having forms of construction differing from those detailed in the requirements of this standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the safety principles of the standard.

### 3 Scope

This standard deals with the electrical safety of electrical submersible motors for use with pumps and mixers, with a rated voltage of not more than 250 V for single-phase motors and 1000 V for other motors. This

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standard applies only to motors intended exclusively for AC-industrial use, such as sewage treatment plants, flood stations, irrigation and water deep well applications.

This standard does not apply to:

- motors for use with household appliances. Such devices are covered by IEC 60335.
- appliances intended to be used in locations where special conditions prevail, such as the presence of explosive atmosphere (dust, vapour or gas);

### NOTES

Attention is drawn to the fact that

- for appliances intended to be used in vehicles or on board ships or aircraft, additional requirements may be necessary;
- for appliances intended to be used in tropical countries, special requirements may be necessary;
- in many countries additional requirements are specified by the national health authorities, the national authorities responsible for the protection of labour, the national water supply authorities and similar authorities.

## 4 Definitions

For the purpose of this standard, the following definitions apply.

NOTE - Where the terms voltage and current are used they imply r.m.s. values, unless otherwise specified.

4.1 **rated voltage:** Voltage assigned to the appliance by the manufacturer.

NOTE - For three-phase supply it is the voltage between phases.

4.2 **rated voltage range:** Voltage range assigned to the appliance by the manufacturer, expressed by its lower and upper limits.

4.3 **working voltage:** Maximum voltage to which the part under consideration is subjected when the appliance is supplied at its rated voltage and operating under normal operation.

NOTE - When deducing the working voltage, the effect of transient voltages is ignored.

4.4 **rated power Input:** Power input assigned to the appliance by the manufacturer.

4.5 **rated current:** Current assigned to the appliance by the manufacturer.

NOTE - For motor-operated appliances, the current measured when the appliance is supplied at rated voltage and operated under normal operation;

4.6 **rated frequency:** Frequency assigned to the appliance by the manufacturer.

4.7 **rated frequency range:** Frequency range assigned to the appliance by the manufacturer, expressed by its lower and upper limits.

4.8 **normal operation:** see ISO 12223

4.9 **supply cable:** Flexible **cable**, for electrical supply purposes, which is **fixed** to the appliance.

4.10 **control cable:** Flexible **cable**, for connecting sensors and control devices, which is **fixed** to the appliance.

4.11 **basic Insulation:** Insulation applied to **live parts** to provide **basic** protection against electric shock.

NOTE - Basic insulation does not necessarily include insulation used exclusively for functional purposes.

4.12 **supplementary Insulation:** Independent insulation applied in addition to the basic Insulation, in order to provide protection against electric shock in the event of a failure of the basic Insulation.

4.13 **double Insulation:** Insulation system comprising both basic Insulation and supplementary insulation.

4.14 **reinforced insulation:** Single insulation applied to **live parts**, which provides a degree of protection against electric shock equivalent to **double insulation** under the conditions specified in this standard.

NOTE - It is not implied that the insulation is one homogeneous piece. The insulation may comprise several layers which cannot be tested singly as supplementary insulation or basic insulation.

4.15 **class I appliance:** Appliance in which protection against electric shock does not rely on **basic insulation** only but which includes an additional safety precaution in that conductive **accessible parts** are connected to the protective earthing conductor in the fixed wiring of the installation in such a way that conductive **accessible parts** cannot become live in the event of a failure of the **basic Insulation**.

NOTE - This provision includes a protective conductor in the **supply cable**.

4.16 **creepage distance:** Shortest path between two conductive parts or between a conductive part and the accessible surface of the appliance, measured along the surface of the insulating material.

4.17 **clearance:** Shortest distance between two conductive parts or between a conductive part and the accessible surface of the appliance, measured through air.

4.18 **extra-low voltage:** Voltage supplied from a source within the appliance which, when the appliance is supplied at **rated voltage** does not exceed 50 V between conductors and between conductors and earth.

4.19 **safety extra-low voltage:** Voltage not exceeding 42 V between conductors and between conductors and earth, the no-load voltage not exceeding 50 V.

When safety extra-low voltage is obtained from the supply mains, it is to be through a safety isolating transformer or a converter with separate windings, the insulation of which complies with double insulation or reinforced Insulation requirements.

NOTE - The voltage limits specified are based on the assumption that the safety isolating transformer is supplied at its rated voltage.

4.20 **safety Isolating transformer:** Transformer, the input winding of which is electrically separated from the output winding by an insulation at least equivalent to **double Insulation** or **reinforced** Insulation and which is intended to supply an appliance or circuit at **safety extra-low voltage**.

4.21 **portable appliance:** Either an appliance which is intended to be moved while in operation or an appliance, other than a **fixed appliance**.

4.22 **fixed appliance:** Appliance which is intended to be used while fastened to a support or otherwise secured in a specific situation.

4.23 **thermal cut-out:** Device which during abnormal operation limits the temperature of the controlled part by automatically opening the circuit or by reducing the current and constructed so that its setting cannot be altered by the user.

4.24 **self-resetting thermal cut-out:** **Thermal cut-out** which automatically restores the current after the relevant part of the appliance has **cooled down** sufficiently.

4.25 **non-self-resetting thermal cut-out:** **Thermal cut-out** which requires a manual operation for resetting or replacement of a part, in order to restore the current.

NOTE - Manual operation includes disconnection of the supply.

4.26 **protective device:** Device, the operation of which prevents a hazardous situation under abnormal operation conditions.

4.27 **all-pole disconnection:** For single-phase appliances disconnection of both supply conductors by a single initiating action or, for three-phase appliances disconnection of all supply conductors except the earthed (grounded) conductor, by a single initiating action.

NOTE - The protective earthing conductor is not considered to be a supply conductor.

4.28 **off position:** Stable position of a switching device in which the circuit controlled by the switch is disconnected from its supply.

NOTE - The off position does not imply an all-pole disconnection.

4.29 **accessible part:** Part or surface which can be touched by means of the test finger of figure 1, including any conductive part connected to accessible metal parts.

4.30 **live part:** Any conductor or conductive part intended to be **energised** in normal use, including a neutral conductor but, by convention, not a **PEN conductor**.

### NOTES

1. Parts, accessible or not, complying with 8.1.4 are not considered to be live parts.

2. A PEN conductor is a protective earthed neutral conductor combining the functions of both protective conductor and neutral conductor.

4.31 **user maintenance:** Any maintenance operation stated in the instructions for use or marked on the appliance which the user is intended to perform.

4.32 **electronic component:** Part in which conduction is achieved principally by electrons moving through a vacuum, gas or semiconductor.

4.33 **electronic circuit:** Circuit incorporating at least one electronic component.

4.34 **pump:** Combination of mechanical, hydraulic and electrical parts of an appliance for moving liquids.

4.35 **submersible pump:** Pump driven by a submersible motor.

4.36 **submersible motor:** motor which in its normal use is, or may become, completely or partly immersed. Motor windings may be dry, immersed in oil or other isolated liquid or immersed in the liquid to be pumped.

## 5 General conditions for the tests

5.1 Tests according to this standard are type tests. All tests are based on the range of application of the particular pump or mixer.

5.2 *Unless otherwise specified, the tests are made on a single appliance which shall withstand all the relevant tests. However the tests of clauses 22 to 26 and 28 may be made on separate samples.*

### NOTES

1 Additional samples may be required for example if the appliance can be supplied with different voltages. If the test of annex B has to be made, six samples of the motor are needed. The testing of components may require the submission of additional samples of these components.

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2 The cumulative stress resulting from successive tests on electronic circuits is to be avoided. It may be necessary to replace components or to use additional samples. The number of additional samples should be kept to a minimum by an evaluation of the relevant electronic circuits.

3 If an appliance has to be dismantled in order to carry out a test, care is to be taken to insure that it is reassembled as originally supplied. In case of doubt subsequent tests may be carried out on a separate sample.

5.3 *Unless otherwise specified, the tests are carried out in the order of the clauses. However, the test of 22.11 on the appliance at room temperature is made before the tests of clause 8.*

If it is evident from the construction of the appliance that a particular test is not applicable, the test is not made.

5.4 *The tests are carried out with the appliance or any movable part of it placed in the most unfavourable position which may occur in normal use.*

5.5 *Appliances provided with controls or switching devices are tested with these controls or devices adjusted to their most unfavourable setting, if the setting can be altered by the user.*

#### NOTES

1. If the adjusting means of the control is accessible without the aid of a tool, this subclause applies whether the setting can be altered by hand or with the aid of a tool. If the adjusting means is not accessible without the aid of a tool and if the setting is not intended to be altered by the user, this subclause does not apply.

2 Adequate sealing is regarded as preventing alteration of the setting by the user.

5.6 *The tests are carried out in general at an ambient temperature of 20 °C ± 5 °C (see also section 11).*

*If the motor is intended for use at an ambient temperature higher than 25°C, temperature rise is added to the intended ambient temperature.*

5.7 *Appliances for a.c. which are not marked with rated frequency or which are marked with a frequency range of 50 Hz to 60 Hz are tested with either 50 Hz or 60 Hz, whichever is the more unfavourable.*

NOTE - For testing of motors supplied by frequency inverters see EN 12483.

5.8 Appliances having more than one rated voltage are tested on the basis of the most unfavourable voltage.

5.9 Tests are carried out with clean water at 20°C ± 5°C,  $\rho = 1,0 \text{ g/cm}^3$

5.10 *For appliances marked with a rated voltage range the power input corresponds to the power input at the most unfavourable voltage within the rated voltage range.*

5.11 *The tests are made on the appliance as supplied. However, an appliance constructed as a single appliance but supplied in a number of units is tested after assembly in accordance with the instructions provided with the appliance.*

5.12 *Electrical submersible motors are tested with the appropriate flexible cable connected to the appliance. If more than one cable type may be used tests relevant to the cables are repeated with all types.*

5.13 *If appliances have parts operating at safety extra-low voltage (e.g. control and sensing circuits), such parts are checked for compliance with the appropriate requirements specified for class III construction.*

5.14 *When testing electronic circuits, the supply is to be free from perturbations from external sources that can influence the results of the tests.*

5.15 *Stationary motors having a three phase motor which does not incorporate a protective device are installed with an appropriate device in accordance with the instructions.*

## 6 Classification

6.1 Electrical submersible motors shall be of class I with respect to protection against electric shock.

NOTE - Swimming pool applications are not considered industrial use and therefore such pumps are not covered by this guideline but by IEC 60335.

*Compliance is checked by inspection and by the relevant tests.*

6.2 Electrical submersible motors shall be IP 68

*Compliance is checked by inspection and by the relevant tests.*

NOTE - The degrees of protection against harmful ingress of water are given in IEC 60529.

## 7 Marking and Instructions

7.1 Appliances shall be marked with the

- **rated voltage** or **rated voltage** range in volts;
- **rated frequency** in Hertz;
- **rated power** Output ( $P_2$ ) in watts or kilowatts or **rated current** in amperes;
- name, trade mark or identification mark of the manufacturer or responsible vendor;
- **model** or **type** reference;
- **IP 68**
- connection methode (e.g. Y/ $\Delta$ )
- the maximum operating depth in m
- the maximum ambient temperature if higher then 40 °C

*Compliance is checked by inspection.*

### NOTES

Additional markings are allowed provided they do not give rise to misunderstanding.

If components are marked separately, the marking of the appliance and that of the components is to be such that there can be no doubt with regard to the marking of the appliance itself.

7.2 Appliances having a range of rated values and which can be operated without adjustment throughout the range, shall be marked with the lower and upper limits of the range separated by a hyphen.

NOTE - Example: 380-415 V: The electrical submersible motors is suitable for any value within the marked range.

Appliances having different rated values and which have to be adjusted for use at a particular value by the user or installer, shall be marked with the different values separated by an oblique stroke.

NOTE - Example: 380/415 V: The appliance is only suitable for the marked values.

*Compliance is checked by inspection.*

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7.3 If the electrical submersible motor can be adjusted for different **rated voltages**, the voltage to which the appliance is adjusted shall be clearly discernible.

NOTE - This requirement is considered to be met if the rated voltage to which the appliance is to be adjusted can be determined from a wiring diagram fixed to the appliance. The wiring diagram may be on the inside of a cover which has to be removed to connect the supply conductors. It is not to be on a label loosely attached to the appliance.

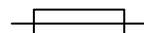
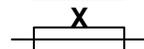
*Compliance is checked by inspection.*

7.4 For appliances marked with more than one **rated voltage** or with more than one **rated voltage range**, the **rated power** input for each of these voltages or ranges shall be marked. However, if the difference between the limits of a **rated voltage range** does not exceed 10 % of the mean value of the range, the marking for **rated power input** may be related to the mean value of the range.

The upper and lower limits **of the rated power input** shall be marked on the appliance so that the relation between input and voltage is clear.

*Compliance is checked by inspection.*

7.5 When symbols are used, they shall be as follows:

V	volt
A	amperes
Hz	hertz
W	watts
F	farads
l	litres
g	gramm
Pa	Pascal
bar	bars
h	hours
min	minutes
S	seconds
— — — or d.c	direct current
~ or a.c	alternating current
2~	two-phase alternating current
2N~	two-phase alternating current with neutral
3 ~	three-phase alternating current
3N~	three-phase alternating current with neutral
	rated current of the appropriate fuse-link in amperes
	time-lag miniature fuse-link where X is the symbol for the time / current characteristic as given in IEC 60127
	protective earth
IP68	IP number
	maximum operating depth.
.....m	
	Read instruction manual

The symbol for nature of supply shall be placed next to the marking for **rated voltage**.

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When other units are used the units and their symbols shall be those of the international standardised system.

*Compliance is checked by inspection and by measurement.*

### NOTES

- 1 Multiple or submultiple units are also allowed.
  - 2 Additional symbols are allowed provided they do not give rise to misunderstanding.
  - 3 Symbols specified in IEC 60417 may be used.
- 7.6 Appliances to be connected to more than two supply conductors and appliances for multiple supply shall have a connection diagram supplied with them, unless the correct mode of connection is obvious.

*Compliance is checked by inspection.*

### NOTES

- 1 The correct mode of connection is considered to be obvious if for three-phase appliances the terminals for the supply conductors are indicated by arrows pointing towards the terminals. The earthing conductor is not a supply conductor.
  - 2 Marking in words is an acceptable means of indicating the correct mode of connection.
  - 3 The connection diagram may be the wiring diagram referred to in 8.4.
- 7.7 Protective earthing terminals shall be indicated by the symbol .

These indications shall not be placed on screws, removable washers or other parts which can be removed when conductors are being connected.

*Compliance is checked by inspection.*

- 7.8 Instructions for use shall be provided with the appliance so that the appliance can be used safely.

*Compliance is checked by inspection.*

- 7.8.1 If it is necessary to take special precautions for installation or user maintenance, details of these shall be supplied.

*Compliance is checked by inspection*

- 7.8.2 The instructions for installation shall state that pollution of the liquid could occur due to leakage of lubricants, for submersible motors containing lubricants;

*Compliance is checked by inspection.*

- 7.9 The markings required by the standard shall be clearly legible and durable.

- 7.10 The markings specified above shall be on a main part of the appliance and shall be clearly visible.

*Compliance is checked by inspection.*

## 8 Protection against access to live parts

- 8.1 Appliances shall be constructed and enclosed so that there is adequate protection against accidental contact with live parts. Connection chambers shall be only accessible by aid of a tool.

*Compliance is checked by inspection*

## **9 Power Input and current**

9.1 The measuring tolerance of the power input of the electrical submersible motors at **rated voltage** and at normal operating temperature shall not deviate from the **rated power Input** by more than +10%.

NOTE - This specification is dealing with electrical safety only NOT with acceptance tests!

*Compliance is checked by measurement when the power input has stabilised (temperature rise  $\leq 2^{\circ}\text{C}$  per hour):*

- *all circuits which can operate simultaneously being in operation;*
- *the appliance being supplied at rated voltage;*
- *the appliance being operated under normal operation.*

*If the power input varies throughout the operating cycle, the power input is determined as the mean value of the power input occurring during a representative period.*

### NOTES

- 1 The test is made at both the upper and lower limits of the ranges for appliances marked with one or more rated voltage ranges, unless the marking of the rated power input is related to the mean value of the relevant voltage range, in which case the test is made at a voltage equal to the mean value of that range.
- 2 The permissible deviations apply for both limits of the range for appliances marked with a rated voltage range having limits differing by more than 10 % of the mean value of the range.
- 3 The negative deviation is not limited.

If an appliance is marked with **rated current**, the current at normal operating temperature shall not deviate **from rated current by** more than +20%.

*Compliance is checked by measurement when the current has stabilized:*

- *the appliance being supplied at rated voltage;*
- *the appliance being operated under normal operation.*

*If the current varies throughout the operating cycle, the current is determined as the mean value of the current occurring during a representative period.*

### NOTES

- 1 The test is made at both the upper and lower limits of the ranges for appliances marked with one or more rated voltage ranges, unless the marking of the rated current is related to the mean value of the relevant voltage range, in which case the tests are made at a voltage equal to the mean value of that range.
- 2 The permissible deviations apply for both limits of the range for appliances marked with a rated voltage range having limits differing by more than 10 % of the mean value of the range.
- 3 A negative deviation is not limited.

## **10 Heating**

10.1 Appliances and their surroundings shall not attain excessive temperatures in normal use.

*Compliance is checked by determining the temperature rise of the various parts under the conditions specified in 11.2 to 11.7 but if the temperature rise of the motor winding exceeds the value specified in table*

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3 or if there is doubt with regard to the classification of the insulation system employed in a motor, by the tests of annex B.

10.2 *Motors are positioned as normally operated. If there is a minimum operating depth specified it shall be installed submerged to the minimum allowed operating depth or if intermittent submergence is allowed then it shall be installed to run dry. Cooling jackets shall be connected as specified in the instruction manual.*

10.3 *Temperature rises are preferably determined by means of fine-wire thermocouples positioned so that they have minimum effect on the temperature of the part under test.*

NOTE - Thermocouples having wires with a diameter not exceeding 0,3 mm are considered to be finewire thermocouples. If other thermal sensors are embedded in the windings these may be used as well.

So far as is possible, the appliance is positioned so that the thermocouples detect the highest temperatures.

The temperature rise of electrical insulation, other than that of windings, is determined on the surface of the insulation, at places where failure could cause a short circuit, contact between live parts and accessible metal parts, bridging of insulation or reduction of creepage distances or clearances below the values specified in 29.1.

### NOTES

2 If it is necessary to dismantle the motor to position thermocouples, care is taken to ensure that the motor has been correctly reassembled and the power input is measured again.

3 The point of separation of the cores of a multicore cord is an example of places where thermocouples are positioned.

10.4 *Motors are operated under normal operation, supplied with the most unfavourable voltage between 0,95 times and 1.05 times the rated voltage.*

In the case of continuous operation at the extreme voltage limits specified above the temperature-rise limits stated in 10.5 may be exceeded by:

- 10 K for machines of outputs up to 1000 KW
- 5 K for machines of outputs exceeding 1000 KW

10.5 During the test the temperature rises are monitored continuously and shall not exceed the values shown in table. protective devices shall not operate and sealing compound shall not flow out.

Limits of temperature of directly cooled machines and their coolants

Item No	Part of machine	Class of insulation														
		A Method			E Method			B Method			F Method			H Method		
		Thermo-resistor	ETD	Thermo-resistor	ETD	Thermo-resistor	ETD	Thermo-resistor	ETD	Thermo-resistor	ETD	Thermo-resistor	ETD	Thermo-resistor	ETD	
		°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	
1	Coolant at the outlet of directly-cooled active parts															
	a) Gas	110	110	85	85	130	130	85	85	130	130	85	85			
	b) Water or oil	85	85	85	85	85	85	85	85	85	85	85	85			
c) Other liquids																
2	A.C. windings															
	a) Gas cooled	120	120 <sup>b)</sup>	120	120 <sup>b)</sup>	140	140	140	140 <sup>b)</sup>	140	140	140	140 <sup>b)</sup>			
b) Liquid cooled																
3	Field windings of turbine-type machines (cooled by gas leaving the rotor through the following number of gas outlet regions <sup>d)</sup> ):	a) 1 and 2	100	100	115	115	115	115	115	115	115	115	115			
		3 and 4	105	105	110	110	120	120	120	120	120	120	120	120		
		5 and 6	110	110	115	115	125	125	125	125	125	125	125	125		
		7 and 8	115	115	120	120	130	130	130	130	130	130	130	130		
		8 and above	120	120	125	125	135	135	135	135	135	135	135	135		
b) Liquid cooled																
4	Field windings of a.c. and d.c. machines having d.c. excitation other than that in item 3	a) Gas cooled	130	130	130	130	150	150	150	150	150	150	150			
		b) Liquid cooled														
5	Permanently short-circuited insulated windings															
6	Permanently short-circuited uninsulated windings															
7	Magnetic core and other parts not in contact with windings															
8	Magnetic core and other parts in contact with windings	a) 130	130	130	130	140	140	140	140	140	140	140	140			
		b) 130 <sup>4)</sup>	130	130	130	130	130 <sup>4)</sup>									
9	Commutators and slip-rings open or enclosed <sup>b)</sup>															

Values for these classes are under consideration

Values for this class are under consideration

Observance of the maximum coolant temperatures given in item 1 will ensure that the hot-spot temperature of the winding is not excessive

Observance of the maximum coolant temperatures given in item 1 will ensure that the hot-spot temperature of the winding is not excessive

The temperature of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on the windings or on adjacent parts

1) It is important to note that the temperature measured by ETD is no indication of the hot-spot temperature of the stator winding. Observance of maximum coolant temperatures given in item 1 will ensure that the hot-spot temperature of the winding is not excessive. The limit of permissible temperature of the stator windings however is intended to be a safeguard against excessive heating of the insulation from the core. The readings of the ETD temperatures may be used to monitor the operation of the cooling system of the stator winding.

2) The rotor ventilation is classified by the number of radial outlet regions on the total length of the rotor. Special outlet regions for the coolant of the end windings are included as one outlet for each end. The common outlets of two axially opposed cooling flows are to be counted as two regions.

3) The temperatures in item 9 are permissible provided that insulation of the commutator or slip-rings appropriate to the temperature rise is used, except where a commutator or slip-ring is adjacent to windings in which case the temperature should not exceed that for the winding insulation class. The values of temperatures given apply only to measurements made by bulb thermometers. In the case of thermocouples or resistance thermometers being used, the limits of temperature shall be agreed between manufacturer and purchaser.

4) Special precautions may be necessary in the choice of brush grades in using a temperature of 130 °C and higher.



Item No.	Part of machine	Class of insulation														
		A Method		B Method		C Method		D Method		E Method		F Method		H Method		
		Thermometer K	Resistance K	ETD K	Thermometer K	Resistance K	ETD K	Thermometer K	Resistance K	ETD K	Thermometer K	Resistance K	ETD K	Thermometer K	Resistance K	ETD K
1	A.C. windings of machines having outputs of 5000 kW (or kVA) or more, or having a core length of 1 m or more  <i>Absolute hydrogen pressure</i> <sup>(1)</sup> < 150 kPa > 150 kPa < 200 kPa (1.5 bar) > 200 kPa < 300 kPa (2.0 bar) > 300 kPa < 400 kPa (3.0 bar) > 400 kPa < 500 kPa (4.0 bar) > 500 kPa < 600 kPa (5.0 bar) > 600 kPa < 700 kPa (7.0 bar)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	a) A.C. windings of machines having outputs less than 5000 kW (or kVA) and having a core length less than 1 m b) D.C. field windings of a.c. and d.c. machines other than those in items 3 and 4 c) Windings of armatures having commutators	—	60	60 <sup>(2)</sup>	—	75	75 <sup>(2)</sup>	—	80	80 <sup>(2)</sup>	—	100	100 <sup>(2)</sup>	—	—	—
		—	60	—	—	75	—	—	80	—	—	100	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3	Field windings of turbine-type machines having d.c. excitation	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4	a) Low-resistance field windings of more than one layer, and compensating windings b) Single-layer windings with exposed bare or varnished metal surfaces <sup>(3)</sup>	—	60	—	—	75	—	—	80	—	—	100	—	—	—	—
		—	65	—	—	80	—	—	90	—	—	110	—	—	—	—
5	Permanently short-circuited insulated windings	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	Permanently short-circuited uninsulated windings	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7	Magnetic core and other parts not in contact with windings	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8	Magnetic core and other parts in contact with windings	60	—	60	75	—	75	—	80	80	—	100	—	—	—	—
		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9	Commutators and slip-rings, open or enclosed <sup>(4)</sup>	60	—	—	70	—	—	—	80	—	—	—	—	—	—	—

The temperature rise of these parts shall in no case reach such a value that there is a risk of injury to any insulating or other material on the windings or on adjacent parts

(1) This is the only item where the permissible temperature rise is dependent on hydrogen pressure.  
 (2) A correction for high-voltage a.c. windings may be applicable to these items (see Sub-clause 16.2).  
 (3) Also includes multiple-layer field windings provided that the under layers are each in contact with the circulating primary coolant.  
 (4) The temperature rises in item 9 are permissible provided that insulation of the commutator or slip-rings appropriate to the temperature rise is used, except where a commutator or slip-ring is adjacent to windings in which case the temperature rise should not exceed that for the winding insulation class. The values of temperature rises given apply only to measurements made by bulb thermometers. In the case of thermocouples or resistance thermometers being used, the limits of temperature rise shall be agreed between manufacturer and purchaser.  
 (5) Special precautions may be necessary in the choice of brush grades in using temperature rises of 90 K and higher.

### NOTES

The temperature rise of a winding is calculated from the formula:

$$\Delta t = \frac{R_2 - R_1}{R_1} (k + t_1) - (t_2 - t_1)$$

where

- $\Delta t$  is the temperature rise of the winding;
- $R_1$  is the resistance at the beginning of the test;
- $R_2$  is the resistance at the end of the test;
- $k$  is equal to 234.5 for copper windings and 225 for aluminium windings;
- $t_1$  is the room temperature at the beginning of the test;
- $t_2$  is the room temperature at the end of the test.

At the beginning of the test, the windings are to be at room temperature. It is recommended that the resistance of windings at the end of the test be determined by taking resistance measurements as soon as possible after switching off and then at short intervals so that a curve of resistance against time can be plotted for ascertaining the resistance at the instant of switching off.

## 11 Leakage current and electric strength at operating temperature

*The high-voltage test shall be applied between the windings under test and the frame of the machine, with the core and the windings not under test connected to the frame. It shall be applied only to a new and completed machine with all its parts in place under conditions equivalent to normal working conditions and shall be carried out at the manufacturer's works. When a temperature-rise test is carried out, the dielectric test shall be carried out immediately after this test.*

*In the case of polyphase machines with rated voltage above 1 kV having both ends of each phase individually accessible, the test voltage shall be applied between each phase and the frame, with the core and the other phases and windings not under test connected to the frame.*

*The test voltage shall be of power-frequency, and shall be as near as possible to sine wave form.*

The test shall be commenced at a voltage of not more than one-half of the full test voltage. The voltage shall then be increased to the full value steadily or in steps of not more than 5% of the full value, the time allowed for the increase of the voltage from half to full value being not less than 10 s. The full test voltage shall then be maintained for 1 min in accordance with the value as specified in Table V.

During the routine testing of quantity produced machines up to 5 kW (or kVA), the 1 min test may be replaced by a test of approximately 5 s at the normal test voltage specified in Table V or of approximately 1 s at 120% of the normal test voltage in Table V, the test voltage being applied by means of prods.

*The high-voltage test at full voltage made on the windings on acceptance shall not be repeated. If, however, a second test is made at the request of the purchaser, after further drying if considered necessary, the test voltage shall be 80 % of the voltage specified in Table V.*

Completely rewound windings shall be tested at the full test voltage for new machines.

When a user and a repair contractor have agreed to carry out dielectric tests in cases where windings have been partially rewound or in the case of an overhauled machine, the following provisions are recommended:

- a) partially rewound windings are tested at 75% of the test voltage for a new machine. Before the test, the old part of the winding shall be carefully cleaned and dried;

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b) overhauled machines, after cleaning and drying, are subjected to a test at a voltage equal to 1.5 times the rated voltage, with a minimum of 1000 V if the rated voltage is equal to or greater than 100 V and a minimum of 500 V if the rated voltage is less than 100 V.

**TABLE V**  
Dielectric tests

Item No.	11.1 Machine or part	Test voltage (r.m.s)
1	Insulated windings of rotating machines of size less than 1 kW or kVA, and of rated voltage less than 100 V with the exception of those in Items 4 to 8	500 V + twice the rated voltage
2	Insulated windings of rotating machines of size less than 10000 kW (or kVA) with the exception of those in Item 1 and Items 4 to 8 (see Note 2)	1000 V + twice the rated voltage with a minimum of 1500 V (see Note 1)
3	Insulated windings of rotating machines of size 10000 kW (or kVA) or more with the exception of those in Items 4 to 8 (see Note 2). Rated voltage (see Note 1):	
	– up to 24 000 V – above 24 000 V	1000 V + 2 <i>U</i> Subject to agreement between manufacturer and purchaser
4	Separately-excited field windings of d.c. machines	1000 V + twice the maximum rated circuit voltage with a minimum of 1500 V
5	Secondary (usually rotor) windings of induction motors or synchronous induction motors if not permanently short-circuited (e.g. if intended for rheostatic starting)	
a)	– For non-reversing motors or motors reversible from standstill only	1000 V + twice the open-circuit standstill voltage as measured between slip-rings or secondary terminals with rated voltage applied to the primary windings
b)	– For motors to be reversed or braked by reversing the primary supply while the motor is running	1000 V + four times the open-circuit standstill secondary voltage as defined in Item 5a)
6	Exciters (except as below)	11.1.1 As for the windings to which they are connected
	<i>Exception 1</i> - Exciters of synchronous motors (including synchronous induction motors) if connected to earth or disconnected from the field windings during starting	1000 V + twice the <b>rated exciter</b> voltage, with a minimum of 1 500 V
	<i>Exception 2</i> - Separately excited field windings of exciters (see Item 4)	
7	Assembled group of machines and apparatus	A repetition of the tests in Items 1 to 7 above should be avoided if possible, but if a test on an assembled group

	of several pieces of new apparatus, each one of which has previously passed its high-voltage test, is made, the test voltage to be applied to such assembled group shall be 80% of the lowest test voltage appropriate for any part of the group (see Note 4)
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### NOTES

- 1 For two-phase windings having one terminal in common, the voltage in the formula shall be the highest r.m.s. voltage arising between any two terminals during operation.
- 2 High-voltage tests on machines having graded insulation should be the subject of an agreement between manufacturer and purchaser.
- 3 The voltage occurring between the terminals of the field windings, or sections thereof, under the specified starting conditions may be measured at any convenient reduced supply voltage, and the voltage so measured shall be increased in the ratio of the specified starting supply voltage to the test supply voltage.
- 4 For windings of one or more machines connected together electrically, the voltage to be considered is the maximum voltage that occurs in relation to earth.

## 12 Moisture resistance

- 12.1 The enclosure of the appliance shall provide the degree of protection against moisture in accordance with the IP 68 classification.

*Compliance is checked while the appliance is not being connected to the supply.*

*Submersible motors without "pressure expansion device" are immersed for 24 h in water containing approximately 1 % NaCl and having a temperature of 30 °C ± 5 °C. The water pressure on the enclosure is equal to*

- *1,5 times the pressure occurring at the maximum depth, when the maximum operating depth does not exceed 10 m.*
- *1,3 times the pressure occurring at the maximum depth or at 15 m. whichever is greater, when the maximum operating depth exceeds 10 m.*

*Before the test the temperature of the pump is raised to within 5 K of the water temperature.*

*The appliance shall then withstand the electric strength test of 16.3 and inspection shall show that there is no trace of water on insulation which could result in a reduction of creepage distances and clearances below the values specified in 29.1.*

## 13 Abnormal operation

- 13.1 Appliances shall be constructed so that the risk of fire, mechanical damage impairing safety or protection against electric shock as a result of abnormal or careless operation, is obviated as far as is practicable.

**Electronic circuits** shall be designed and applied so that a fault condition will not render the appliance unsafe with regard to electric shock, fire hazard, mechanical hazard or dangerous malfunction.

*Unless otherwise specified, the tests are continued until a non-self-resetting thermal cut-out operates or until steady conditions are established. If a heating element or an intentionally weak part becomes permanently open-circuited, the relevant test is repeated on a second sample. This second test shall be terminated in the same mode unless the test is otherwise satisfactorily completed.*

*Only one abnormal condition is simulated each time.*

### NOTES

1 An intentionally weak part is a part intended to rupture under conditions of abnormal operation to prevent the occurrence of a condition which could impair compliance with this standard. Such a part may be a replaceable component, such as a resistor or a capacitor or a part of a component to be replaced, such as an inaccessible thermal link incorporated in a motor.

2 Fuses, thermal cut-outs, overcurrent protection devices or similar devices incorporated in the appliance, may be used to provide the necessary protection. The protective device in the fixed wiring does not provide the necessary protection.

3 If more than one of the tests are applicable to the same appliance, these tests are made consecutively after the appliance has cooled down to room temperature.

*13.2 The appliance is tested under the conditions specified in clause 11, the power input being 1,15 times rated power input. Any control which limits the temperature during the test of clause 11 is short-circuited.*

NOTE - If the appliance is provided with more than one control, these are short-circuited in turn.

*13.3 The appliance is operated under stalled conditions by locking the rotor (the voltage may be reduced in order to control the locked rotor torque).*

*Appliances incorporating motors and having capacitors in the circuit of an auxiliary winding, are operated with the rotor locked, the capacitors being open-circuited one at a time. The test is repeated with the capacitors short-circuited one at a time unless they comply with IEC 60252.*

NOTE - This test is made with the rotor locked because certain motors with capacitors may or may not start so that variable results could be obtained.

*For each of the tests, appliances provided with a timer or programmer for a period equal to the maximum period allowed by the timer or programmer.*

*Other appliances are supplied at rated voltage for a period until steady conditions are established.*

*13.4 One phase of appliances incorporating three-phase motors is disconnected. The appliance is then operated under normal operation and supplied at rated voltage for the period specified in 19.7.*

*13.5 Compliance for electronic circuits within the submersible motor is checked by evaluation of the fault conditions specified appropriate standards, as far as possible.*

## 14 Mechanical strength

Appliances shall have adequate mechanical strength and be constructed to withstand such rough handling that may be expected in normal use (see prEN 13386).

### NOTES

1 Damage to the finish, small dents which do not reduce creepage distances and clearances below the values specified in 29.1 and small chips which do not adversely affect protection against electrical shock or moisture are neglected.

2 Cracks not visible to the naked eye and surface cracks in fibre-reinforced mouldings and similar materials are ignored.

3 To ensure that the appliance is rigidly supported, it may be necessary to place it against a solid wall of brick, concrete or similar material, covered by a sheet of Polyamide which is tightly fixed to the wall, care being taken that there is no appreciable air gap between the sheet and the wall. The sheet has a Rockwell hardness of HR 100, a

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thickness of at least 8 mm and a surface area such that no part of the appliance is mechanically overstressed due to insufficient supporting area.

## **15 Construction**

15.1 The motors shall be marked with IP 68 and the relevant requirements of IEC 60529 shall be fulfilled.

*Compliance is checked by the relevant tests.*

15.2 Means shall be provided to ensure all-pole disconnection from the supply. Such means shall be one of the following:

- a switch complying with 24.3;
- a statement in the instructions for installation that a disconnection incorporated in the fixed wiring is to be provided;

*Compliance is checked by inspection.*

Appliances shall be constructed so that their electrical insulation cannot be affected by water which could condense on cold surfaces or by liquid which could leak from cooling systems, hoses, couplings and similar parts of the appliance

*Compliance is checked by inspection and in case of doubt by the following test:*

*Drops of coloured water solution are applied by means of a syringe to those parts inside the appliance where leakage of a liquid could occur and affect the electrical insulation. The appliance is in operation or at rest, whichever is the most unfavourable.*

*After this test, inspection shall show that there is no trace of liquid on windings or insulation which could result in a reduction of creepage distances below the values specified in 2.9.1.*

15.3 If the construction is such that insulation is exposed to substances such as oil or grease, the substance shall have adequate insulating properties so that compliance with the standard is not impaired.

*Compliance is checked by inspection and by the tests of this standard*

15.4 Non-detachable parts, which provide the necessary degree of protection against access to live parts, moisture or contact with moving parts, shall be fixed in a reliable manner and shall withstand the mechanical stress occurring in normal use.

15.5 Appliances shall have no ragged or sharp edges, other than those necessary for the function of the appliance or accessory, that could create a hazard for the user in normal use or during user maintenance.

There shall be no exposed pointed ends of self-tapping screws or other fasteners that are liable to be touched by the user in normal use or during user maintenance.

*Compliance is checked by inspection.*

15.6 Current-carrying parts and other metal parts, the corrosion of which could result in a hazard, shall be resistant to corrosion under normal conditions of use.

*Compliance is checked by verifying that after the tests of clause 19, the relevant parts show no sign of corrosion.*

### **NOTES**

1 Attention is to be paid to the compatibility of the materials of terminals and to the effect of heating.

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2 Stainless steel and similar corrosion-resistant alloys and plated steel are considered to be satisfactory for the purpose of this requirement.

3 Direct contact between copper and aluminium or their alloys is to be avoided.

15.7 Wood, cotton, silk, ordinary paper and similar fibrous or hygroscopic material shall not be used as insulation, unless impregnated.

NOTE - Insulating material is considered to be impregnated if the interstices between the fibres of the material are substantially filled with a suitable insulant.

*Compliance is checked by inspection.*

15.8 Asbestos shall not be used in the construction of submersible motors.

*Compliance is checked by inspection.*

NOTE - The intention of this requirement is to avoid the risk associated with the inhalation of asbestos fibre or dust.

15.9 Oils containing polychlorinated biphenyl (PCB) shall not be used in appliances.

*Compliance is checked by inspection.*

15.10 Creepage distances and clearances over supplementary Insulation and reinforced Insulation shall not be reduced below the values specified in 29.1 as a result of wear. If any wire, screw, nut, washer, spring or similar part becomes loose or fails out of position, creepage distances and clearances over supplementary Insulation or reinforced insulation shall not be reduced to less than 50 % of the value specified in 29.1.

*Compliance is checked by inspection, by measurement and by manual test.*

NOTE - For the purpose of this requirement:

- only the normal position of use of the appliance is taken into account;
- it is not to be expected that two independent fixings will become loose at the same time;
- parts fixed by means of screws or nuts provided with locking washers are regarded as not liable to become loose, provided these screws or nuts are not required to be removed during the replacement of the supply cord or other servicing;
- wires connected by soldering are not considered to be adequately fixed, unless they are held in place near the terminals, independently of the solder.
- wires connected to terminals are not considered to be adequately secured, unless an additional fixing is provided near to the terminal, so that in the case of stranded conductors, this fixing clamps both the insulation and the conductor;
- short rigid wires are not regarded as liable to come away from a terminal if they remain in position when the terminal screw is loosened.

15.11 Supplementary Insulation and reinforced insulation shall be designed or protected so that the deposition of dirt or the dust resulting from wear of parts within the appliance, does not reduce creepage distances or clearances below the values specified in 29.1.

Ceramic material which is not tightly sintered, similar materials or beads alone shall not be used as supplementary insulation or reinforced Insulation.

Parts of natural or synthetic rubber used as supplementary Insulation shall be resistant to ageing or be arranged and dimensioned so that creepage distances are not reduced below the values specified in 29.1 even if cracks occur.

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NOTE - Insulating material in which heating conductors are embedded is considered to be basic insulation and not reinforced insulation.

*Compliance is checked by inspection, by measurement and, for rubber, by the following test*

*Parts of rubber are aged in an atmosphere of oxygen under pressure. The samples are suspended freely in an oxygen bomb, the effective capacity of the bomb being at least ten times the volume of the samples. The bomb is filled with commercial oxygen not less than 97 % pure, to a pressure of 2,1 MPa  $\pm$  0,07 MPa.*

*The samples are kept in the bomb at a temperature of 70°C  $\pm$  1°C for 96 h. Immediately afterwards they are removed from the bomb and left at room temperature, avoiding direct sunlight, for at least 16 h.*

*After the test, the samples are examined and shall show no crack visible to the naked eye.*

### NOTES

- 1 In case of doubt with regard to materials other than rubber, other tests may be made.
- 2 The use of the oxygen bomb presents some danger unless handled with care. Precautions should be taken to avoid the risk of explosion due to sudden oxidation.

15.12 Conductive liquids which are or may become accessible in normal use shall not be in direct contact with live parts.

*Compliance is checked by inspection.*

15.13 Capacitors shall not be connected between the contacts of a thermal cut-out.

*Compliance is checked by inspection.*

15.14 Mercury switches shall not be used

*Compliance is checked by inspection.*

15.15 Appliances which can be adjusted for different voltages shall be constructed so that accidental changing of the setting is unlikely to occur.

*Compliance is checked by manual test.*

## 16 Internal wiring

16.1 Wire ways shall be smooth and free from sharp edges.

Wires shall be protected so that they do not come into contact with burrs, cooling fins or similar edges which may cause damage to their insulation.

Holes in metal through which Insulated wires pass shall have smooth well-rounded surfaces or be provided with bushings.

Wiring shall be effectively prevented from coming into contact with moving parts.

*Compliance is checked by inspection.*

16.2 Beads and similar ceramic insulators on live wires shall be fixed or supported so that they cannot change their position; they shall not rest on sharp edges or sharp corners. If beads are inside flexible

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metal conduits, they shall be contained within an insulating sleeve, unless the conduit cannot move in normal use.

*Compliance is checked by inspection and by manual test*

16.3 Different parts of an appliance which can move in normal use or during user maintenance relative to each other, shall not cause undue stress to electrical connections and internal conductors, including those providing earthing continuity. Flexible metallic tubes shall not cause damage to the insulation of the conductors contained within them.

Open-coil springs shall not be used to protect conductors. If a coiled spring, the turns of which touch one another, is used for this purpose, an adequate insulating lining shall be provided in addition to the insulation of the conductors.

*Compliance is checked by*

16.4 Bare internal wiring shall be rigid and fixed so that, in normal use, creepage distances and clearances cannot be reduced below the values specified in 29.1.

*Compliance is checked during the test of 29.1.*

16.5 The insulation of internal wiring shall withstand the electrical stress likely to occur in normal use.

*Compliance is checked as follows:*

*The insulation shall be electrically equivalent to the insulation of cords complying with IEC 60227 or IEC 60245 or comply with the following electric strength test:*

*A voltage of 2 000 V is applied for 15 min between the conductor and metal foil wrapped around the insulation. There shall be no breakdown.*

### NOTES

- 1 If the insulation of the conductor does not fulfil one of these conditions, the conductor is considered to be bare.
- 2 The test is only applied to wiring subjected to the supply mains voltage.

16.6 When sleeving is used as supplementary insulation on internal wiring it shall be retained in position by positive means.

*Compliance is checked by inspection and by manual test.*

NOTE - A sleeve is considered to be fixed by positive means if it can only be removed by breaking or cutting or if it is clamped at both ends.

16.7 Conductors identified by the colour combination green / yellow shall only be used for earthing conductors.

*Compliance is checked by inspection.*

16.8 Stranded conductors shall not be consolidated by lead-tin soldering where they are subjected to contact pressures unless the clamping means is constructed so that there is no risk of bad contact due to cold flow of the solder.

*Compliance is checked by inspection.*

### NOTES

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- 1 The requirements may be met by using spring terminals. Securing the clamping screws alone is not considered adequate.
- 2 Soldering of the tip of a stranded conductor is allowed.

## 17 Components

17.1 Components shall comply with the safety requirements specified in the relevant IEC standards as far as they reasonably apply.

*Compliance is checked by inspection and by the tests of 24.1.1 to 24.1.5.*

NOTE - Compliance with the IEC standard for the relevant component does not necessarily ensure compliance with the requirements of this standard.

*17.2 Fixed capacitors for radio interference suppression shall comply with IEC 60384-14.*

*Isolating transformers and safety isolating transformers shall comply with IEC 60742.*

*Automatic controls shall comply with IEC 60730 unless they are tested with the appliance.*

*Switches shall comply with IEC 60328 unless they are tested with the appliance.*

*17.3 Automatic controls which have not been separately tested and found to comply with IEC 60730 shall be tested according to this standard and according to subclause 11.3.5 to 11.3.8 and clause 17 of IEC 60730 as type 1 controls.*

*The tests according to IEC 60730 are carried out under the conditions occurring in the appliance.*

*For the tests of clause 17 of IEC 60730 the number of cycles of operation are*

- |  |            |
|--|------------|
| <i>– self-resetting thermal cut-outs</i>     | <i>300</i> |
| <i>– non-self-resetting thermal cut-outs</i> | <i>30</i>  |

### NOTES

- 1 The tests of clauses 12, 13 and 14 are not carried out before making the test of clause 17 of IEC 60730.
- 2 The tests of clause 17 of IEC 60730 are not carried out on automatic controls which operate during clause 11. If the appliance meets the requirements of this standard when they are short-circuited.
- 3 Automatic controls may be tested separately from the appliance.

*17.4 If components are marked with their operating characteristics, the conditions under which they are used in the appliance shall be in accordance with these markings, unless otherwise specified.*

NOTE - For automatic controls, the term "making" includes documentation and declaration as specified in clause 7 of IEC 60730.

*The testing of components which have to comply with other standards is, in general, carried out separately, according to the relevant standard.*

*If the component is used within the limits of its marking, it is tested in accordance with the conditions occurring in the appliance, the number of samples being that required by the relevant standard.*

*When no IEC standard exists for the relevant component, when the component is not marked or is not used in accordance with its marking, it is tested under the conditions occurring in the appliance. The number of samples is, in general, that required by a similar specification.*

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*Components not mentioned in table 3 are tested as a part of the appliance, their T-marking, if any, being taken into account.*

17.5 For capacitors connected in series with a motor winding, it is verified that, when the appliance is supplied at 1.1 times rated voltage and under minimum load, the voltage across the capacitor does not exceed 1.1 times its rated voltage.

NOTE - Capacitors in auxiliary Windings of motors are to be marked with their rated voltage and their rated capacitance.

17.6 Appliances shall not be fitted with **thermal cut-outs** which can be reset by a soldering operation.

*Compliance is checked by inspection.*

## 18 Supply connection

18.1 Submersible motors shall be provided with at least one of the following means for connection to the supply:

- a set of terminals allowing the connection of cables
- a set of terminals and cable entries, which allow the connection of the appropriate types of cable or conduit;
- A connecting device which is only accessible with special tools.

NOTE - If a fixed appliance is constructed so that parts can be removed to facilitate easy installation, the requirement is considered to be met if it is possible to connect the supply wires without difficulty after a part of the appliance has been fixed to its support. In this case removable parts are to be constructed to be easily reassembled to the part which has been fixed in position, without risk of incorrect assembly or %damage to the wiring and without exposing the wiring to stress which may cause damage to the terminals or to the insulation of the wires.

*Compliance is checked by inspection and if necessary by making the appropriate connections.*

18.2 Cable entries shall be constructed or located so that the introduction of the conduit or cable does not affect the protection against access to live parts or reduce creepage distances and clearances below the value specified in 29.1.

*Compliance is checked by inspection and by measurement.*

18.3 Supply cords shall be assembled to the appliance by type Y or X attachment.

*Compliance is checked by inspection.*

18.4 The supply cord shall be polychloroprene sheathed or equivalent synthetic elastomer and be not lighter than heavy polychloroprene sheathed flexible cord (code designation 245 IEC 60066, H07). The cable shall be certified for submerged use.

*Compliance is checked by inspection and by measurement.*

18.5 Conductors of supply cable shall have a nominal cross-sectional area not less than specified by the manufacturer of the cable and local national standards (size is depending on rated current, temperature, cable type, etc.).

*Compliance is checked by measurement.*

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18.6 Supply cords shall not be in contact with sharp points or edges of the appliance.

*Compliance is checked by inspection.*

18.7 The supply cable shall have a green / yellow core which is connected to the earthing terminal of the appliance.

*Compliance is checked by inspection.*

18.8 Conductors of supply cords shall not be consolidated by lead-tin soldering where they are subject to contact pressure, unless the clamping means is constructed so that there is no risk of a bad contact due to cold flow of the solder.

*Compliance is checked by inspection.*

### NOTES

- 1 The requirement may be met by using spring terminals. Securing the clamping screws alone is not considered adequate.
- 2 Soldering of the tip of a stranded conductor is allowed.

18.9 The insulation of the supply cord shall not be damaged when moulding the cord to part of the enclosure.

*Compliance is checked by inspection.*

18.10 Inlet openings shall be provided with a bushing or shall be constructed so that the sheath of the supply cord can be introduced without risk of damage.

*Compliance is checked by inspection and by manual test.*

18.10.1 Inlet bushings shall be shaped to prevent damage to the **supply cord**.

*Compliance is checked by inspection and by manual test.*

18.10.2 At inlet openings, the insulation between the conductor of a supply cord and the enclosure of the appliance shall consist of the insulation of the conductor and in addition at least two separate insulation. Only one separate insulation is required if the enclosure at the inlet opening is of insulating material.

A separate insulation shall consist of

- the sheath of a supply cord at least equivalent to that of a cord complying with IEC 60227 or IEC 60245;
- a lining or bushing of insulating material complying with the requirements of 29.2 for supplementary Insulation.

*Compliance is checked by inspection.*

Appliances provided with a supply cable shall have cable anchorages such that the conductors are relieved from strain, including twisting, where they are connected within the appliance and that the insulation of the conductors is protected from abrasion.

It shall not be possible to push the cord into the appliance to such an extent that the cord or internal parts of the appliance could be damaged.

*Compliance is checked by inspection, by the following test.*

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18.11 Cord anchorage's for type X attachments shall be constructed and located so that

- replacement of the cord is easily possible;
- it is clear how the relief from strain and the prevention of twisting are obtained;
- they are suitable for the different types of cord which may be connected, unless the cord is specially prepared;
- the cord cannot touch the clamping screws of the cord anchorage if these screws are accessible, unless they are separated from accessible metal parts by supplementary Insulation;
- the cord is not clamped by a metal screw which bears directly on the cord;
- at least one part of the cord anchorage is securely fixed to the appliance unless it is part of a specially prepared cord:
- screws which have to be operated when replacing the cord do not fix any other component. However this does not apply if
  - the screws are omitted or components are incorrectly positioned and the appliance becomes inoperative or is obviously incomplete;
  - the parts intended to be fastened by them cannot be removed without the aid of a tool during the replacement of the cord.
- if labyrinths can be bypassed the test of 25.15 is nevertheless withstood;
- they are of insulating material or are provided with an insulating lining, unless a failure of the insulation of the cord does not make accessible metal parts live;

### NOTES

1 It the cord anchorage for type X attachment comprises one or more clamping members to which pressure is applied by means of nuts engaging with studs which are securely attached to the appliance, the cord anchorage is considered to have one part securely fixed to the appliance, even if the clamping member can be removed from the studs.

2 If the pressure on the clamping members is applied by means of one or more screws engaging with separate nuts or with a thread in a part which is integral with the appliance, the cord anchorage is not considered to have one part securely fixed to the appliance. This does not apply if one of the clamping members is fixed to the appliance or the surface of the appliance is of insulating material and shaped so that it is obvious that this surface is one of the clamping members.

3 Examples of acceptable and unacceptable constructions of cord anchorage's are shown in figure 13.

*Compliance is checked by inspection and by the test of 25.15 under the following conditions.*

*The tests are made with the lightest permissible type of cord of the smallest cross-sectional area specified in table 11 and then with the next heavier type cord having the largest cross-sectional area specified. However, if the appliance is fitted with a specially prepared cord, the test is carried out with this cord.*

*The conductors are placed in the terminals and any terminal screws tightened just sufficiently to prevent the conductors from easily changing their position. The clamping screws of the cord anchorage are tightened with two-thirds of the torque specified in 28.1.*

*Screws of insulating material bearing directly on the cord are fastened with two-thirds of the torque specified in column I of table 12. the length of the slot in the screw head being taken as the nominal diameter of the screw.*

18.12 For type Y attachment cord anchorage's shall be adequate.

*Compliance is checked by the test of 25.15.*

NOTE - The test is carried out on the cord supplied with the appliance.

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18.13 Cord anchorage's shall be arranged so that they are only accessible with the aid of a tool or be constructed so that the cord can only be fitted with the aid of a tool.

*Compliance is checked by inspection.*

18.14 For **type X attachment**, glands shall not be used as cord anchorages in **portable appliances**. Tying the cord into a knot or tying the cord with string **is not allowed**.

*Compliance is checked by inspection.*

18.15 The insulated conductors of the supply cord for type Y attachment shall be additionally insulated from accessible metal parts by basic Insulation. This insulation may be provided by the sheath of the supply cord or by other means.

*Compliance is checked by inspection and by the relevant tests.*

18.16 The space for connection of the supply cables for fixed wiring or for the connection of the supply cord provided for type X attachment shall be constructed

- to permit checking that the supply conductors are correctly positioned and connected before fitting any cover;
- so that any covers can be fitted without risk of damage to the conductors or their insulation;
- for portable appliances, so that the uninsulated end of a conductor, should it become free from the terminal, cannot come into contact with accessible metal parts, unless the end of the cord is such that the conductors are unlikely to slip free.

*Compliance is checked by inspection and by an installation test with cables of flexible cords of the largest cross-sectional area specified in table 11.*

18.17 Appliance inlets shall

- be located so that the connector can be inserted without difficulty;
- be located so that, after insertion of the connector, the appliance is not supported by the connector when it is placed in any position of normal use on a flat surface;

*Compliance is checked by inspection.*

NOTE - Appliances provided with appliance inlets complying with IEC 60320 are considered to comply with the first requirement.

18.18 Interconnection cords shall comply with the requirements for the supply cord, except that

- the cross-sectional area of the conductors of the interconnection cord is determined on the basis of the maximum current carried by the conductor during the test of clause 11 and not by the rated current of the appliance;
- the thickness of the insulation of the conductor may be reduced if the voltage of the conductor is less than the rated voltage.

*Compliance is checked by inspection, by measurement and if necessary by tests, such as the electric strength test of 16.3.*

18.19 Interconnection cords shall not be detachable without the aid of a tool if compliance with this standard is impaired when they are disconnected.

*Compliance is checked by inspection and if necessary by appropriate tests.*

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### 19 Terminals for external conductors

- 19.1 Electrical apparatus which is intended for connection to external circuits shall include connection facilities, except if the electrical apparatus is manufactured with a cable permanently connected to it. All apparatus constructed with permanently connected unterminated cable shall be marked with the symbol „X“, to indicate the need for appropriate connection of the free end of the cable.
- 19.2 Terminal compartments and their access openings shall be dimensioned so that the conductors can be readily connected.
- 19.3 Terminal compartments shall comply with one of the specific European Standards listed in 1.2.
- 19.4 Terminal compartments shall be so designed that after proper connection of the conductors, the creepage distances and the clearances comply with the requirements, if any, of the specific European Standard for the type of protection concerned.
- 19.5 Motors shall be provided with terminals in which connection is made by means of screws, nuts or equally effective devices. This requirement does not apply to appliances provided with a type X attachment having a specially prepared cable.

Screws and nuts shall not serve to fix any other component, except that they may also clamp internal conductors if these are arranged so that they are unlikely to be displaced when fitting the supply conductors.

*Compliance is checked by inspection.*

#### NOTES

- 1 Safety requirements for screw type and screwless type clamping units for electrical copper conductors are under consideration. Screwless type clamping units according to subclause 2.10 of I 5 EC 999 provided with an actuating element are regarded as equally effective devices.
- 2 Requirements for screwless terminals are given in IEC 60685-2-1.

For appliances with **type Y attachment** welded, crimped and similar connections may be used for the connection of external conductors. The wires shall be fixed in it's position.

*Compliance is checked by inspection.*

#### NOTES

- 1 It is not to be expected that two independent fixings will become loose at the same time.
- 2 Conductors connected to terminals by other means are not considered to be adequately fixed, unless an additional fixing is provided near to the terminals. This additional fixing is to clamp both the insulation and the conductor of flexible cable.
- 3 The terminals of a component such as a contactor may be used as terminals for external conductors if they comply with the requirements of this clause.

- 19.6 Terminals for type X attachment and for connection to fixed wiring shall be suitable for the connection of cables specified by the manufacturer.

*Compliance is checked by inspection, by measurement and by fitting cables of the smallest and largest cross-sectional areas specified.*

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19.7 Terminals for type X attachment and those for connection to fixed wiring shall be fixed so that when the clamping means is tightened or loosened

- the terminal does not loosen;
- internal wiring is not subjected to stress;
- creepage distances and clearances are not reduced below the values specified in 29.1.

*Compliance is checked by inspection and by the test of subclause 8.6 of IEC 60999. the torque applied being equal to two-thirds of the torque specified.*

### NOTES

1 Terminals may be prevented from loosening by fixing with two \*crews, by fixing with one screw in a recess such that there is no appreciable movement or by other suitable means.

2 Covering with sealing compound without other means of locking is not considered to be sufficient. However self-hardening resins may be used to lock terminals which are not subject to torsion in normal use.

19.8 Terminals for type X attachment and for connection to fixed wiring shall be constructed so that they clamp the conductor between metal surfaces with sufficient contact pressure and without damaging the conductor.

*Compliance is checked by inspection of the terminals and of the conductors, after the test of 26.4.*

19.9 Terminals for type X attachment, except those connected to a specially prepared cord, and terminals for connection to fixed wiring, shall not require special preparation of the conductor. They shall be constructed or placed so that the conductor cannot slip out when clamping screws or nuts are tightened.

*Compliance is checked by inspection of the terminals and of the conductors after the test of 26.4.*

### NOTES

1 The term "special preparation of the conductors" covers soldering of the strands, the use of cable lugs, eyelets or similar devices, but not the reshaping of the conductor before its introduction into the terminal or the twisting of a stranded conductor to consolidate the end.

2 Conductors are considered to be damaged if they show deep or sharp indentations.

19.10 Terminals, including the earthing terminal, shall be located close to each other.

*Compliance is checked by inspection.*

19.11 Terminals shall be accessible after removal of a cover or part of the enclosure.

*Compliance is checked by inspection.*

19.12 Terminals shall not be accessible without the aid **of a tool, even if their live parts** are not accessible.

*Compliance is checked by inspection and by manual test.*

19.13 Terminals for type X attachment shall be located or shielded so that if a wire of a stranded conductor escapes when the conductors are fitted, there is no risk of accidental connection between live parts and accessible metal parts.

*Compliance is checked by inspection and by the following test.*

*A 8 mm length of insulation is removed from the end of a flexible conductor having a nominal cross-sectional area as specified in table 9.*

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*One wire of the stranded conductor is left free and the other wires are fully inserted and clamped in the terminal.*

*The free wire is bent, without tearing the insulation back, in every possible direction but without making sharp bends around barriers.*

NOTE - The test is also applied to earthing conductors.

## 20 Provision for earthing

20.1 A connection facility for the connection of an earthing or equipotential bonding conductor shall be provided inside the terminal compartment of electrical apparatus and near the other connection facilities.

20.2 Electrical apparatus with a metallic enclosure shall have an additional external connection facility for an earthing or equipotential bonding conductor. This external connection facility shall be electrically in contact with the facility required in **15.1**. The external connection facility is not required for electrical apparatus which is designed to be moved when energized and is supplied by a cable incorporating an earthing or equipotential bonding conductor.

NOTE - The expression 'electrically in contact' does not necessarily involve the use of a conductor.

20.3 Neither an internal nor external earthing or bonding connection facility is required for electrical apparatus for which earthing (or bonding) is not required, such as electrical apparatus having double or reinforced insulation, or for which supplementary earthing is not necessary, such as apparatus with metallic enclosures used with metallic conduit systems.

**Table 3: Minimum cross-sectional areas of protective conductors**

Cross-sectional area of phase conductors of the installation <b>S (mm<sup>2</sup>)</b>	Minimum cross-sectional area of corresponding protective conductor <b>Sp (mm<sup>2</sup>)</b>
$S \leq 16$	S
$16 < S \leq 35$	16
$S > 35$	0,5 S

20.4 Earthing or equipotential bonding connection facilities shall allow for the effective connection of at least one conductor with a cross-sectional area as in table 3 below.

In addition to meeting this requirement, earthing or bonding connection facilities on the outside of electrical apparatus shall provide for effective connection of a conductor of at least 4 mm<sup>2</sup>.

20.5 Connection facilities shall effectively be protected against corrosion. They shall also be designed so that the conductors are secured against loosening and twisting and so that the contact pressure is maintained.

Special precautions shall be taken if one of the parts in contact consists of a material containing light metal. One example of a means of connection to a material containing light metal is to use an intermediate part made from steel.

Accessible metal parts which may become live in the event of an insulation fault, shall be permanently and reliably connected to an earthing terminal within the appliance or to the earthing contact of the appliance inlet.

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Earthing terminals and earthing contacts shall not be connected to the neutral terminal.

*Compliance is checked by inspection.*

### NOTES

1 If accessible metal parts are screened from live parts by metal parts which are connected to the earthing terminal or to the earthing contact, they are not regarded as likely to become live in the event of an insulation fault.

20.6 Terminals with screw clamping shall comply with the relevant requirements of clause 26. Screwless terminals shall comply with IEC 60685-2-1.

20.7 Terminals for the connection of external equipotential bonding conductors shall allow the connection of conductors having nominal cross-sectional areas as shown in Table .... and shall not be used to provide earthing continuity between different parts of the appliance. It shall not be possible to loosen the conductors without the aid of a tool.

The clamping means of earthing terminals shall be adequately secured against accidental loosening.

*Compliance is checked by inspection, by manual test and for screwless terminals by the tests specified in IEC 60685-2-1.*

### NOTES

1 The earthing conductor in a supply cable is not considered to be an equipotential bonding conductor

2 In general, the constructions commonly used for current-carrying terminals, other than some terminals of the pillar type, provide sufficient resiliency to comply with the latter requirement. For other constructions, special provisions, such as the use of an adequately resilient part which is not likely to be removed inadvertently, may be necessary.

20.8 If a detachable part is plugged into another part of the appliance and has an earth connection, this connection shall be made before the current-carrying connections are established when placing the part in position and the current-carrying connections shall be separated before the earth connection is broken when removing the part.

For appliances with supply cable, the arrangement of the terminals or the length of the conductors between the cable anchorage and the terminals, shall be such that the current carrying conductors become taut before the earthing conductor if the cord slips out of the cord anchorage.

*Compliance is checked by inspection and by manual test.*

20.9 All parts of the earthing terminal intended for the connection of external conductors shall be such that there is no risk of corrosion resulting from contact between these parts and the copper of the earthing conductor or any other metal in contact with these parts.

Parts providing earthing continuity, other than parts of a metal frame or enclosure shall be of coated or uncoated metal having adequate resistance to corrosion. If such parts are of steel, they shall be provided at the essential areas with an electroplated coating having a thickness of at least 5 µm.

Parts of coated or uncoated steel which are only intended to provide or to transmit contact pressure shall be adequately protected against rusting.

If the body of the earthing terminal is a part of a frame or enclosure of aluminium or aluminium alloy, precautions shall be taken to avoid the risk of corrosion resulting from contact between copper and aluminium or its alloys.

*Compliance is checked by inspection and by measurement.*

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### NOTES

- 1 Parts of copper or copper alloys containing at least 58 % copper for parts that are worked cold and at least 60 % copper for other parts and parts of stainless steel containing at least 13 % chrome, are considered to be sufficiently resistant to corrosion.
- 2 Parts subjected to a treatment such as chromate conversion coating are in general not considered to be adequately protected against corrosion, but they may be used to provide or to transmit contact pressure.
- 3 Examples of parts providing earthing continuity and parts which are only intended to provide or to transmit contact pressure are shown in figure 14.
- 4 The essential areas of steel parts are, in particular, those transmitting current. In evaluating such areas, the thickness of the coating in relation to the shape of the part has to be taken into account. In case of doubt, the thickness of the coating is measured as described in ISO 2178 or in ISO 1463.

The connection between the earthing terminal or earthing contact and earthed metal parts shall have low resistance.

*Compliance is checked by the following test.*

*A current derived from a source having a no-load voltage not exceeding 12 V (a.c. or d.c.) and equal to 1,5 times rated current of the appliance or 25 A, whichever is the greater, is passed between the earthing terminal or earthing contact and each of the accessible metal parts in turn.*

*The voltage drop between the earthing terminal of the appliance or the earthing contact of the appliance inlet and the accessible metal part is measured. The resistance calculated from the current and this voltage drop shall not exceed 0,1  $\Omega$ .*

### NOTES

- 1 In case of doubt, the test is carried out until steady conditions have been established.
- 2 The resistance of the supply cord is not included in the measurement.
- 3 Care is taken that the contact resistance between the tip of the measuring probe and the metal part under test does not influence the test results.

## 21 Screws and connections

21.1 Fixings, the failure of which may impair compliance with this standard and electrical connections shall withstand the mechanical stresses occurring in normal use.

Screws used for these purposes shall not be of metal which is soft or liable to creep, such as zinc or aluminium. If they are of insulating material they shall have a nominal diameter of at least 3 mm and they shall not be used for any electrical connection.

Screws transmitting electrical contact pressure shall screw into metal.

Screws shall not be of insulating material if their replacement by a metal screw could impair supplementary Insulation or reinforced Insulation. Screws which may be removed when replacing a supply cord having a type X attachment or when undertaking user maintenance shall not be of insulating material if their replacement by a metal screw could impair basic Insulation.

NOTE - Electrical connections include earthing connections.

*Compliance is checked by inspection.*

*Screws and nuts transmitting contact pressure or which are likely to be tightened during user maintenance or installation are tested as follows.*

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*The screws or nuts are tightened and loosened without jerking:*

- 10 times for screws in engagement with a thread of insulating material;
- 5 times for nuts and other screws.

*Screws in engagement with a thread of insulating material are completely removed and reinserted each time.*

*When testing terminal screws and nuts, a cable or flexible Cord of the largest cross-sectional area specified is placed in the terminal. It is repositioned before each tightening.*

*The test is made by means of a suitable screwdriver, spanner or key and by applying a torque as specified by the manufacturer.*

*Column I is applicable for metal screws without heads if the screw does not protrude from the hole when tightened.*

*Column II is applicable*

- for other metal screws and for nuts;
- for screws of insulating material
  - having a hexagonal head with the dimension across flats exceeding the overall thread diameter,
  - with a cylindrical head and a socket for a key, the socket having a cross-corner dimension exceeding the overall thread diameter,
  - with a head having a slot or cross slots, the length of which exceeds 1,5 times the overall thread diameter.

*Column III is applicable for other screws of insulating material*

*No damage impairing the further use of the fixings or electrical connections shall occur.*

### NOTES

1 Space-threaded (sheet metal) screws having a nominal diameter of 2,9 mm are considered to be equivalent to screws having a metric ISO thread of 3 mm diameter.

2 The shape of the blade of the screwdriver is to fit the head of the screw.

21.2 Electrical connections shall be constructed so that contact pressure is not transmitted through insulating material which is liable to shrink or to distort unless there is sufficient resiliency in the metallic parts to compensate for any possible shrinkage or distortion of the insulating material.

*Compliance is checked by inspection.*

NOTE - Ceramic material is not liable to shrink or to distort.

21.3 Space-threaded (sheet metal) screws shall not be used for the connection of current-carrying parts, unless they clamp these parts directly in contact with each other.

Thread-cutting (self-tapping) screws shall not be used for the electrical connection of current-carrying parts, unless they generate a full form standard machine screw thread. Such screws shall not be used if they are likely to be operated by the user or installer unless the thread is formed by a swaging action.

Thread-cutting and space-threaded screws may be used to provide earthing continuity, provided that it is not necessary to disturb the connection in normal use and that at least two screws are used for each connection.

*Compliance is checked by inspection.*

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21.4 Screws and nuts which make a mechanical connection between different parts of the appliance shall be secured against loosening if they also make electrical connections or provide earthing continuity.

### NOTES

- 1 This requirement does not apply to screws in the earthing circuit if at least two screws are used for the connection or if an alternative earthing circuit is provided.
- 2 Spring washers, lock washers and crown type locks as part of the screw head are means which may provide satisfactory security.
- 3 Sealing compound which softens on heating provides satisfactory security only for screw connections not subject to torsion in normal use.

Rivets used for electrical connections shall be secured against loosening if these connections are subject to torsion in normal use.

### NOTES

- 4 This requirement does not imply that more than one rivet is necessary for providing earthing continuity.
- 5 A non-circular shank or an appropriate notch may be sufficient.

*Compliance is checked by inspection and by manual test.*

## 22 Creepage distances, clearances and distances through Insulation

22.1 Creepage distances and clearances shall not be less than the values in millimetres shown in table 13.

If a resonant voltage occurs between the point where a winding and a capacitor are connected together and metal parts separated from live parts by basic insulation only, creepage distances and clearances shall not be less than the values specified for the value of the voltage produced by the resonance, these values being increased by 4 mm in the case of reinforced insulation.

*Compliance is checked by measurement.*

*For appliances with type X attachment other than those having a specially prepared cord, they are made with supply conductors of the largest cross-sectional area specified in table 11 and also without conductors. For other appliances, they are made on the appliance as delivered.*

*Movable parts are placed in the most unfavourable position. Nuts and screws with non-circular heads are assumed to be tightened in the most unfavourable position.*

*The clearances between terminals and accessible metal parts are also measured with the screws or nuts unscrewed as far as possible but the clearances shall then be not less than 50 % of the values shown in table 13.*

*If necessary, a force is applied to any point on bare conductors to any point on uninsulated metal capillary tubes of thermostats and similar devices and to the outside of metal enclosures, in an endeavour to reduce the creepage distances and clearances while taking the measurements.*

*The force is applied by means of the test finger of figure 1 and has a value of*

- 2 N for bare conductors, uninsulated capillary tubes of thermostats, conductive hoses, metal foil within the appliance and similar parts.
- 30 N for enclosures.

### NOTES

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- 1 Methods of measuring creepage distances and clearances are indicated in annex C.
- 2 Clearances are measured over barriers. If the barrier is in two parts which are not cemented together, creepage distances and clearances are measured through the joint.
- 3 For appliances having parts with double insulation where there is no metal between basic insulation and supplementary insulation, the measurements are made as though there is metal foil between the two insulation.
- 4 When assessing creepage distances and clearances, the effect of insulating linings of metal enclosures or covers is taken into consideration.
- 5 Means provided for fixing the appliance to a support are considered to be accessible.
- 6 The values specified in the table do not apply to cross-over points of motor windings.

**Table 4 - Minimum creepage distances and clearances (in millimetres)**

Distances mm	Class III appliances and constructions		Other appliances					
			Working ≤130 V		Working > 130 V and ≤250 V		Working > 250 V and ≤480 V	
	Creepage distance	Clearance	Creepage distance	Clearance	Creepage distance	Clearance	Creepage distance	Clearance
Between live parts of different potential <sup>1)</sup>								
- if protected against deposition of dirt <sup>2)</sup>	1,0	1,0	1,0	1,0	2,0	2,0	2,0	2,0
- if not protected against deposition of dirt	2,0	1,5	2,0	1,5	3,0	2,5	4,0	3,0
- if lacquered or enamelled windings	1,0	1,0	1,5	1,5	2,0	2,0	3,0	3,0
- for positive temperature coefficient (PTC) resistors including their connecting wires, if protected against deposition of moisture or dirt <sup>2)</sup>	—	—	1,0	1,0	1,0	1,0	—	—
Between live parts and other metal parts over basic insulation:								
- if protected against deposition of dirt <sup>2)</sup>								
if of ceramic, pure mica and similar materials	1,0	1,0	1,0	1,0	2,5 <sup>3)</sup>	2,5 <sup>3)</sup>	—	—
- if of other material	1,5	1,0	1,5	1,0	3,0	2,5 <sup>3)</sup>	—	—
- if not protected against deposition of dirt	2,0	1,5	2,0	1,5	4,0	3,0	—	—
- if the live parts are lacquered or enamelled windings	1,0	1,0	1,5	1,5	2,0	2,0	—	—
Between live parts and other metal parts over reinforced insulation:								
- if the live parts are lacquered or enamelled windings	—	—	6,0	6,0	6,0	6,0	—	—
- for other live parts	—	—	8,0	8,0	8,0	8,0	—	—
Between metal parts separated by supplementary insulation	—	—	4,0	4,0	4,0	4,0	—	—
Between live parts in recesses in the mounting face of the appliance and the surface to which it is fixed	2,0	2,0	6,0	6,0	6,0	6,0	—	—

Notes to table 13

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- 1) The clearances specified do not apply to the air gap between the contacts of automatic controls, switches of micro-gap construction and similar devices or to the air gap between the current-carrying members of such devices where the clearance varies with the movement of the contacts.
- 2) In general, the interior of an appliance having a reasonably dust-proof enclosure is considered to be protected against deposition of dirt, provided the appliance does not generate dust within itself: hermetic sealing is not required.
- 3) If the parts are rigid and located by mouldings or if the construction is such that there is no likelihood of the distance being reduced by distortion or movement of the parts, this value may be reduced to 2,0 mm.
- 4) If protected against deposition of dirt.
- 5) If over ceramic, pure mica and similar materials, protected against deposition of dirt,

*For conductive patterns on printed circuit boards, except at their edges, the values in the table between parts of different potential may be reduced as long as the peak value of the voltage stress does not exceed*

- 150 V per mm with a minimum distance of 0,2 mm, if protected against the deposition of dirt;
- 100 V per mm with a minimum distance of 0,5 mm, if not protected against the deposition of dirt.

*For peak voltages exceeding 50 V, the reduced creepage distances only apply if the proof tracking index (PTI) of the printed circuit board is greater than 175 when measured in accordance with annex L.*

*These distances may be reduced further provided that the appliance complies with the requirements of clause 19 when the distances are short-circuited in turn.*

NOTE 7 - When the limits specified above lead to higher values than those of the table, the values of the table apply.

*Creepage distances and clearances within optocouplers are not measured.*

*For five parts of different potential separated by basic Insulation only, creepage distances and clearances smaller than those specified in the table are allowed provided the requirements of clause 19 are met if these creepage distances and clearances are short-circuited in turn.*

22.2 The distance through insulation between metal parts for working voltages up to and including 250 V shall not be less than 1,0 mm if they are separated by supplementary Insulation and not be less than 2,0 mm if they are separated by reinforced insulation.

*Compliance is checked by inspection and by measurement.*

### NOTES

1 This does not imply that the distance has to be through solid insulation only. The insulation may consist of solid material plus one or more air layers.

2 For appliances having parts with double Insulation where there is no metal between basic insulation and supplementary insulation, the measurements are made as though there is a metal foil between the two insulation.

22.2.1 This requirement does not apply if the insulation is applied in thin sheet form, other than mica or similar scaly material and

- for supplementary insulating consists of at least two layers, provided that each of the layers withstands the electric strength test of 16.3 for supplementary Insulation;
- for reinforced Insulation, consists of at least three layers, provided that any two layers together withstand the electric strength test of 16.3 for reinforced Insulation.

*Compliance is checked by inspection.*

22.2.2 This requirement also does not apply if the supplementary insulation or the reinforced Insulation is inaccessible and meets one of the following conditions:

- the maximum temperature rise determined during the tests of clause 19 does not exceed the value specified in 11.8;
- the insulation, after having been conditioned 168 h in an oven maintained at a temperature equal to 50 K in excess of the maximum temperature rise determined during the tests of clause 19, withstands the electric strength test of 16.3. this test being made on the insulation both at the temperature occurring in the oven and after cooling to approximately room temperature.

*Compliance is checked by inspection and by test.*

*For optocouplers the conditioning procedure is carried out at a temperature of 50 K in excess of the maximum temperature rise measured on the optocoupler during the tests of clauses 11 or 19. The optocoupler being operated under the most unfavourable conditions which occur during these tests.*

## 23 Resistance to heat, fire and tracking

NOTE - The tests specified in this clause are based on the present IEC standards dealing with this subject.

Other concepts for determining the resistance to fire, such as preselection testing, are under consideration.

\*Appendix H shows the selection and sequence of the tests of this clause.

23.1 External parts of non-metallic material, parts of insulating material supporting live parts including connections and parts of thermoplastic material providing supplementary insulation or reinforced Insulation, the deterioration of which might cause the appliance to fail to comply with this standard, shall be sufficiently resistant to heat.

*Compliance is checked in accordance with EN 60 335-1 by subjecting the relevant part to the ball-pressure test made by means of the apparatus shown in figure 12, relevant chapter hereunder copied, tested by the material manufacturer, other competent body or the manufacturer of the submersible electrical motor.*

*Before starting the test, the pan is maintained for 24 h in an atmosphere having a temperature between 15 °C and 35 °C and a relative humidity between 45 % and 75 %.*

*The part is supported so that its upper surface is horizontal and the spherical part of the apparatus is pressed against this surface with a force of 20 N. The thickness of the part under test shall be at least 2,5 mm.*

NOTE 1 - If necessary, the required thickness may be obtained by using two or more sections of the part.

*The test is made in a heating cabinet at a temperature of 40 °C ± 2 °C plus the maximum temperature rise determined during the test of clause 11, but it shall be at least:*

- for external parts  $75\text{ °C} \pm 2\text{ °C}$
- for parts supporting live parts  $125\text{ °C} \pm 2\text{ °C}$

*However, for parts of thermoplastic material providing supplementary Insulation or reinforced Insulation, the test is made at a temperature of 25 °C±2 °C plus the maximum temperature rise determined during the tests of clause 19.13, if this is higher. The temperature rises of 19.4, 13.2 are not taken into account provided the test of 19.4, 13.2 is terminated by the operation of a non-self-resetting protective device and it is necessary to remove a cover or to use a tool to reset it.*

*Before the test is started, the test apparatus is brought to the temperature determined above.*

*After 1 h the apparatus is removed and the part is immediately immersed in cold water so that it is cooled to approximately room temperature. The diameter of the impression shall not exceed 2 mm.*

### NOTES

- 2 For coil formers, only those parts which support or retain terminals in position are subjected to the test.
- 3 The test is not made on parts of ceramic material.

23.2 Parts of non-metallic material shall be resistant to ignition and spread of fire.

This requirement does not apply to decorative trims, knobs and other parts not likely to be ignited or to propagate flames originating from inside the appliance.

*Compliance is checked in accordance with EN 60335-1, relevant chapter hereunder copied by the tests of 23.2.1, 23.2.4 and either 23.2.2 or 23.2.3 as applicable, in accordance with EN 60335-1, relevant chapter hereunder copied.*

23.2.1 *Separately moulded samples of the relevant parts are subjected to the burning test of annex F. However, instead of the burning test, the glow-wire test of annex G is made at a temperature of 550 °C on corresponding parts of the appliance if*

- *separately moulded samples are not available;*
- *there is no evidence that the material withstands the burning test;*
- *the separately moulded samples do not withstand the burning test.*

23.2.2 *For appliances which are operated while attended, parts of insulating material supporting connections which carry a current exceeding 0,5 A during normal operation, are subjected to the glow-wire test of annex G. The test being made at a temperature of 650 °C. This test is also carried out on parts in contact with, or in close proximity to, such connections.*

*This test is not made on hand-held appliances, on appliances which have to be kept switched on by hand or foot and on appliances which are continuously loaded by hand.*

### NOTES

- 1 The test is not carried out on parts supporting welded connections.
- 2 "In close proximity" is considered to be a distance not exceeding 3 mm.

23.2.3 *For other appliances, connections supported by parts of insulating material and which carry a current exceeding 0,5 A during normal operations are subjected to the bad-connection test of annex H. If this test cannot be made due to the design of the connection, the parts of insulating material supporting the connection are subjected to the glow-wire test of annex G. The test being made at a temperature of 750 °C. In this case, the test is also carried out on parts in contact with, or in close proximity to, the connection.*

### NOTES

- 1 The test is not carried out on parts supporting welded connections.
- 2 "In close proximity" is considered to be a distance not exceeding 3 mm.

*During the application of the glow-wire, the height and duration of flames are measured.*

*In addition, for parts which withstand the glow-wire test but which flame during the application of the glow-wire, the surrounding parts are subjected to the needle-flame test of annex H for the measured duration of the flame if*

- *they are positioned within a distance equal to the height of the flame and*
- *they are likely to be impinged upon by the flame.*

*However, parts shielded by a separate barrier which meets the needle-flame test are not tested.*

*The needle-flame test is not carried out on parts which are made of material classified as FV-0 or FV-1 according to IEC 60707. The sample of material submitted to the test of IEC 60707 shall be no thicker than the relevant part.*

NOTE 3 - Parts likely to be impinged upon by the flame are considered to be those within the envelope of a vertical cylinder having a radius of 10 mm and a height equal to the height of the flame, positioned above the point of application of the glow-wire.

*23.2.4 If the parts do not withstand the test of 30.2.2 or 30.2.3, the needle-flame test of annex H is made on all other parts of non-metallic material which are within a distance of 50 mm. However, parts shielded by a separate barrier which meets the needle-flame test are not tested.*

*The needle-flame test is not carried out on parts which are made of material classified as FV-0 or FV-1 according to JEC 707. The sample of material submitted to the test of IEC 60707 shall be no thicker than the relevant part.*

23.3 Insulating material across which a tracking path may occur shall have adequate resistance to **tracking**.

A tracking path is liable to occur

- between live parts of different potential;
- between live parts and earthed metal parts;

*Parts of insulating material used under normal duty conditions and parts of ceramic material are not tested.*

- A totally enclosed brushless motor for use in a submersible pump is always running under normal duty condition, as there is no risk for deposition of conductive material.
- *For other types of motors, for which deposition of conductive material may occur, compliance is checked by the material manufacturer, other competent body or the manufacturer of the submersible electrical motor by the proof tracking test in accordance with IEC 60112.*

The test method described in IEC 60112 "Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions", indicates the relative resistance of solid electrical insulating materials to tracking for voltage up to 600 Volts when the surface is exposed under electric stress to water with the addition of contaminants.

For voltages above 600 V up to 1000 V

For safe dimensioning, solid insulation materials with sufficient resistance to tracking shall be used.

For voltages up to 1000 Volts insulating materials having a Comparative Tracking Index (CTI) better than 425 are preferred.

*Compliance is checked by the material manufacturer, other competent body or the manufacturer of the submersible electrical motor by determination of the CTI in accordance with IEC 60112.*

Note - The maximum listed CTI-value is 600

## 24 Resistance to rusting

Ferrous parts, the rusting of which might cause the appliance to fall to comply with this standard, shall be adequately protected against rusting.

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## Europump Guideline

Safety of Electrical Submersible Motors, 2000-08

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Figure 1 - Test finger

$$\frac{g}{cm^3}$$

Material: metal, except where otherwise specified.

Linear dimensions in millimetres

Tolerances on dimensions without specific Tolerance:

on angles: 0/-10'

on linear dimensions:

up to 25 mm: 0/-0,05

over 25 mm: +0,2

Both joints shall permit movement in the same plane and the same direction through an angle of 90' with a 0 to +10' tolerance.

## Annex A (normative)

### Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid together with their amendments. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60051-2:1984, *Direct acting indicating analogue electrical-measuring instruments and their accessories - Part 2: Special requirements for amperemeters and voltmeters.*

IEC 60065:1985, *Safety requirements for mains operated electronic and related apparatus for household and similar general use.*

IEC 60068-2-63:1991, *Environmental testing*  $\frac{3}{4}$  *Part 2: test methods*  $\frac{3}{4}$  *test e.g.: Impact, spring hammer.*

IEC 60085:1984, *Thermal evaluation and classification of electrical insulation.*

IEC 60112:1979; *Recommended method for determining the comparative tracking index of solid insulating materials under moist conditions.*

IEC 60127:1974; *Cartridge fuse-links for miniature fuses.*

IEC 60227:1979; *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V.*

IEC 60245:1985; *Rubber insulated cables of rated voltages up to and including 450/750 V.*

IEC 60252:1975; *A.C. motor capacitors.*

IEC 60328:1972; *Switches for appliances.*

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

*IEC 60685-2-1:1980; Connecting devices (junction an/or tapping) for household and similar fixed electrical installations, Part 2: Particular requirements. Screwless terminals for connecting copper conductors without special preparation.*

IEC 60695-2-1:1980, *Fire hazard testing*  $\frac{3}{4}$  *Part 2: Test methods. Glow-wire test and guidance.*

IEC 60695-2-2:1980, *Fire hazards testing*  $\frac{3}{4}$  *Part 2: Test methods. Needle-flame test.*

IEC 60695-2-3:1984, *Fire hazards testing*  $\frac{3}{4}$  *Part 3: Test methods. Bad-connection test with heaters.*

IEC 60707:1981; *Methods of test for the determination of the flammability of solid electrical insulating materials when exposed to an igniting source.*

IEC 60730; *Automatic electrical controls for household and similar use.*

IEC 60730-1:1986; *Part 1: General requirements.*

IEC 60742:1983, *Isolating transformers and safety isolating transformers - Requirements.*

IEC 60999:1990; *Connecting devices*  $\frac{3}{4}$  *Safety requirements for screw-type and screwless-type clamping units for electrical copper conductors.*

ISO 1463:1982; *Metallic and oxide coatings*  $\frac{3}{4}$  *Measurement of coating thickness*  $\frac{3}{4}$  *Microscopic method.*

ISO 2178:1982; *Non-magnetic coatings on magnetic substrates*  $\frac{3}{4}$  *Measurement of coating thickness*  $\frac{3}{4}$  *Magnetic method.*

## Annex B (normative)

### Ageing test on motors

*This test may be carried out when there is doubt with regard to the classification of the insulating system of a motor winding, for example:*

*when well-known insulating materials are used in an unconventional way;*

*where combinations of materials of different temperature classes are used at a temperature higher than that allowed for the lowest class used,.*

*when materials are used for which sufficient experience is not available, for*

*instance in motors having integral core insulation.*

*This test is made on 6 samples of the motor.*

*The rotor of each motor is locked and a current is passed individually through the rotor winding and stator winding, this current being such that the temperature of the relevant winding is equal to the maximum temperature rise measured during the test of clause 1 1 increased by 25 K. This temperature is further increased by one of the values chosen from the following table. The corresponding total time during which the current is passed is indicated in the table.*

<i>Temperature increase</i>	<i>Total time</i>
<i>K</i>	<i>h</i>
<i>0 ± 3</i>	<i>p 1)</i>
<i>10 ± 3</i>	<i>0,5 p</i>
<i>20 ± 3</i>	<i>0,25 p</i>
<i>30 ± 3</i>	<i>0, 125 p</i>

1) *p is a 8 000 unless otherwise specified in the part 2.*

NOTE 1 - The temperature increase chosen is to be agreed by the manufacturer.

*The total time is divided into four equal periods, each of them being followed by a period of 48 h during which the motor is subjected to the humidity test of 15.3. After the final humidity test, the insulation shall withstand the electric strength test of 16.3. the test voltage being, however, reduced to 50 % of the value specified in item 1 of table 5.*

*After each of the four periods and before the subsequent humidity test, the leakage current of the insulating system is measured as specified in 13.2. any component not forming part of the insulation system under test being disconnected before the measurement is made.*

*The leakage current shall not exceed 0,5 MA.*

*Failure of only one of the six motors during the first of the four periods of the test is ignored.*

*If one of the six motors fails during the second, third or fourth period of the test, the remaining five motors are subjected to a fifth period followed by the humidity test and the electric strength test.*

*The remaining five motors shall complete the test.*

NOTE 2 - In order to verify that the insulation system is within the temperature C1853 claimed by the manufacturer, the winding temperature for the test is to be equal to the temperature limit for the class of insulation, increased by the temperature increase chosen from the table.

**Annex C**  
(normative)

**Measurement of creepage distances and clearances**

The methods of measuring **creepage distances** and **clearances** which are specified in 29.1 are indicated in cases 1 to 10.

These cases do not differentiate between gaps and grooves or between types of insulation.

*The following assumptions are made:*

- . a groove may have parallel, converging or diverging sides;*
- . any groove having diverging sides, a minimum width exceeding 0,25 mm, a depth exceeding 1 f 5 mm and a width at the bottom equal to or greater than 1 mm, is regarded as an air gap, the creepage path following the contour of the groove (case 8);*
- any corner including an angle less than 80° is assumed to be bridged with an insulating link of 1 mm width (0,25 mm for when protection against deposition of dirt is provided) moved into the most unfavourable position (case 3);*
- where the distance over the top of a groove is 1 mm (0,25 mm when protection against deposition of dirt is provided) or more, the creepage path follows the contour of the groove (case 2);*
- creepage distances and clearances measured between parts moving relative to each other are measured when these parts are placed in their most unfavourable stationary positions;*
- . any air gap less than 1 mm wide (0,25 mm when protection against deposition of dirt is provided) is ignored in computing the total creepage distance.*

**The Annexes listed on this side are taken from EN 60335-2-41: Safety of household and similar electrical appliances - Part 2-41: Particular requirements for pumps for liquids having a temperature not exceeding 35 °C (IEC 60335-2-41:1996/A1:2000)**

**Annex D**

(normative)

**Circuit for measuring leakage currents**

**Annex E**

(informative)

**Selection and sequence of the tests of clause 30**

Resistance to heat and fire All appliances

**Annex F**

(normative)

**Burning test**

**Annex G**

(normative)

**Glow-wire test**

**Annex H**

(normative)

**- Void -**

**Needle-flame test**

**Annex L**

(normative)

**Proof tracking test**

**Annex M**

(normative)

**Severity of duty conditions of insulating material  
with respect to the risk of tracking**