17.1.1 Tests

A *Solid-object-proof transformers (first characteristic IP numeral 2) shall be tested with the standard test finger specified in IEC 60529 and the test pin specified in figure 3 according to the requirements of clauses 9 and 26.*

NOTE – **Ordinary transformers** are not required to be tested with the sphere specified in IEC 60529.

B *Solid-object-proof transformers (first characteristic IP numerals 3 and 4) shall be tested at every possible point (excluding gaskets) with a probe according to test probe C or D of IEC 61032, applied with a force as follows:*

Table 6 – Solid-object-proof transformer test

	Test probe according to IEC 61032	Probe wire diameter mm	Application force
First IP numeral 3	C	$2{,}5^{+0{,}05}_{0}$	3 N ± 10 %
First IP numeral 4	D	$1^{+0{,}05}_{0}$	1 N ± 10 %

The end of the probe wire shall be cut at right angles to its length and be free from burrs.

C *Dust-proof transformers (first characteristic IP numeral 5) are tested in a dust chamber similar to that shown in figure 2 of IEC 60529, in which talcum powder is maintained in suspension by an air current; during the test the vacuum pump as shown is not connected. The chamber shall contain 2 kg of powder for every cubic metre of its volume. The talcum powder used shall pass through a square-meshed sieve whose nominal wire diameter is 50 µm, and whose nominal free distance between wire is 75 µm, and shall have a range of particle size down to and including 1 µm with at least 50 % by weight less than 5 µm. It should not have been used for more than 20 tests.*

The test shall be carried out as follows:

a) the transformer is suspended outside the dust chamber and operated at ***rated output*** *until operating temperature is achieved;*

b) the transformer, while still operating, is placed with the minimum disturbance in the dust chamber;

c) the door of the dust chamber is closed;

d) the fan/blower causing the talcum powder to be in suspension is switched on;

e) after 1 min the transformer is switched off and allowed to cool for 3 h while the talcum powder remains in suspension.

NOTE –The 1 min interval between the switching on of the fan/blower and the switching off of the transformer is to ensure that the talcum powder is properly in suspension around the transformer during initial cooling, which is most important with smaller transformers. The transformer is operated initially as in item a) to ensure that the test chamber is not overheated.

D *Dust-tight transformers (first characteristic IP numeral 6) are tested in accordance with C.*

E *Drip-proof transformers (second characteristic IP numeral 1) are subjected for 10 min to an artificial rainfall of 3 mm/min by means of a device as shown in figure 3 of IEC 60529, falling vertically from a height of 200 mm above the top of the transformer.*

F *Rain-proof transformers (second characteristic IP numeral 3) are sprayed with water for 10 min by means of a spray apparatus as shown in figure 4 of IEC 60529. The radius of the semi-circular tube shall be as small as possible and compatible with the size and position of the transformer.*

The tube shall be perforated so that jets of water are directed towards the centre of the circle, and a water pressure at the inlet of the apparatus shall be approximately 80 kN/m².

The tube shall be caused to oscillate through an angle of 120°, 60° on either side of the vertical, the time for one complete oscillation (2 × 120°) being about 4 s.

The transformer shall be mounted above the pivot line of the tube so that the ends of the transformer receive adequate coverage from the jets. The transformer shall be turned about its vertical axis during the test at a rate of 1 rev/min.

After this 10 min period, the transformer shall be switched off and allowed to cool naturally while the water spray is continued for a further 10 min.

G *Splash-proof transformers (second characteristic IP numeral 4) are sprayed from every direction with water for 10 min by means of the spray apparatus shown in figure 4 of IEC 60529 and described in F. The transformer shall be mounted under the pivot line of the tube so that the ends of the transformer receive adequate coverage from the jets.*

The tube shall be caused to oscillate through an angle of almost 360°, 180° on either side of the vertical, the time for one complete oscillation (2 × 360°) being about 12 s. The transformer shall be turned about its vertical axis during the test at a rate of 1 rev/min.

The support for the equipment under test shall be grid shaped in order to avoid acting as a baffle. After this 10 min period, the transformer shall be switched off and allowed to cool naturally, while the water spray is continued for a further 10 min.

H *Jet-proof transformers (second characteristic IP numeral 5) are switched off and immediately subjected to a water jet for 15 min from all directions by means of a hose, having a nozzle with the shape and dimensions shown in figure 6 of IEC 60529, the dimension D' being 6,3 mm. The nozzle shall be held 3 m away from the sample.*

The water pressure at the nozzle shall be approximately 30 kN/m².

I *Water-tight transformers (second characteristic IP numeral 7) are switched off and immediately immersed for 30 min in water, so that there is at least 150 mm of water above the top of the transformer, and the lowest portion is subjected to at least 1 m head of water. Transformers shall be held in position by their normal fixing means.*

NOTE – This treatment is not sufficiently severe for transformers intended for operation under water.

J *Pressure watertight transformers (second characteristic IP numeral 8) are heated either by operating or by other suitable means, so that the temperature of the transformer* ***enclosure*** *exceeds that of the water in the test tank by between 5 °C and 10 °C.*

The transformer shall then be switched off and subjected to a water pressure of 1,3 times that pressure which corresponds to the rated maximum immersion depth for a period of 30 min.

17.2 Transformers shall be proof against humid conditions which may occur in normal use.

Compliance is checked by the humidity treatment described in this subclause, followed immediately by the tests of clause 18.

Transformers intended for fixed connection to the supply are tested with the cable fitted but with cable entries open. If knock-outs are provided, one of them is opened. Transformers intended to be used with an ***external flexible cable or cord*** *are tested with the cord and cord entries correctly fitted.*

Electrical components, covers and other parts which can be removed without the aid of a ***tool*** *are removed and subjected to the humidity treatment with the main part, if necessary.*

The humidity treatment is carried out in a humidity cabinet containing air with a relative humidity maintained between 91 % and 95 %. The temperature of the air, at all places where specimens can be located, is maintained to within 1 °C of any convenient value t between 20 °C and 30 °C.

Before being placed in the humidity cabinet, the specimen is brought to a temperature between t and (t + 4) °C.

The specimen is kept in the cabinet for:

- *two days (48 h) for* ***ordinary transformers*** *and transformers with protection index IP20, or lower;*
- *seven days (168 h) for other transformers.*

In most cases, the specimens may be brought to the specified temperature by keeping them at this temperature for at least 4 h before the humidity treatment.

NOTE – A relative humidity between 91 % and 95 % can be obtained by placing a saturated solution of sodium sulphate (Na_2SO_4) or potassium nitrate (KNO_3) in water, the solution having a sufficiently large contact surface with the air in the humidity cabinet. In order to achieve the specified conditions within the cabinet, it is necessary to ensure constant circulation of the air and, in general, to use a cabinet which is thermally insulated.

After this treatment and the tests of clause 18, the transformer shall show no damage within the meaning of this standard.

18 Insulation resistance and dielectric strength

18.1 The insulation resistance and the dielectric strength of transformers shall be adequate.

Compliance is checked by the tests of 18.2 to 18.4 which are made immediately after the test of 17.2, in the humidity cabinet or in the room in which the specimen was brought to the prescribed temperature, after reassembling those parts which may have been removed.

18.2 *The insulation resistance is measured with a d.c. voltage of approximately 500 V applied, the measurement being made 1 min after application of the voltage.*

The insulation resistance shall be not less than that shown in table 7.

Table 7 – Values of insulation resistance

Insulation to be tested	Insulation resistance MΩ
Between **hazardous live parts** and the **body**:	
– for **basic insulation**	2
– for **reinforced insulation**	7
Between **input circuits** and **output circuits** (**basic insulation**)	2
Between **input circuits** and **output circuits** (**double** or **reinforced insulation**)	5
Between each **input circuit** and all other **input circuits** connected together	2
Between each **output circuit** and all other **output circuits** connected together	2
Between **hazardous live parts** and metal parts of **class II transformers** which are separated from **hazardous live parts** by **basic insulation** only	2
Between metal parts of **class II transformers** which are separated from **hazardous live parts** by **basic insulation** only, and the **body**	5
Between two metal foils in contact with the inner and outer surfaces of **enclosures** of insulating material	2

18.3 *Immediately after the test of 18.2, the insulation is subjected for 1 min to a voltage of substantially sine-wave form at 50/60 Hz. The value of the test voltage and the points of application are given in table 8.*

Resistors, capacitors and other components are disconnected before carrying out the test.

Table 8 – Table of test voltages

Application of test voltage	Working voltage V*				
	<50	150	300	600	1 000
1) Between **live parts** of **input circuits** and **live parts** of **output circuits** (**basic insulation**)	250	1 400	2 100	2 500	2 750
2) Between **live parts** of **input circuits** and **live parts** of **output circuits** (**double** or **reinforced insulation**)	500	2 800	4 200	5 000	5 500
3) Over **basic** or **supplementary insulation** between: a) **live parts** of different polarity b) **live parts** and the **body** if intended to be connected to protective earth c) accessible conductive parts and a metal rod of the same diameter as the flexible cable or cord (or metallic foil wrapped round the cord) inserted inside inlet bushing, cord guards and anchorage, and the like d) **live parts** and an intermediate conductive part e) intermediate conductive parts and the **body**	250	1 400	2 100	2 500	2 750
4) Over **reinforced insulation** between the **body** and **live parts**	500	2 800	4 200	5 000	5 500
* Values of test voltage for intermediate values of **working voltage** are found by interpolation between tabulated values.					

Initially, not more than half the prescribed voltage is applied, then it is raised rapidly to the full value.

No flashover or breakdown shall occur during the test, corona effects and similar phenomena being disregarded. Diagrams showing examples of the application of test voltages are shown in annex N.

*The high-voltage transformer used for the test shall be capable of supplying a current of at least 200 mA when the output terminals are short-circuited. The **overload releases** of the circuit shall not operate for any current less than 100 mA. The voltmeter used to measure the value of the test voltage shall be of class 2.5 according to IEC 60051.*

*Care shall be taken that the voltage applied for the test between **input** and **output circuits** does not over-stress other insulation. If it is stated by the manufacturer that a **double insulation** system exists between **input** and **output circuits**, such as from **input circuit** to core and from core to **output circuit**, each insulation is then tested separately according to the test voltage of item 3 of table 8. The same applies to a **double insulation** between input and the **body**.*

*For class II situations incorporating both **reinforced insulation** and **double insulation**, care shall be taken that the voltage applied to the **reinforced insulation** does not over-stress the **basic** or **supplementary insulation**.*

18.4 *After the test of 18.3, one **input circuit** is connected to a voltage equal to double the **rated supply voltage**, at double the **rated frequency** for 5 min. No load is connected to the transformer. During the test, polyfilar windings, if any, are connected in series.*

*A higher test frequency may be used; the duration of the period of connection, in minutes, then being equal to 10 times the **rated frequency** divided by the test frequency, but not less than 2 min.*

*During the test, there shall be no breakdown of the insulation between turns of a winding, between **input** and **output circuits**, between adjacent **input** or **output circuits**, or between the windings and any conductive core.*

19 Construction

19.1 The **input** and **output circuits** as specified in the relevant part 2 in general shall be separated by insulation, and the construction in general shall be such that there is no possibility of any connection, except by deliberate action, between these circuits, either directly or indirectly, through other metal parts.

19.2 Materials which burn fiercely, such as celluloid, shall not be used in the construction of transformers.

Cotton, silk, paper and similar fibrous material shall not be used as insulation, unless impregnated.

Wax and similar impregnates shall not be used, unless suitably restrained from migration.

Compliance is checked by inspection and, in case of doubt regarding fiercely burning materials, by the glow-wire test of 27.2.

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

Wood, even if impregnated, shall not be used as **supplementary** or **reinforced insulation**.

19.3 **Portable transformers** shall be either **short-circuit proof** or **fail-safe transformers**.

Compliance is checked by inspection.

19.4 Provisions shall be taken to prevent contact between accessible metal parts and conduits or metal sheaths of supply wiring for **class II transformers**.

Compliance is checked by inspection.

19.5 Parts of **class II transformers,** which serve as **supplementary insulation** or **reinforced insulation** and which might be omitted during reassembling after routine servicing, shall either:

- be fixed in such a way that they cannot be removed without being seriously damaged; or
- be so designed that they cannot be replaced in an incorrect position and that, if they are omitted, the transformer is rendered inoperable or is manifestly incomplete.

Compliance is checked by inspection and by manual test.

NOTE 1 – Sleeving may, however, be used as **supplementary insulation** on internal wiring, if it is retained in position by positive means.

NOTE 2 – A sleeve is considered to be fixed by positive means if it can be removed only by breaking or cutting, or if it is clamped at both ends.

NOTE 3 – Routine servicing includes replacement of switches, protective devices and of **power supply cords** when the type of attachment allows this.

NOTE 4 – Lining metal **enclosures** with a coating of lacquer or with material in the form of a coating which does not withstand the test of 19.10 is not considered to be adequate for the purpose of these requirements.

19.6 **Class I** and **class II transformers** shall be so constructed that, should any wire, screw, nut, washer, spring or similar part become loose or fall out of position, they cannot, in normal use, become so disposed that **creepage distances** or **clearances** over **supplementary insulation** or **reinforced insulation** or the distance between input and output terminals are reduced to less than 50 % of the value specified in clause 26.

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

NOTE – For the purpose of this requirement:

- it is not 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 removed during the replacement of the supply flexible cable or cord, or other routine servicing;
- conductors connected by soldering are not considered to be adequately fixed unless they are held in place near to the termination by means such as hooking in, independently of the solder;
- screwless terminals complying with IEC 60998-2-2 are considered to provide adequated fixing of the conductor without any additional means;
- wires connected to terminals are not considered to be adequately secured, unless an additional fixing of an appropriate type is provided near to the terminal; in the case of stranded conductors, this additional fixing is to clamp the insulation and not the conductor only;
- 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.

19.7 Parts connected to accessible metal parts by resistors or capacitors shall be separated from the **hazardous live parts** by **double insulation** or **reinforced insulation**.

*Compliance is checked by the tests for **double insulation** or **reinforced insulation**.*

19.8 Resistors or capacitors connected between **hazardous live parts** and accessible metal parts shall consist of at least two separate components whose impedance is unlikely to change significantly during the lifetime of the transformer. If any one of the components is short-circuited or open-circuited, the values specified in clause 9 shall not be exceeded.

Compliance is checked by inspection and by measurement.

NOTE – Resistors complying with 14.1 of IEC 60065 and capacitors complying with IEC 60384-14 are considered to be appropriate components. One capacitor complying with the requirements of class Y1 of IEC 60384-14 is also considered to be sufficient.

19.9 Insulating material separating **input** and **output windings**, and parts of natural or synthetic rubber used as **supplementary insulation** in **class II transformers**, shall be either resistant to ageing or so arranged and dimensioned that, whatever cracks may occur, **creepage distances** are not reduced below the values specified in clause 26.

Compliance is checked by inspection, by measurement and, in case of doubt concerning the ageing properties of rubber, by the following test.

Rubber parts are aged in an atmosphere of oxygen under pressure. The specimens are suspended freely in an oxygen bomb, the effective capacity of the bomb being at least 10 times the volume of the specimens. The bomb is filled with commercial oxygen not less than 97 % pure, to a pressure of (210^{+7}_{0}) *N/cm².*

The specimens are kept in the bomb at a temperature of $\left(70^{+1}_{0}\right)$ *for four days (96 h). Immediately afterwards they are taken out of the bomb and left at ambient temperature, avoiding direct daylight, for at least 16 h.*

After the test, the specimens are examined and shall show no cracks with normal vision or corrected vision without magnification.

NOTE – In case of doubt with regard to materials other than rubber, a special test may be made (c.f. 14.3 and 26.3).

The use of the oxygen bomb presents some danger, unless handled with care. All precautions should be taken to avoid the risk of explosion due to sudden oxidation.

19.10 When protection of **hazardous live parts** against accidental contact is ensured by an insulating coating, this coating shall be capable of withstanding the following tests.

a) Ageing test

The coated part is subjected to the conditions described in section one (test Ba) of IEC 60068-2-2, at a temperature of (70 ± 2) °C for a period of seven days (168 h).

After this treatment, the part is allowed to cool to ambient temperature and inspection shall show that the coating has not loosened or shrunk away from the base material.

b) Impact test

The part is then conditioned for a period of 4 h at a temperature of (–10 ± 2) °C. While still at this temperature, the coating is subjected to a blow, applied to any point of the layer that is likely to be weak, from a spring-operated impact hammer according to IEC 60068-2-63 with an energy of (0,5 ± 0,05) J.

After this test, the coating shall not be damaged. In particular, it shall show no cracks visible with normal vision, or corrected vision without magnification.

c) Scratch test

Finally, the part at the highest temperature attained under normal operating conditions is subjected to a scratch test. The scratches are made by means of a hardened steel pin, the end of which has the form of a cone having a top angle of 40°, its tip being rounded with a radius of (0,25 ± 0,02) mm.

Scratches are made by drawing the pin along the surface at a speed of about 20 mm/s as shown in figure 4. The pin is so loaded that the force exerted along its axis is (10 ± 0,5) N. The scratches are at least 5 mm apart and at least 5 mm from the edge of the specimen.

After this test, the coating shall neither have loosened nor be pierced, and it shall withstand a dielectric strength test as specified in clause 18, the test voltage being applied between the base material and a metal foil in contact with the layer.

NOTE – The tests may be made on a separate specimen of the coated part.

19.11 Handles, operating levers, knobs and the like shall be of insulating material or be adequately covered by **supplementary insulation**, or separated from their shafts or fixing by such insulation, if their shafts or fixing are likely to become live in the event of an insulation fault.

Compliance is checked by inspection and, if necessary, by the requirements specified for ***supplementary insulation.***

19.12 Winding construction

19.12.1 In all types of transformer, precautions shall be taken to prevent:

- undue displacement of **input** or **output windings** or the turns thereof;
- undue displacement of internal wiring or wires for external connections;
- undue displacement of parts of windings or of internal wiring, in the event of rupture of wires or loosening of connections;

Compliance is checked by inspection and by the tests of clause 16.

The last turn of each winding shall be prevented from being displaced.

NOTE 1 – Means of prevention may be:

- positive means such as tape, suitable bonding agent, or anchoring the wire;
- or process technology.

NOTE 2 – A **protective screen**, if necessary, in order to prevent eddy current losses due to creation of a short turn, should be so arranged that both edges can neither simultaneously touch each other nor touch an iron core.

19.12.2 Where serrated tape is used as insulation, it is assumed that the serration of the different layers will coincide. For distance through insulation, the reduced values of table 13, table C.1 and table D.1 may be used if one additional layer of serrated tape and one additional layer without serration placed at the location of the serration are used.

NOTE 1 – An example is given in M.2.1 b).

Where cheekless bobbins are used, the end turns of each layer shall be prevented from being displaced.

NOTE 2 – Each layer can, for example, be interleaved with adequate insulation material projecting beyond the end turns of each layer and, moreover:

- either the winding(s) may be impregnated with hard-baking or cold-setting material, substantially filling the intervening spaces and effectively sealing-off the end turns;
- or the winding(s) may be held together by means of insulating material or by process technology.

Compliance is checked by inspection and by the tests of clauses 16, 17, and 18.

19.12.3 Insulated winding wires, the insulation of which provides **basic**, **supplementary** or **reinforced insulation**, shall meet the following requirements.

These additional requirements are applicable to all types of transformers for **basic** or **supplementary insulation** taken separately, and to transformers for switch mode power supplies for all types of insulation even in combination.

NOTE – Additional requirements are under consideration to apply this technology to all types of transformers, including combination of insulation.

Insulated winding wires of wound parts shall meet the following requirements:

a) where the insulation on the winding wire is used to provide **basic** or **supplementary insulation** in a wound component without additional interleaved insulation:

- the insulated wire (for example polyimide or insulation of equivalent quality) shall comply with annex K;
- the insulation of the conductor shall consist of at least two layers;

b) where the insulation on the winding wire is used to provide **double** or **reinforced insulation** in a wound part:

- the insulated wire (for example polyimide or insulation of equivalent quality) shall comply with annex K;
- the insulation of the conductor shall consist of at least three layers;
- two adjacent insulated wires that are adjacent to each other are considered to be separated by **double insulation** if the insulation of each conductor is rated for the **working voltage**;

c) the manufacturer shall demonstrate that the wire in the finished component has been subjected to 100 % routine dielectric strength test as in K.3.

For windings giving **double** or **reinforced insulation,** the following additional tests and requirements shall be fulfilled:

- thermal cycling test in accordance with 14.3;
- test from 27.3 – Resistance to heat, abnormal heat, fire and tracking;
- in table 13, table C.1 and table D.1, box 2) c), no value is required.

19.13 Handles, operating levers and the like shall be fixed in a reliable manner so that they will not become loose as a result of heating, vibration, etc. which may occur in normal use.

Compliance is checked by inspection and by the tests of clauses 14 and 16.

19.14 Covers providing protection against electric shock shall be securely fixed. The fixing shall be achieved by at least two independent means, one of which at least requires the use of a **tool**.

Compliance is checked by inspection and by manual test.

NOTE 1 – The cover may incorporate a means, such as a notch or a rim, which forms one of the required fixing means.

NOTE 2 – Screws may be used as means requiring the use of a **tool**, but knurled nuts or screws, even if they have provision for sealing, are not suitable.

19.15 Transformers provided with pins intended to be introduced into fixed socket-outlets shall not impose undue strain on these socket-outlets.

Compliance is checked by inserting the transformer, as in normal use, into a fixed socket-outlet complying with IEC 60083, the socket-outlet being pivoted about the horizontal axis through the central lines of the contact tubes at a distance of 8 mm behind the engagement face of the socket-outlet.

The additional torque which has to be applied to the socket-outlet to maintain the engagement face in the vertical plane shall not exceed 0,25 Nm.

19.16 **Portable transformers** with a **rated output** not exceeding 200 VA shall either be an **ordinary transformer** or have a protection index IP20 or higher. For **ordinary transformers** and transformers having a protection index of IPX0, it shall be stated in the instructions for use that such transformers are only intended for indoor use.

Portable transformers having a **rated output** exceeding 200 VA but not exceeding 2,5 kVA for single-phase transformers, or not exceeding 6,3 kVA for polyphase transformers, shall have a protection index IPX4 or higher.

Portable transformers having a **rated output** exceeding 2,5 kVA for single-phase transformers, or exceeding 6,3 kVA for polyphase transformers, shall have a protection index IP21 or higher.

19.17 Transformers having a protection index from IPX1 up to and including IPX6 shall have an effective drain hole at least 5 mm in diameter or 20 mm² in area, with a width of at least 3 mm.

The drain hole is not required if the transformer, including winding and core, is completely filled with insulating materials.

Transformers having a protection index IPX7 or higher shall be totally enclosed when installed in the correct manner.

19.18 Transformers having a protection index higher than IPX1 shall be provided with a moulded-on plug, if any.

19.19 **Class I transformers** designed for connection by means of a flexible cable or cord, shall be provided with a non-detachable flexible cable or cord with earthing conductor and a plug with earthing contact.

Compliance with the requirements of 19.16 to 19.19 is checked by inspection, by measurement, and by the tests of 17.1.

19.20 **Live parts** of **SELV-** and **PELV-circuits** shall be electrically separated from each other and from other circuits. Arrangements shall ensure electrical separation not less than between the **input** and the **output circuit** of a **safety isolating transformer,** taking the relevant **working voltage** into account.

NOTE 1 – This requirement does not exclude the connection of **PELV-circuit** to earth.

NOTE 2 – In particular, electrical separation not less than that provided between the **input** and the **output windings** of a **safety isolating transformer** is necessary between the **live parts** of electrical equipment such as relays, contactors, auxiliary switches, and any part of higher voltage circuit.

*Compliance is checked by compliance with 19.20.1 for **SELV-circuits** and 19.20.2 for **PELV-circuits***

19.20.1 **Live parts** of **SELV-circuits** shall not be connected to earth, to **live parts,** or protective conductors forming part of other circuits.

Exposed conductive parts of **SELV-circuits** shall not intentionally be connected to:

- earth; or
- protective conductors or exposed conductive parts of another circuit; or
- extraneous conductive parts, except where electrical equipment is inherently required to be connected to extraneous conductive parts, and it is ensured that those parts cannot attain a voltage exceeding the nominal voltage specified for **SELV**.

NOTE – If the exposed conductive parts of **SELV-circuits** are liable to come into contact, either fortuitously or intentionally, with the exposed conductive parts of other circuits, protection against electric shock no longer depends solely on protection by **SELV**, but also on the protective measures to which the latter exposed conductive parts are subjected.

If the nominal voltage exceeds 25 V a.c. or 60 V ripple-free d.c., protection against direct contact shall be provided by insulation capable of withstanding a test voltage for **double** or **reinforced insulation** according to table 8.

If the nominal voltage does not exceed 25 V a.c. or 60 V ripple-free d.c., protection against direct contact is generally unnecessary. However, it may be necessary under certain conditions of external influences (see relevant part 2).

19.20.2 For **PELV-circuits**, the following requirements shall be fulfilled.

Protection against direct contact shall be ensured by insulation capable of withstanding a test voltage for **double** or **reinforced insulation** according to table 8.

NOTE – This requirement implies that **PELV-circuits** have to be insulated even for voltages below 25 V a.c. or 60 V ripple-free d.c. Exempted are **live parts** directly connected to earth.

19.21 For **FELV-circuits**, the following requirements shall be fulfilled to ensure protection against both direct and indirect contact.

NOTE – Such conditions may, for example, be ensured when the circuit contains equipment (such as transformers, relays, remote-control switches, contactors) insufficiently insulated with respect to circuits at higher voltages.

Protection against indirect contact shall be provided by insulation corresponding to the minimum test voltage required for the primary circuit.

19.22 **Class II transformers** shall not be provided with means for protective earthing.

However, a fixed **class II transformer** intended for looping-in may have an internal terminal for maintaining the electrical continuity of an earthing conductor not terminating in the transformer, provided that the terminal is insulated from the accessible metal parts by class II insulation.

Compliance is checked by inspection.

19.23 **Class III transformers** shall not be provided with means for protective earthing.

Compliance is checked by inspection.

20 Components

20.1 Components such as switches, plugs, fuses, lampholders, capacitors and flexible cables and cords shall comply with the relevant IEC standard as far as it reasonably applies.

Appliance couplers for mains supply shall comply with IEC 60320 for IPX0 transformers and IEC 60309 for other transformers.

Automatic controls shall comply with IEC 60730-1 unless they are tested with the appliance.

Thermal-links shall comply with IEC 60691 as far as reasonable.

Switches shall comply with IEC 61058 as stated in annex F.

The testing of these components is, in general, carried out separately, according to the relevant standard, as follows:

- *components marked with individual ratings are checked to establish that they suit the conditions which may occur in the transformer, including inrush current. The component is then tested in accordance with its marking, the number of specimens being that required by the relevant standard;*
- *components not marked with individual ratings are tested under the conditions occurring in the transformer, including inrush current, the number of specimens being, in general, that required by the relevant standard;*
- *where no IEC standard exists for the relevant component, or where the component is not marked, or where the component is not used in accordance with its marking, the component is tested under the conditions occurring in the transformer; the number of specimens being, in general, that required by a similar specification.*

NOTE – Fuses according to IEC 60127 and IEC 60269 are allowed to be continuously loaded by a current not exceeding 1,1 times the rated value.

Components incorporated in or supplied with the transformers are subjected to all tests of this standard as part of the transformer.

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

20.2 Switches intended to disconnect the transformer from the supply shall disconnect all poles and shall have a contact separation of at least 3 mm in each pole.

The requirements with regard to all-pole disconnection and contact separation do not apply to transformers which are intended to be connected to the supply by means of a flexible cable or cord and a plug, or to transformers accompanied by an instruction sheet stating that such means for disconnection shall be incorporated in the fixed wiring.

Compliance is checked by inspection.

20.3 Socket-outlets in the **output circuit** shall be such that there is no dangerous compatibility between such a socket-outlet and a plug intended for direct connection to a socket-outlet which could be used for the **input circuit** in relation to installation rules, voltages and frequencies.

[C11] Plugs and socket-outlets for SELV systems with both a rated current ≤ 3 A and a rated voltage ≤ 24 V shall comply with the following requirements:

- plugs shall not be able to enter socket-outlets of other standardised voltage systems;
- socket-outlets shall not admit plugs of other standardised voltage systems;
- socket-outlets shall not have a protective earthing contact.

Other plugs and socket-outlets for SELV systems shall comply with the requirements of IEC 60906-3 and IEC 60884-2-4. [C11]

[C] NOTE – As IEC 60906-3 covers only 6, 12, 24, 48 V, the attention of the appliance manufacturer is called that:
- either their appliance with intermediate supply voltage shall be able to withstand the immediate upper voltage;
- or, to ask for SC 23C of IEC to design intermediate values.

Other plugs and socket-outlets systems are allowed for associated transformers only. [C]

Plugs and socket-outlets for **PELV** systems shall comply with the following requirements:

- plugs shall not be able to enter socket-outlets of other standardized voltage systems;
- socket-outlets shall not admit plugs of other standardized voltage systems;
- socket-outlets shall not have a protective earthing contact.

NOTE – This does not preclude the use of socket-outlets incorporating functional bonding contact.

Plugs and socket-outlets for **FELV** systems shall comply with the following requirements:

- plugs shall not be able to enter socket-outlets of other standardized voltage systems; and
- socket-outlets shall not admit plugs of other standardized voltage systems.

Compliance is checked by inspection and by manual test.

20.4 **Thermal cut-outs, overload releases**, fuses and other overload protecting devices shall have adequate breaking capacity.

Compliance is checked by the relevant test of 20.5 or 20.6.

20.5 **Thermal cut-outs** shall meet one of the following requirements.

20.5.1 The **thermal cut-out** when tested as a separate component shall comply with the requirements and tests of IEC 60730-1 as far as applicable.

For the purpose of this standard the following applies.

a) The **thermal cut-out** shall be of type 1 or type 2 (see 6.4 of IEC 60730-1).

b) The **thermal cut-out** shall have at least micro-disconnection (type 2B) (see 6.4.3.2 and 6.9.2 of IEC 60730-1).

c) The **thermal cut-out** shall have a trip free mechanism in which contacts cannot be prevented from opening against a continuation of a fault (type 2E) (see 6.4.3.5 of IEC 60730-1).

d) The number of cycles of automatic action shall be:

– 3 000 cycles for **thermal cut-outs with self-resettable reset**;

– 300 cycles for **thermal cut-outs that are non-self-resettable**, and which are reset when the transformer is disconnected, and for **thermal cut-outs** which can be reset by hand without the use of a **tool** to reach the reset (see 6.11.10 of IEC 60730-1);

– 30 cycles for **thermal cut-outs** with no automatic reset, and which cannot be reset by hand without the use of a **tool** to reach the reset (see 6.11.11 of IEC 60730-1).

e) The **thermal cut-out** shall be tested as designed for a long period of electrical stress across insulating parts (see 6.14.2 of IEC 60730-1).

f) The characteristics of the **thermal cut-out** with regard to:

– the ratings of the **thermal cut-out** (see clause 5 of IEC 60730-1);

– the classification of the **thermal cut-out** according to:

1) nature of supply (see 6.1 of IEC 60730-1),

2) type of load to be controlled (see 6.2 of IEC 60730-1),

3) degree of protection provided by **enclosures** against ingress of solid objects and dust (see 6.5.1 of IEC 60730-1),

4) degree of protection provided by **enclosures** against harmful ingress of water (see 6.5.2 of IEC 60730-1),

5) **pollution** situation for which the **thermal cut-out** is suitable (see 6.5.3 of IEC 60730-1),

6) comparative tracking index for which the **thermal cut-out** is suitable (see 6.13 of IEC 60730-1),

7) maximum ambient temperature limit (see 6.7 of IEC 60730-1)

shall be appropriate for the application in the apparatus under normal operating conditions and under fault conditions.

20.5.2 The **thermal cut-out** when tested as a part of the transformer shall:

– have at least micro-disconnection according to IEC 60730-1 withstanding a test voltage according to 13.2 of IEC 60730-1;

– have a trip free mechanism in which contacts cannot be prevented from opening against a continuation of a fault;

– be aged for 300 h at a temperature corresponding to the ambient temperature of the **thermal cut-out** when the transformer is operated under normal operating conditions at an ambient temperature of 35 °C or, where relevant, t_a + 10 °C;

– be subjected to a number of cycles of automatic action as specified under 20.5.1 for **thermal cut-outs** tested as a separate component, by establishing the relevant fault condition(s).

The tests are carried out on three samples.

Compliance is checked by inspection and by the specified tests in the given order.

During these tests, no sustained arcing shall occur, and there shall be no damage from other causes.

*After the test, the **thermal cut-out** shall show no damage in the sense of this standard; in particular, it shall show no deterioration of its **enclosure**, no reduction of **clearances** and **creepage distances**, and no loosening of electrical connections or mechanical fixing.*

20.5.3 A PTC resistor of the indirect heating type is considered in this standard as a **non-self-resetting thermal cut-out**.

Compliance is checked by the following test:

The transformer is connected for 48 h (two days) at 1,1 times the rated input voltage with the output terminals short-circuited.

- *After 48 h, the transformer shall be allowed to cool down to approximately ambient temperature; this test shall be repeated five times at the maximum ambient temperature declared for the transformer.*
- *The same test cycles shall be repeated but at 0,9 times the rated input voltage and the minimum ambient temperature declared for the transformer.*

During the part of the cycle where the transformer is under load, the PTC shall operate and stay in high impedance position until the supply is switched off. At the end of the test, the transformer shall withstand the test of clause 18, shall show no damage, and shall work correctly in the sense of this standard.

20.6 **Thermal-links** shall meet one of the following requirements.

20.6.1 The **thermal-link**, when tested as a separate component, shall comply with the requirements and tests of IEC 60691.

If the **thermal-link** is tested according to IEC 60691, the following applies:

Its characteristics with regard to:

- the ambient conditions (see 6.1 of IEC 60691);
- the circuit conditions (see 6.2 of IEC 60691);
- the ratings of the **thermal-link** (see 8 b) of IEC 60691);
- the suitability for sealing in, or use with, impregnating fluids or cleaning solvents (see 8 c) of IEC 60691);

shall be appropriate for the application in the apparatus under normal operating conditions and under short-circuit and overload conditions.

Compliance is checked according to the test specification of IEC 60691, by inspection and measurement.

20.6.2 The **thermal-link** when tested as a part of the transformer:

- shall be aged for 300 h at a temperature corresponding to the ambient temperature of the **thermal-link** when the transformer is operated under normal operating conditions at an ambient temperature of 35 °C or, where relevant, t_a + 10 °C;
- shall be subjected to those fault condition(s) of the transformer which cause the **thermal-link** to operate. During the test, no sustained arcing and no damage in the sense of this standard shall occur;
- shall be capable of withstanding two times the voltage across the disconnection, and have an insulation resistance of at least 0,2 MΩ when measured with a voltage equal to two times the voltage across the disconnection.

The test is made 10 times; no failure is allowed.

The **thermal-link** is replaced, partially or completely, after each test.

Where the **thermal-link** is not replaceable, the test is made on three new specimens.

Compliance is checked by inspection and by specified tests in the given order.

20.7 Self-resetting devices shall not be used unless it is certain that there will be no hazards, mechanical, electrical or otherwise, resulting from their operation.

Compliance is checked by inspection.

20.8 **Thermal cut-outs** intended to be reset by a soldering operation shall not be used for overload protection.

Compliance is checked by inspection.

20.9 Overload protection devices shall not operate when the supply voltage is switched on.

Compliance is checked by the following test.

The transformer, with no load, is connected to a voltage equal to 1,06 times ***rated supply voltage****. The supply voltage is then switched on and off 20 times at intervals of approximately 10 s.*

The supply source shall be such that there is no appreciable drop in voltage as a result of inrush current.

21 Internal wiring

21.1 Internal wiring and electrical connections between different parts of the transformer shall be adequately protected or enclosed.

Wire-ways shall be smooth and free from sharp edges, burrs, flashes etc. which may damage the insulation of conductors.

21.2 Openings in sheet metal through which insulated wires pass shall have rounded edges with a radius not less than 1,5 mm, or the openings shall be provided with bushing of insulating material.

21.3 Bare conductors shall be so fixed that the distance from one another and from the **enclosure** is adequately maintained.

Compliance with the requirements of 21.1 to 21.3 is checked by inspection.

21.4 Internal wiring shall not work loose when external wires are connected to the input or output terminals.

Compliance is checked by inspection and by the test of 23.3.

21.5 Insulated conductors which, in normal use, are subjected to a temperature exceeding the limiting values given in 14.2 shall have an insulation of heat-resisting and non-hygroscopic material, if compliance with this standard is likely to be impaired by deterioration of the insulation.

Compliance is checked by inspection and, if necessary, by additional tests; the temperature is determined during the test of 14.2.

22 Supply connection and other external flexible cables or cords

22.1 All cables, flexible cords and connecting means referred to in clause 22 shall have appropriate current and voltage ratings suitable for the ratings of the transformers to which they are connected.

Compliance is checked by inspection.

22.2 Separate entries shall be provided for the input and output wiring.

Inlet and outlet openings for external wiring shall be so designed that the protective covering of the cord can be introduced without risk of damage.

Inlet and outlet openings for flexible cables or cords shall be of insulating material, or be provided with bushing of insulating material which is substantially free from ageing effects under conditions expected in service. The openings of bushings shall be so shaped as to prevent damage to the cord.

Bushings for external wiring shall be reliably fixed, and shall be such that they are unlikely to be damaged by the material in which they are mounted.

Bushings shall not be of natural rubber unless they form part of a cord guard (see 22.9).

NOTE – These requirements do not preclude the use of removable bushings.

Compliance is checked by inspection.

22.3 **Fixed transformers** shall be so designed that, after the transformer has been fixed to its support in the normal way, it shall be possible to connect the rigid or flexible conductors of the external wiring.

Transformers other than those intended to be permanently connected to fixed wiring may be provided with an appliance inlet on the input side.

The space for the wires inside the transformer shall be adequate to allow the conductors to be easily introduced and connected, and the cover, if any, fitted without risk of damage to the conductors or their insulation.

It shall be possible to connect the external supply wires to terminals without their insulation coming into contact with **hazardous live parts** of a different polarity from that of the relevant wire, including **live parts** of the **output circuits**.

Compliance is checked by inspection and by an installation test with conductors of the largest cross-sectional area corresponding to the rated connecting capacity of the terminals.

22.4 **Portable transformers**, other than those intended to be mounted directly on a socket-outlet, shall be provided with a **power supply cord** (see 3.2.1) having a length between 2 m and 4 m.

Portable transformers which are permitted to be provided with a **power supply cord** having a cross-sectional area of 0,5 mm² are excepted from this requirement.

Compliance is checked by inspection.

[C] **22.5 Power supply cords** of transformers with protection index IPX0 shall be not lighter than ordinary tough rubber sheathed flexible cable or cords (code designation HO RR-F),or ordinary polyvinyl chloride sheathed flexible cable or cords (code designation HO5 VV-F or HO5 VVH2 -F).

Power supply cords of transformers with protection index greater than IPXO shall be not lighter than ordinary polychloroprene sheathed cord (code designation HO5 RN-5 , except for transformers for indoor use only.

For IPXO transformers with a mass less than 3 kg, the power supply cords shall be not lighter than HO3 VV-F. [C]

22.6 **Power supply cords** may be a cord set fitted with an appliance coupler in accordance with IEC 60320, provided that the transformer is a single-phase **portable transformer**, having an input current at **rated output** not exceeding 16 A.

22.7 The nominal cross-sectional area of **external flexible cable or cords** shall be not less than that shown in table 9.

Table 9 – Nominal cross-sectional areas of external flexible cable or cords

Input or output current at rated output A	**Nominal cross-sectional areas** mm²
Up to and including 3*	0,5
Over 3 up to and including 6	0,75
Over 6 up to and including 10	1
Over 10 up to and including 16	1,5
Over 16 up to and including 25	2,5
Over 25 up to and including 32	4
Over 32 up to and including 40	6
Over 40 up to and including 63	10
* These cords may be used as **power supply cords** if their length does not exceed 2 m between the point where the cord or cord guard enters the transformer and the entry to the plug.	
NOTE – In Japan, cords having a nominal cross-sectional area of 0,5 mm² are not allowed for external **power supply cord**.	

Compliance is checked by inspection and by measurement.

22.8 **Power supply cords** of **class I transformers** shall be provided with a green/yellow covered core, which is connected to the earthing terminal of the transformer and to the earthing contact of the plug, if any.

Power supply cords of single-phase **portable transformers** having an input current at **rated output** not exceeding 16 A shall be provided with a plug complying with IEC 60083 or IEC 60906-1. Other **portable transformers** may be provided with a plug complying with IEC 60309.

Compliance is checked by inspection.

22.9 **External flexible cable or cords** shall be attached to the transformer by **type X**, **Y** or **Z attachments** unless otherwise specified in the relevant part 2.

Compliance is checked by inspection and, if necessary, by manual test.

22.9.1 For **type Z attachments**, moulding the **enclosure** of the transformer and the **external flexible cable or cord** together shall not affect the insulation of the cord.

Compliance is checked by inspection.

22.9.2 Inlet openings shall be so designed and shaped, or shall be provided with an inlet bushing, so that the protective covering of the **external flexible cable or cord** can be introduced without risk of damage.

The insulation between the conductor and the **enclosure** shall consist of the insulation of the conductor and, in addition:

- for **class I transformers**, at least **basic insulation**;
- for **class II transformers**, at least **double** or **reinforced insulation**.

NOTE 1 – The sheath of an **external flexible cable or cord** equivalent to at least that of a cord complying with IEC 60227 or 60245 is regarded as a **basic insulation**.

NOTE 2 – A lining of insulating material is regarded as a **supplementary insulation** if it complies with the relevant requirements.

NOTE 3 – In the case of metal **enclosures**, a bushing of insulating material is regarded as a **supplementary insulation** if it complies with the relevant requirements.

NOTE 4 – An **enclosure** of insulating material is regarded as **reinforced insulation**, in which case two separate insulations are not necessary.

Compliance is checked by inspection and by manual test.

22.9.3 Inlet bushings shall:

- be so shaped as to prevent damage to the **external flexible cable or cord**;
- be reliably fixed;
- not be removable without the aid of a **tool**;
- not be of natural rubber, except if it is an integral part of the rubber sheath of the **external flexible cable or cord** for **type X** with a special cord, **type Y** and **type Z attachments** for **class I transformers**.

Compliance is checked by inspection and by manual test.

22.9.4 Transformers provided with cords which are moved while in operation shall be constructed so that the cord is adequately protected against excessive flexing where it enters the transformer. Cord guards, if any, shall be of insulating material and be fixed in a reliable manner.

Compliance is checked by the following test which is made on an apparatus having an oscillating member as shown in figure 7.

The part of the transformer comprising the cord entry, the cord guard, if any, and the ***external flexible cable or cord*** *is fixed to the oscillating member so that, when the latter is at the middle of its travel, the axis of the cord where it enters the cord guard or inlet is vertical and passes through the axis of oscillation. The major axis of the section of flat cords shall be parallel to the axis of oscillation.*

The cord is loaded so that the force applied is:

- *10 N for cords having a cross-sectional area exceeding 0,75 mm²;*
- *5 N for other cords.*

The distance A shown in figure 7, between the axis of oscillation and the point where the cord guard enters the transformer, is adjusted so that when the oscillating member moves over its full range, the cord and load make the minimum lateral movement.

The oscillating member is moved through an angle of 90° (45° on either side of the vertical), the number of flexings for ***type Z attachments*** *being 20 000, and for other attachments 10 000. The rate of flexing is 60 per min.*

NOTE 1 – A flexing is one movement of 90°.

The cord and its associated parts are turned through an angle of 90° after half the number of flexings, unless a flat cord is fitted.

During the test, the conductors are loaded with the maximum rated current of the circuit in question, at rated voltage.

NOTE 2 – Current is not passed through the earthing conductor.

The test shall not result in:

- *a short circuit between the conductors;*
- *breakage of more than 10 % of the strands of any conductor;*
- *separation of the conductor from the terminal;*
- *loosening of any cord guard;*
- *damage, within the meaning of this standard, to the cord or cord guard;*
- *broken strands piercing the insulation and becoming accessible.*

NOTE 3 – Conductors include earthing conductors.

NOTE 4 – A short circuit between conductors of the cord is considered to occur if the current exceeds a value equal to twice the rated maximum current of the circuit in question.

22.9.5 **Stationary transformers** intended for use with an **external flexible cable or cord** and **portable transformers** shall have cord anchorages so that the conductors are relieved from strain, including twisting, where they are connected within the transformer, and so that the insulation of the conductors is protected from abrasion.

For **type X attachments**, glands shall not be used as cord anchorages in **portable transformers** unless they have provision for clamping all types and sizes of cables and cords which might be used as **external flexible cable or cords**. Production methods, such as moulded-on designs, tying the cord into a knot or tying the ends with string, are not allowed; labyrinths or similar means are permitted, provided that it is clear how the **external flexible cable or cord** is to be assembled.

For **type X attachments,** the cord anchorage shall be so designed or located that:

- replacement of the cord is possible easily;
- it is clear how the relief from strain and the prevention of twisting are to be obtained;
- it is suitable for the different types of cord which may be connected, unless the transformer is designed so that only one type of cord can be fitted;
- the whole flexible cable or cord with its covering, if any, is capable of being mounted into the cord anchorage;
- it does not damage the cord and is unlikely to be damaged when it is tightened or loosened in normal use;
- the cord cannot touch the clamping screws of the cord anchorage if these screws are accessible or electrically connected to accessible metal parts;
- 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 transformer;
- screws, if any, which have to be operated when replacing the cord do not serve to fix any other component, unless, when omitted or incorrectly mounted, they render the transformer inoperative or clearly incomplete, or unless the parts intended to be fastened by them cannot be removed without the aid of a **tool** during the replacement of the cord;
- for **class I transformers**, it is of insulating material or, if of metal, is provided with an insulating lining if an insulation fault on the cord could make accessible metal parts live;
- for **class II transformers**, it is of insulating material, or, if of metal, is insulated from accessible metal parts by insulation complying with the requirements for **supplementary insulation.**

For **type X** with a special cord, **type Y** and **type Z attachments**, the cores of the **external flexible cable or cord** shall be insulated from accessible metal parts by insulation complying with the requirements for **basic insulation** for **class I transformers**, and complying with the requirements for **supplementary insulation** for **class II transformers**.

This insulation may consist of:

- a separate insulating barrier fixed to the cord anchorage;
- a special lining fixed to the cord; or
- for **class I transformers**, the sheath of a sheathed cord.

For **type X** with a special cord and **type Y attachments**, the cord anchorage shall be so designed that:

- the replacement of the **external flexible cable or cord** does not impair compliance with this standard;
- the whole flexible cable or cord with its covering, if any, is capable of being mounted into the cord anchorage;
- it does not damage the cord and is unlikely to be damaged when it is tightened or loosened in normal use;
- the cord cannot touch clamping screws of the cord anchorage, if these screws are accessible or electrically connected to accessible metal parts;

- the cord is not clamped by a metal screw which bears directly on the cord;
- knots in the cord are not to be used;
- labyrinths or similar means are permitted, provided that it is clear how the **external flexible cable or cord** is to be assembled.

Compliance is checked by inspection and by the following test.

*For **type X attachments**, except with a special cord, the transformer is fitted with a suitable **external flexible cable or cord**. The conductors are introduced into the terminals, the terminal screws, if any, being tightened just sufficiently to prevent the conductors from easily changing their position. The cord anchorage is used in the normal way, its clamping screws being tightened with a torque equal to two-thirds of that specified in table 11.*

The tests are first made with the lightest permissible type of cord of the smallest cross-sectional area specified in table 9 and then with the next heavier type of cord of the largest cross-sectional area specified, unless the transformer is so designed that only one type of cord can be fitted.

*For **type X** with a special cord, **type Y** and **type Z attachments**, the transformer is tested with the cord in place.*

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

The cord is then subjected 25 times to a pull of the value shown in table 10. The pulls are applied in the most unfavourable direction without jerks, each time for 1 s.

Immediately afterwards, the cord is subjected for 1 min to a torque of the value shown in table 10.

Table 10 – Pull and torque to be applied to external flexible cable or cords

Mass of transformer kg	Pull N	Torque Nm
Up to and including 1	30	0,1
Over 1 up to and including 4	60	0,25
Over 4	100	0,35

The cord shall not be damaged during the tests.

After the tests, the cord shall not have been longitudinally displaced by more than 2 mm, and the conductors shall not have moved over a distance of more than 1 mm in the terminals, nor shall there be appreciable strain at the connection.

***Creepage distances** and **clearances** shall not be reduced below the values specified in clause 26.*

For the measurement of the longitudinal displacement, a mark is made on the cord which is subjected to a pull, at a distance of approximately 20 mm from the cord anchorage or other suitable point, before starting the tests.

After the tests, the displacement of the mark on the cord in relation to the cord anchorage or other point is measured, while the cord is still subjected to a pull.

22.9.6 The space for the supply cables or the **external flexible cable or cord** provided inside, or added as a part of the transformer for the connection:

a) to fixed wiring and for **type X** and **Y attachments**:

– shall be so designed as to permit checking, before fitting the cover, if any, that the conductors are correctly connected and positioned;

– shall be so designed that covers, if any, can be fitted without risk of damage to the conductors or their insulation;

– for **portable transformers**, shall be so designed that the uninsulated end of the conductor, should it come free from the terminal, cannot come into contact with accessible metal parts, unless, for **type X** and **Y attachments**, the cord is provided with terminations that are unlikely to slip free of the conductor;

b) to fixed wiring and for **type X attachments**, in addition:

– shall be adequate to allow the conductors to be easily introduced and connected;

– shall be so designed that covers, if any, giving access to terminals for external conductors can only be removed with the aid of a **tool**.

Compliance is checked by inspection and by manual tests.

23 Terminals for external conductors

23.1 Transformers intended to be permanently connected to fixed wiring, and transformers other than those provided with external flexible cords with **type Y** or **type Z attachments** shall be provided with terminals in which connection is made by means of screws, nuts or equally effective devices.

Terminals which are integral part of the transformer have to comply with IEC 60999-1 under the conditions prevailing in the transformer.

Other terminals shall be:

[C] – either separately checked according to IEC 998-2-1, IEC 998-2-2 or IEC 60947-7-1 and used in accordance with their marking, or [C]

– checked according to IEC 60999-1 under the conditions prevailing in the transformer.

For transformers with **type X attachment**, soldered connections may be used for external conductors, provided that the conductor is so positioned or fixed that reliance is not placed upon the soldering alone to maintain the conductor in position, unless barriers are provided so that **creepage distances** and **clearances** between **hazardous live parts** and other metal parts cannot be reduced to less than 50 % of the values specified in clause 26, should the conductor break away at the soldered joint.

For transformers with **type Y** and **type Z attachments**, soldered, welded, crimped and similar connections may be used for external conductors.

For **class II transformers**, the conductor shall be so positioned or fixed that reliance is not placed upon the soldering, crimping, or welding alone to maintain the conductor in position, unless barriers are provided so that **creepage distances** and **clearances** between **hazardous live parts** and other metal parts cannot be reduced to less than 50 % of the values specified in clause 26, should the conductor break away at the soldered or welded joint, or slip out of the crimped connections.

NOTE – In general, hooking-in before soldering is considered to be a suitable means for retaining the conductor of a flexible cable or cord in position, provided that the hole through which the conductor is passed is not unduly large.

23.2 Terminals for **type X** with a special cord, **Y** and **Z attachments** shall be suitable for their purpose.

Compliance with the requirements of 23.1, and 23.2 is checked by inspection and by applying a pull of 5 N to the connection immediately before the test of 14.2.

23.3 Terminals, other than those with **type Y** or **Z attachments**, shall be so fixed that, when the clamping means is tightened or loosened, the terminal does not work loose, internal wiring is not subjected to stress, and **creepage distances** and **clearances** are not reduced below the values specified in clause 26.

23.4 Terminals, other than those with **type Y** or **Z attachments**, shall be so designed that they clamp the conductor between metallic surfaces with sufficient contact pressure, and without damage to the conductor.

Compliance with the requirements of 23.3 and 23.4 is checked by inspection and by measurement after fastening and loosening 10 times a conductor of the largest cross-sectional area corresponding to the rated connecting capacity of the terminal, the torque applied being equal to two-thirds of the torque specified in clause 25.

NOTE – Locking with sealing compound, without other means of clamping, is not considered sufficient. However, self-hardening resins may be used to lock terminals which are not subjected to torsion in normal use.

23.5 Terminals provided for the connection to fixed wiring, and terminals with **type X attachment** shall be located near their associated terminals of different polarities and the earthing terminal, if any.

Compliance is checked by inspection.

23.6 Terminal blocks and similar devices shall not be accessible without the aid of a **tool**, even if their **hazardous live parts** are not accessible.

Compliance is checked by inspection and by manual test.

23.7 Terminals or terminations of transformers with **type X attachment** shall be so located or shielded that, should a wire of a stranded conductor escape when the conductors are fitted, there shall be no risk of accidental connection between **live parts** and accessible metal parts and, in the case of **class II transformers**, between **live parts** and metal parts separated from accessible metal parts by **supplementary insulation** only.

Compliance is checked by inspection, by manual test and by the following test.

An 8 mm length of insulation is removed from the end of a flexible conductor having a nominal cross-sectional area as specified in clause 22. One wire of the stranded conductor is left free, and the other wires are fully inserted into and clamped in the terminal.

The free wire is bent, without tearing the insulation back, in every possible direction, but without making sharp bends round barriers. The free wire of a conductor connected to a live terminal shall not touch any metal part which is accessible, or which is connected to an accessible metal part or, for ***class II transformers****, any metal part which is separated from accessible metal parts by* ***supplementary insulation*** *only. The free wire of a conductor connected to an earthing terminal shall not touch any* ***hazardous live part****.*

Terminals without pressure plate shall be provided with at least two clamping screws if the current exceeds 25 A.

23.8 Terminal screws, other than screws of terminals for the connection of protective earthing conductors, shall not come into contact with any metal part which is accessible, or which is connected to an accessible metal part, or, for **class II transformers**, inaccessible metal parts, when the screw is loosened as far as possible.

Compliance is checked by inspection during the test of 23.2.

24 Provision for protective earthing

24.1 Accessible metal parts of **class I transformers** which may become live in the event of an insulation fault shall be permanently and reliably connected to a protective earthing terminal within the transformer.

Class II transformers shall have no provision for earthing the transformer.

Compliance is checked by inspection.

NOTE – If accessible metal parts are screened from **hazardous live parts** by metal parts which are connected to the protective earthing terminal, or if they are separated from **hazardous live parts** by **double insulation** or **reinforced insulation**, they are not, for the purpose of this requirement, regarded as likely to become live in the event of an insulation fault.

24.2 Protective earthing terminals for connection to fixed wiring, and protective earthing terminals with **type X attachment** shall comply with the requirements of clause 23. Their clamping means shall be adequately locked against accidental loosening, and it shall not be possible to loosen them without the aid of a **tool**.

Compliance is checked by inspection, by manual test and by the tests of clause 23.

NOTE – In general, the designs 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 designs, special provisions, such as the use of an adequately resilient part, which is not likely to be removed inadvertently, may be necessary.

24.3 All parts of the protective earthing terminal 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 that is in contact with these parts.

If the **body** of the protective earthing terminal is 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.

The **body** of the protective earthing terminal shall be of brass or other metal not less resistant to corrosion, unless it is a part of the metal frame or **enclosure**, in which case the screw or nut shall be of brass or other metal equally resistant to corrosion.

24.4 The connection between the protective earthing terminal and parts required to be connected thereto shall be of low resistance.

Compliance is checked by the following test.

A current derived from an a.c. source, having a no-load voltage not exceeding 12 V and equal to 1,5 times the rated input current or to 25 A, whichever is greater, is passed for 1 min between the protective earthing terminal and each of the accessible metal parts in turn.

NOTE 1 – Rated input current is determined as the quotient of the **rated output** by the **rated supply voltage** or, for polyphase transformers, by $\sqrt{n}$ times the **rated supply voltage**, n being the number of phase.

The voltage drop between the protective earthing terminal and the accessible metal part is measured, and the resistance calculated from the current and this voltage drop.

In no case shall the resistance exceed 0,1 Ω.

In case of doubt, after 1 min the test is carried out until steady state conditions have been established.

NOTE 2 – 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.

NOTE 3 – The resistance of the supply flexible cable or cord, if used for convenience in the test, is not included in the resistance measurement.

NOTE 4 – The cores of IP00 transformers are considered to be not accessible.

24.5 For **class I transformers** with **external flexible cable or cords**, the arrangement of the terminals, or the length of the conductors between the cord 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.

25 Screws and connections

25.1 Screwed connections, electrical or otherwise, shall withstand the mechanical stresses occurring in normal use.

Screws transmitting contact pressure, and screws which are likely to be tightened by the user and have a nominal diameter less than 2,8 mm, shall screw into metal.

Screws shall not be of metal which is soft or liable to creep, such as zinc or aluminium.

Screws of insulating material shall not be used for any electrical connection.

Screws shall not be of insulating material if their replacement by a metal screw could impair **basic insulation** between **input** and **output circuit**, **supplementary insulation** or **reinforced insulation**, neither shall screws which may be removed when replacing a **power supply cord** be of insulating material if their replacement by a metal screw could impair **basic insulation.**

Compliance is checked by inspection and, for screws and nuts transmitting contact pressure or which are likely to be tightened by the user, by the following test.

The screws or nuts are tightened and loosened:

- *ten times for a screw in engagement with a thread of insulating material;*
- *five times for nuts and other screws.*

Screws in engagement with a thread of insulating material are completely removed and re-inserted each time.

When testing terminal screws and nuts, a flexible cable or cord of the largest cross-sectional area specified in table 9 is placed in the terminal. It is repositioned before each tightening.

The test is made by means of a suitable test screwdriver, spanner or key, applying a torque as shown in table 11, the appropriate column being:

a) for metal screws without heads, if the tightened screw does not protrude from the hole I

b) for other metal screws and for nuts II

c) for screws of insulating material:

– having a hexagonal head with the dimension across flats exceeding the overall thread diameter, or

– with a cylindrical head and a socket for a key, the socket having a dimension across flats not less than 0,83 times the overall thread diameter, or

– with a head having a slot or cross slots, the length of which exceeds 1,5 times the overall thread diameter II

d) for other screws of insulating material III

Table 11 – Torque to be applied to screws and connections

Nominal diameter of screw mm	Torque Nm		
	I	II	III
Up to and including 2,8	0,2	0,4	0,4
Over 2,8 up to and including 3,0	0,25	0,5	0,5
Over 3,0 up to and including 3,2	0,3	0,6	0,6
Over 3,2 up to and including 3,6	0,4	0,8	0,6
Over 3,6 up to and including 4,1	0,7	1,2	0,6
Over 4,1 up to and including 4,7	0,8	1,8	0,9
Over 4,7 up to and including 5,3	0,8	2,0	1,0
Over 5,3 up to and including 6,0	–	2,5	1,25

The conductor is moved each time the screw or nut is loosened.

During the test, no damage impairing the further use of the screwed connections shall occur.

NOTE 1 – Screws or nuts which are likely to be tightened by the user include screws intended to be operated when replacing **power supply cords** for **type X attachment**.

NOTE 2 – The shape of the blade of the test screwdriver shall suit the head of the screw to be tested. The screws and nuts should not be tightened in jerks.

25.2 Screws in engagement with a thread of insulating material shall have a length of engagement of at least 3 mm plus one-third of the nominal screw diameter or 8 mm, whichever is shorter.

Correct introduction of the screw into the screw hole or nut shall be ensured.

Compliance is checked by inspection and by the test of 25.1, the torque applied being, however, increased to 1,2 times the torque specified.

NOTE – The requirement with regard to correct introduction is met if introduction of the screw in a slanting manner is prevented, for example by guiding the screw by the part to be fixed, by a recess in the female thread, or by the use of a screw with the leading thread removed.

25.3 Electrical connections shall be so designed that contact pressure is not transmitted through insulating material other than ceramic or pure mica, unless there is sufficient resiliency in the metallic parts to compensate for any possible shrinkage or distortion of the insulating material.

25.4 Thread-forming screws (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, and are provided with a suitable means of locking.

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

Thread-cutting and thread-forming screws, when used to provide earthing continuity, shall be such that it is not necessary to disturb the connection in normal use, and at least two screws are used for each connection.

Compliance with the requirements of 25.3 and 25.4 is checked by inspection.

25.5 Screws which make a mechanical connection between different parts of the transformer shall be locked against loosening if the connection carries current, or forms part of the protective earthing circuit.

Rivets used for current-carrying connections shall be locked against loosening if these connections are subject to torsion in normal use.

Compliance is checked by inspection and by manual test.

NOTE 1 – Spring washers and the like may provide satisfactory locking.

NOTE 2 – For rivets, a non-circular shank or an appropriate notch may be sufficient.

NOTE 3 – Sealing compound which softens on heating provides satisfactory locking only for screw connections not subjected to torsion in normal use.

25.6 *Screwed glands shall comply with the following test:*

Screwed glands shall be fitted with a cylindrical metal rod having a diameter equal to the nearest whole number of millimetres below the internal diameter of the packing. The glands shall then be tightened by means of a suitable spanner, the force shown in table 12 being applied to the spanner for 1 min at a point 250 mm from the axis of the gland.

Table 12 – Torque test on glands

Diameter of test rod mm	Force	
	Metal glands N	Glands of moulded material N
Up to and including 14	25	15
Over 14 up to and including 20	30	20
Over 20	40	30

After the test, the transformer and the glands shall show no damage.

26 Creepage distances, clearances and distances through insulation

26.1 **Creepage distances**, **clearances** and distances through insulation shall be not less than the values shown in table 13, which are for insulating materials of group IIIa (see IEC 60664-1).

Compliance is checked by measurements under the provisions of 26.2 and 26.3.

NOTE 1 – For materials of groups I and II, see annexes C and D.

NOTE 2 – Table 13, table C.1 and table D.1 are applicable only for frequencies up to and including 30 kHz.

NOTE 3 – **Clearances**, **creepage distances** and distances through insulation for frequencies of more than 30 kHz are under consideration.

Creepage distances and **clearances** are measured, using the supply cable and cords for connection to fixed wiring and those for **type X attachment**, with maximum and minimum size conductors corresponding to the rated connecting capacity of the terminal. For **type X** with a special cord, **Y** or **Z attachments**, the supply cable and cords as delivered are used.

Where layers of serrated tapes are used, the value for **creepage distances** and **clearances** are determined as if the serration coincided through the different layers.

NOTE 4 – Diagrams showing some examples of the methods of measurement of **creepage distances** and **clearances** are to be found in annex A.

NOTE 5 – Diagrams showing some examples of points of measurement of **creepage distances** and **clearances** are given in annex P.

NOTE 6 – Details of the tests necessary to determine the separation of material groups are given in annex G.

NOTE 7 – Table 13, table C.1 and table D.1 take into consideration overvoltages category II for **basic insulation** and overvoltages category III for **double** or **reinforced insulation**.

Values for printed wiring, where failure may cause a hazard in the sense of this standard, shall be the same as unreduced values for **live parts** as in table 13, table C.1 and table D.1, except if the printed wiring complies with the requirements of IEC 60664-3.

If the **pollution** generates high and persistent conductivity caused, for instance, by conductive dust or by rain or snow, the **creepage distances** and **clearances**, as given for **pollution degree 3**, shall be further increased with a minimum **clearance** of 1,6 mm and a value of X in annex A of 4,0 mm.

26.2 Creepage distances (cr)

For windings which are covered with an adhesive bonding tape which adheres to the flanges of a coil former, the values of **creepage distances** are considered along the bonded surface of the adhesive bonding tape and the values are those stated for **pollution degree 1** (P1), provided that all insulating materials are classified according to IEC 60085 and IEC 60216.

Where an insulation barrier consisting of an uncemented pushed-on partition wall is used, **creepage distances** are measured through the joint. If the joint is covered by an adhesive bonding tape, in accordance with IEC 60454, one layer of adhesive bonding tape is required on each side of the wall in order to reduce the risk of tape folding over during production.

For transformers which are declared to have parts cemented (stuck) together, or enclosed or hermetically sealed against ingress of dust and moisture (for example impregnated or potted), and which satisfy the following tests, the minimum **creepage distances** in question can be the reduced values as stated for **pollution degree 1** (P1).

The reduced values shown in table 13, table C.1 and table D.1 can be used when separation is made by the use of impregnation, potting, or by the use of adhesive bonding tape covering the windings, provided that the tests of 4.1.1.2.1 of IEC 60664-1 are fulfilled.

In order to check whether the parts are adequately potted, impregnated or cemented together, the following tests are performed, as appropriate:

A) To test the potting or the impregnation, three transformers are used.

The specimens are subjected 10 times to the following sequence of temperature cycles:

68 h at the highest winding temperature ±2 °C measured in normal use plus 10 K with a minimum of 85 °C

1 h at 25 °C ± 2 °C

2 h at 0 °C ± 2 °C

1 h at 25 °C ± 2 °C

*During each thermal cycling test a voltage of twice the value of the **working voltage** at 50 Hz or 60 Hz is applied to the specimens between the windings where the reduced values apply.*

Two of the three specimens are then subjected to the humidity treatment of 17.2 (48 h treatment) and the relevant dielectric strength test of 18.3, which is made at a voltage multiplied by the factor 1,25.

One of the three specimens is subjected to the relevant dielectric strength test of 18.3, which is made at a voltage multiplied by the factor 1,25, immediately at the end of the last period at highest temperature during the thermal cycling test.

*B) To check whether the parts are cemented (stuck) together, three specially prepared specimens, where winding wires are replaced by uninsulated wires without any impregnation or potting, are required. The windings have to be made in such a way that there is no possible flashover between **input** and **output windings** anywhere other than in the cemented joint to be tested.*

The specimens are subjected 10 times to the following sequence of temperature cycles:

68 h at the highest winding temperature ±2 °C measured in normal use plus 10 K with a minimum of 85 °C

1 h at 25 °C ± 2 °C

2 h at 0 °C ± 2 °C

1 h at 25 °C ± 2 °C

Two of the three specimens are then subjected to the humidity treatment of 17.2 (48 h treatment) and the relevant dielectric strength test of 18.3; however, the test voltage is multiplied by 1,6.

One of the three specimens is subjected to the relevant dielectric strength test of 18.3; however, the test voltage is multiplied by 1,6 immediately after the last period at highest temperature during the thermal cycling test.

NOTE – The test voltage applied to the specimens for cemented parts is to be higher than the normal test voltages in order to ensure that if the surfaces are not cemented together, a breakdown occurs.

26.3 Distance through insulation (dti)

The distance through insulation shown in square brackets in boxes 2 and 7 of tables 13, C.1, and D.1 may be used, provided that the insulation is in thin sheet form and consists of at least three layers (separable or non-separable). If the layers are separate or separable, each layer shall fulfil the thermal material classification, as given in IEC 60085 and IEC 60216, of the transformer and, any combination of two thirds of the number of separate or separable layers, rounded down to the nearest full number, shall fulfil the mandrel test. If the layers are non-separable, the number of layers shall be at least three; the whole composite sheet shall fulfil the classification of the transformer, and the mandrel test.

Mandrel test

Three separate test specimens of thin sheets of 70 mm width shall be supplied by the manufacturer.

The test is carried out by fixing the thin sheet specimen on a mandrel made of steel, nickel plated, or brass with smooth surface finish as shown on figure 6.

A metal foil (aluminium or copper) 0,035 mm ± 0,005 mm thick shall be placed close to the surface of the specimen and submitted to a pull of 1 N. The metal foil shall be so positioned that its borders are 20 mm away from the borders of the specimen and, when the mandrel is in its final position, it covers the edges upon which the specimen is lying by at least 10 mm. The specimen is submitted to a pull of 150 N at its free end by an appropriate clamping device.

The specimen shall be slowly rotated forwards and backwards three times by 230° without jerks. If the specimen breaks at the clamping device during the rotation, the test is repeated. If one or more specimens break at any other place, the test is not fulfilled. While the mandrel is in its final position, within the minute following the final positioning, a test voltage of 5,5 kV is applied, as described in 18.3, between the mandrel and the metal foil.

No flashover or breakdown shall occur during the test; corona effects and similar phenomena being disregarded.

The figures within square brackets in boxes 2 and 7 of table 13, table C.1 and table D.1 are used as follows:

- for transformers having a **rated output** greater than 100 VA, the figures in square brackets apply;
- for transformers having a **rated output** of 25 VA up to and including 100 VA, the figures in square brackets may be reduced to two-thirds of their value;
- for transformers having a **rated output** of less than 25 VA, the figures in square brackets may be reduced to one-third of their value.

Smaller distances through the insulation may be used if it can be shown by the test of 14.3 that the materials have adequate mechanical strength and are resistant to ageing.

The requirements concerning distance through insulation do not imply that the prescribed distance shall be through solid insulation only. It may consist of a thickness of solid insulation plus one or more air layers.

Where serrated tape is used as insulation, it is assumed that the serration of the different layers will coincide. For distance through insulation, the reduced values of table 13, table C.1 and table D.1 may be used if one additional layer of serrated tape and one additional layer without serration, covering the location of the serration, are used.

Table 13 – Creepage distances (cr), clearances (cl) and distances through insulation (dti)

Material group IIIa (175 ≤CTI <400)

P1 = pollution degree 1 P2 = pollution degree 2 P3 = pollution degree 3

	Type of insulation	Measurement				Working voltages[2] V											
		Through winding enamel[1]		Other than through winding enamel		≥25 ≤50		100		150		300		600		1 000	
		P2	P3	P2	P3	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr
1) Insulation between **input** and **output circuits (basic insulation)**	a) **Creepage distances** and **clearances** between **live parts** of **input circuits** and live parts of **output circuits**	X		X	X	0,2 0,8 0,2 0,8	1,2 1,9 1,2 1,9	0,5 0,8 0,2 0,8	1,4 2,2 1,4 2,2	1,5 1,5 0,5 0,8	1,6 2,5 1,6 2,5	3,0 3,0 1,5 1,5	3,0 4,7 3,0 4,7	5,5 5,5 3,0 3,0	6,0 9,5 6,0 9,5	8,0 8,0 5,5 5,5	10,0 16,0 10,0 16,0
			X														
	Reduced values, see 26.2 (P1)					–	0,18	–	0,25	–	0,3	–	0,7	–	1,7	–	3,2
	b) Distances through insulation between **input** or **output circuits** and an earthed metal screen	X	X	X	X	dti		dti		dti		dti		dti		dti	
						No requirements of thickness											
	c) Distances through insulation between **input** and **output circuits**	X	X	X	X	No requirements of thickness											
2) Insulation between **input** and **output circuits (double or reinforced insulation)**	a) **Creepage distances** and **clearances** between **live parts** of **input circuits** and live parts of **output circuits**	X		X	X	0,5 0,8 0,2 0,8	1,4 2,2 1,4 2,2	1,5 1,5 0,5 0,8	2,0 3,2 2,0 3,2	3,0 3,0 1,5 1,5	3,0 4,7 3,0 4,7	5,5 5,5 3,0 3,0	6,0 9,5 6,0 9,5	8,0 8,0 5,5 5,5	12,0 19,2 12,0 19,2	14,0 14,0 8,0 8,0	20,0 32,0 20,0 32,0
			X														
	Reduced values, see 26.2 (P1)					–	0,25	–	0,4	–	0,7	–	1,7	–	4,0	–	7,5
	b) Distances through insulation between **input** or **output circuits** and an earthed metal screen, see 26.3	X	X	X	X	dti		dti		dti		dti		dti		dti	
						0,1 [0,05][7]		0,2 [0,07][7]		0,25 [0,08][7]		0,5 [0,16][7]		0,7 [0,19][7]		1,0 [0,25][7]	
	c) Distances through insulation between **input** and **output circuits**, see 26.3	X	X	X	X	0,2[4] [0,1][5] –[6]		0,3[4] [0,1][5] –[6]		0,5[4] [0,15][5] –[6]		1,0[4] [0,3][5] –[6]		1,5[4] [0,4][5] –[6]		2,0[4] [0,5][5] –[6]	

For notes, see page 157

Dimensions in millimetres

Table 13 *(continued)*

	Type of insulation	Measurement				Working voltages[2] V											
		Through winding enamel[1]		Other than through winding enamel		≥25 ≤50		100		150		300		600		1 000	
		P2	P3	P2	P3	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr
3) Insulation between adjacent **input circuits** or insulation between adjacent **output circuits**[3]	**Creepage distances** and **clearances**	X	X	X	X	0,2 0,8	1,2 1,9	0,2 0,8	1,4 2,2	0,2 0,8	1,6 3,1	0,5 0,8	3,0 4,7	1,5 1,5	6,0 9,5	3,0 3,0	10 16
	Reduced values see 26.2 (P1)					–	0,18	–	0,25	–	0,3	–	0,7	–	1,7	–	3,2
4) **Creepage distances** and **clearances** between terminals for the connection of external cables and cords excluding those between screw terminals for **input** and for **output circuits**	a) Up to and including 6 A	X	X	X	X	3,0		3,6		4,0		6,0		9,0		12,5	
	b) Over 6 A up to and including 16 A	X	X	X	X	5,0		6,0		7,0		10,0		13,0		16,0	
	c) Over 16 A	X	X	X	X	10,0		11,0		12,0		14,0		17,0		20,0	
5) **Basic** or **supplementary insulation**	Between: a) **live parts** of different polarity			X		0,2	1,2	0,5	1,4	1,5	1,6	3,0	3,0	5,5	6,0	8,0	10,0
	b) **live parts** and the **body** if intended to be connected to protective earth				X	0,8	1,9	0,8	2,2	1,5	2,5	3,0	4,7	5,5	9,5	8,0	16,0
	c) accessible metal parts and a metal rod of the same diameter as the flexible cable or cord (or metal foil wrapped around the cord) inserted inside inlet bushing, anchorage and the like	X				0,2	1,2	0,2	1,4	0,5	1,6	1,5	2,9	3,0	6,0	5,5	10,0
			X			0,8	1,9	0,8	2,2	0,8	2,5	1,5	4,7	3,0	9,5	5,5	16,0
	d) **live parts** and an intermediate metal part e) an intermediate metal part and the **body**																
	Reduced values, see 26.2 (P1)					–	0,18	–	0,25	–	0,3	–	0,7	–	1,7	–	3,2

For notes, see page 157

Dimensions in millimetres

Table 13 *(concluded)*

	Type of insulation	Measurement				Working voltages[2] V											
		Through winding enamel[1]		Other than through winding enamel		≥25 ≤50		100		150		300		600		1 000	
		P2	P3	P2	P3	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr	cl	cr
6) **Reinforced** or **double insulation**	Between the **body** and **live parts**			X		0,5	1,4	1,5	2	3,0	3,0	5,5	6,0	8,0	12,0	14,0	20,0
					X	0,8	2,2	1,5	3,2	3,0	4,7	5,5	9,5	8,0	19,2	14,0	32,0
		X				0,2	1,4	0,5	2	1,5	3,0	3,0	6,0	5,5	12,0	8,0	20,0
			X			0,8	2,2	0,8	3,2	1,5	4,7	3,0	9,5	5,5	19,2	8,0	32,0
	Between **body** and **live parts** of the **output circuit** if protected by additional provisions against transient voltages	X		X		0,2	1,4	0,2	2	0,5	3,0	1,5	6,0	3,0	12,0	5,5	20,0
			X		X	0,8	2,2	0,8	3,2	0,8	4,7	1,5	9,5	3,0	19,2	5,5	32,0
	Reduced values, see 26.2 (P1)					–	0,25	–	0,4	–	0,7	–	1,7	–	4,0	–	7,5
7) Distance through insulation (excluding insulation between **input** and **output circuit**)	a) **Basic**[8]	X	X	X	X	No requirement of thickness											
						dti		dti		dti		dti		dti		dti	
	b) **Supplementary**[8]	X	X	X	X	0,1[4] [0,05][5] –[6]		0,15[4] [0,05][5] –[6]		0,25[4] [0,08][5] –[6]		0,5[4] [0,15][5] –[6]		0,75[4] [0,20][5] –[6]		1,0[4] [0,25][5] –[6]	
	c) **Reinforced**	X	X	X	X	0,2[4] [0,1][5] –[6]		0,3[4] [0,1][5] –[6]		0,5[4] [0,15][5] –[6]		1,0[4] [0,3][5] –[6]		1,5[4] [0,4][5] –[6]		2,0[4] [0,5][5] –[6]	

Dimensions in millimetres

NOTES

1) Measurement through winding wire enamel if the winding wire complies at least with grade 1 of IEC 60317.
2) Values of **creepage distances** and **clearances** and distances through insulation may be found for intermediate values of **working voltages** by interpolation between the values in the table. No values are required for **working voltages** below 25 V as the voltage test of table 8 is considered sufficient.
3) These values do not apply:
   – inside each winding or between groups of windings intended to be permanently connected together, provided that the termination of windings to be connected together are at the same potential,
   – where the **working voltage** does not exceed 300 V and the winding wires comply at least with grade 1 of IEC 60317, even if the windings are intended to be connected in a series or parallel arrangement (e.g. input voltage 110/220 V).
4) For solid insulation.
5) In the case of insulation consisting of three layers.
6) In the case of insulation consisting of two separate layers (no glued layers are allowed in this case) and each layer passes the mandrel test of 26.3 at a voltage of 5,5 kV.
7) In the case of insulation consisting of two layers.
8) When **double insulation** is required between **input** and **output windings**, the total thickness through insulation shall be the same as shown in box 2 c) whether measured directly or via metal parts.
9) When the layers of insulation are made of turns of insulating tape, the winding of the tape should be such that at every place there is at least the required number of layers.
10) When a number is replaced by a dash in a column of the table it means that no value is required.

27 Resistance to heat, abnormal heat, fire and tracking

27.1 External **accessible parts** of insulating material, of which the deterioration might cause the transformer to become unsafe, shall be resistant to heat.

*Compliance is checked by subjecting **enclosures** and other external parts of insulating material to a ball-pressure test by means of the apparatus shown in figure 5.*

The surface of the part to be tested is placed in a horizontal position and a steel ball of 5 mm diameter is pressed against this surface with a force of 20 N.

The test is made in a heating cabinet at a temperature of (70 ± 2) °C, or at a temperature of (40 + θ ± 2) °C, where θ is the temperature rise of the relevant part determined during the test of 14.2, whichever is the higher.

After 1 h the ball is removed from the specimen, which is then cooled down, within 10 s, to approximately ambient temperature by immersion in cold water. The diameter of the impression caused by the ball is measured and shall not exceed 2 mm.

NOTE – The test is not made on parts of ceramic material.

27.2 External **accessible parts** of insulating material shall be resistant to ignition and spread of fire.

*Compliance is checked by subjecting **enclosures** and other external **accessible parts** to the glow-wire test (see annex E).*

If possible, the specimen should be a complete transformer.

If the test cannot be made on a complete transformer, a suitable part should be cut from it.

*If it is necessary to take away parts of an **enclosure** or to cut off a suitable part to perform the test, care is taken to ensure that the standard test conditions are not significantly different from those occurring in normal use, with regard to shape, ventilation, effects of thermal stresses and of possible flames, burning droplets or glowing particles falling in the vicinity of the specimen.*

Any flame or glowing of the specimen shall extinguish within 30 s of withdrawing the glow-wire, and any burning or molten drops shall not ignite a single layer of tissue paper, as specified in 6.8 of ISO 4046, spread out horizontally (200 ± 5) mm below the specimen.

Only one specimen is tested. In case of doubt concerning the results, the test is repeated on two further specimens, both of which shall pass the test.

27.3 Parts of insulating material within the transformer **enclosure** of transformers of IP20 or higher shall not act as a source of ignition for the surroundings, even in the case of abnormal heat or fire caused by a fault in the transformer.

Compliance is checked by the tests of 27.3.1 and 27.3.2.

For this test two additional specially prepared specimens are necessary in which short-circuit winding(s) is/are built in, or can be caused from the outside by brought out leads.

The short circuit shall be chosen so that the unloaded transformer is supplied with 1,06 times the **rated input** voltage at ambient temperature, and that the input power (watt) is equal to the value of the **rated output**. Tolerance is ±20 %. The percentage of turns to be short-circuited is approximately equal to the **short-circuit voltage** expressed as a percentage of the **rated supply voltage**. The short circuit is made in the middle of the windings. In one sample the short circuit is applied to the **input winding**, and in the other sample on the **output winding**. If there is more than one winding, the short circuit is applied simultaneously to either all **input windings** or all **output windings**. During the test no adjustment is admitted.

This test is not carried out on transformers already covered by 15.5.

27.3.1 ***Portable transformers*** *are placed on a dull black painted plywood support as described in 14.2.*

Stationary transformers*, which are not designed to be built in, are fixed in the most unfavourable position under normal use to a dull black painted plywood support as described in 14.2. When the most unfavourable position of use is vertical or on the ceiling, the* ***stationary transformer*** *and the support are placed in this position (200 ± 5) mm above a piece of white pinewood board, approximately 10 mm thick, covered with a single layer of tissue paper.*

For transformers with self-resettable devices, all these protective devices are short-circuited.

For this test, the ***input circuits*** *shall be protected by fuse or circuit-breaker with a rated current 10 times the rated current of the transformer, but at least 16 A.*

The transformer, with its protective devices where applicable, is tested as specified above for 15 days but without load. The result shall be a definitive interruption in the circuit. If no definitive interruption occurs after this period, the supply is switched off.

If the non-self-resettable or replaceable protective device, if any, interrupts the circuit, the supply is switched off and the transformer is left to cool down for 2 h. Then the protective device is reset or replaced, the supply is switched on until the device interrupts the circuit or an interruption in the transformer occurs. If no interruption in the transformer occurs, 30 cycles are made in the case of resettable devices, or 10 cycles in the case of replaceable devices. Each cycle consists of supplying the transformer until the protective device interrupts the circuit and the power remains switched off for 2 h.

During the test no flames shall occur, and the transformer shall not act as a source of ignition for the surroundings. The temperature of the support shall not exceed 125 °C. If ***stationary transformers*** *are placed in a vertical position or on the ceiling, burning drops, if any, shall not ignite the tissue paper or scorch the pinewood board.*

27.3.2 *After the test of 27.3.1 and after cooling down to ambient temperature, the following applies.*

a) Transformers where a definitive interruption in the ***input circuit*** *has occurred shall withstand a dielectric strength test, the test voltage being 35 % of the values according to table 8 of clause 18.*

b) Transformers where no definitive interruption has occurred after the cycling test shall withstand the test voltages according to table 8 of clause 18.

The transformer shall show no holes allowing the standard test finger to touch ***hazardous live parts*** *without appreciable force. In case of doubt, contact with* ***hazardous live parts*** *is shown by means of an electrical contact indicator, the voltage being not less than 40 V. If one specimen does not pass the test, the complete test has failed.*

27.4 Parts of insulating material retaining current carrying parts in position shall be resistant to abnormal heat and to fire.

Compliance is checked by the following test.

Parts of insulating material are subjected to a ball pressure test as described in 27.1 but at a temperature of (125 ± 2) °C or at a temperature of (40 + θ ± 2) °C, where θ is the temperature rise of the relevant part determined during the test of 14.2, whichever is the higher.

NOTE – The test is not made on parts of ceramic material, or on bobbins, or on glass.

In addition, parts of insulating material retaining terminals for external conductors which carry a current of more than 0,5 A during normal operation shall comply with the glow-wire test described in 27.2, with the only difference that the glow-wire is electrically heated to 850 °C.

27.5 For transformers with an IP rating other than IPX0, insulating parts retaining current carrying parts in position shall have resistance to tracking corresponding to at least material group IIIa if they are exposed to excessive moisture or deposition of dirt in normal use.

For material other than ceramics, compliance is checked by the tests of annex G.

No flashover or breakdown between electrodes shall occur before a total of 50 drops has fallen.

28 Resistance to rusting

Ferrous parts, the rusting of which might cause the transformer to become unsafe, shall be adequately protected against rusting.

NOTE – This requirement applies to the outer surfaces of iron cores, but in that case protection by a coating of varnish is deemed to be adequate.

Compliance is checked by inspection and, in case of doubt, by the following test.

All grease is removed from the parts to be tested by immersion in trichloroethane for 10 min. The parts are then immersed for 10 min in a 10 % solution of ammonium chloride in water at a temperature of (20 ± 5) °C. Without drying, but after shaking off any drops, the parts are placed for 10 min in a box containing air saturated with moisture at a temperature of (20 ± 5) °C.

After all the parts have been dried for 10 min in a heating cabinet at a temperature of (100 ± 5) °C; their surfaces shall show no signs of rust.

NOTE 1 – This requirement applies to the outer surfaces of iron cores, but in that case protection by a coating of varnish is deemed to be adequate.

NOTE 2 – Traces of rust on sharp edges and any yellowish film removable by rubbing are ignored.

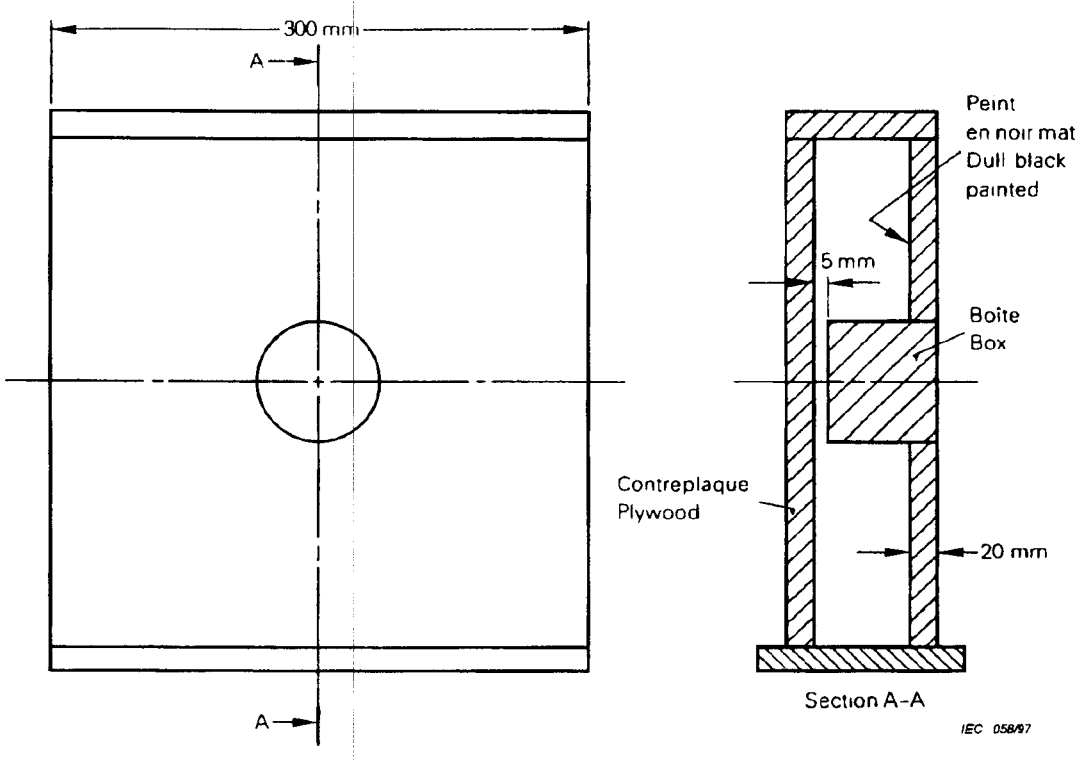
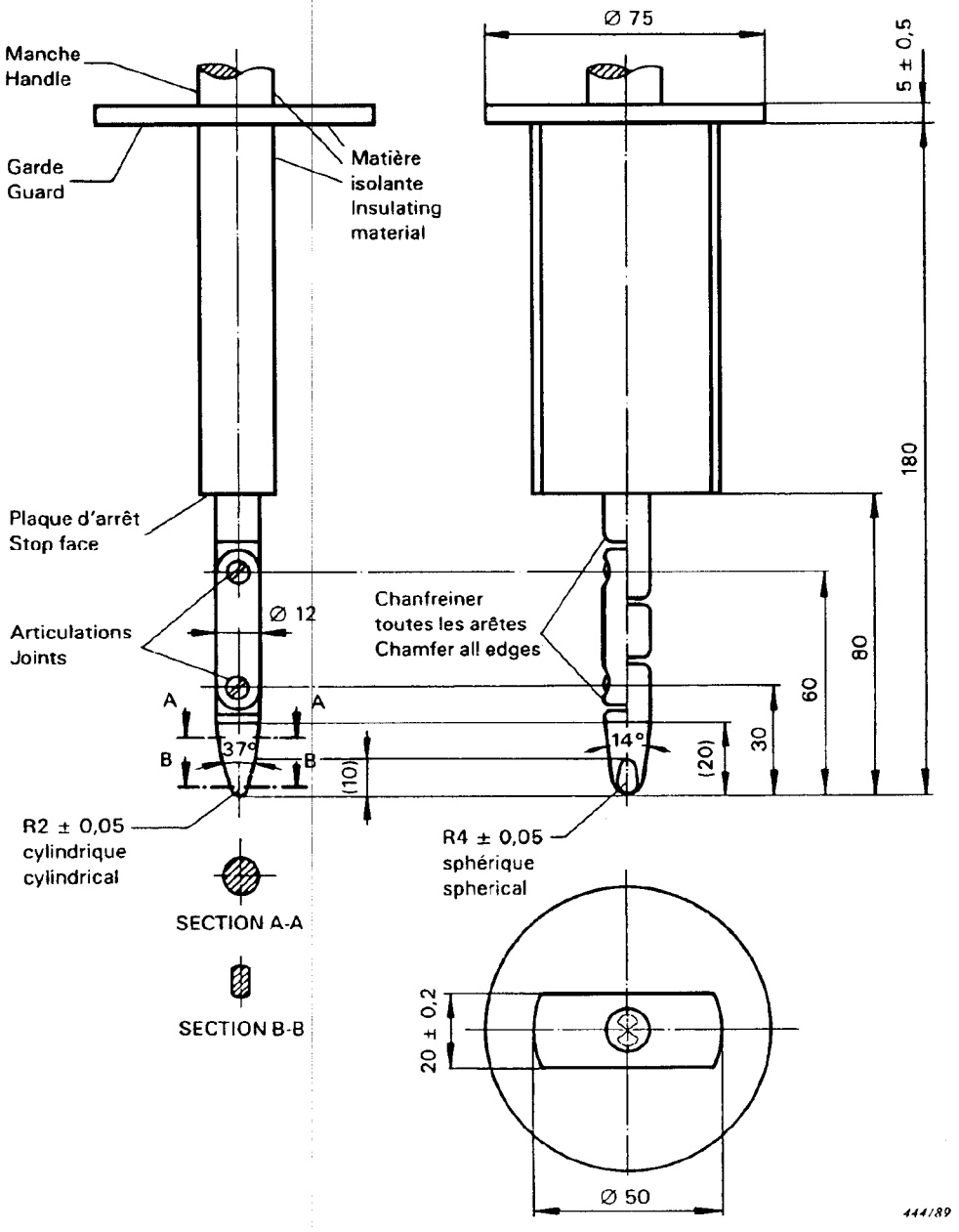


Figure 1 — Boîte de montage pour transformateur pour pose encastrée (voir 5.10)
Mounting box for flush-type transformer (see 5.10)



Matière: métal sauf spécification contraire

Dimensions linéaires en millimètres

Tolérances des dimensions sans indication de tolérance

sur les angles: 0/–10'
sur les dimensions:

- jusqu'à 25 mm: $^{0}_{-0,05}$
- au-dessus de 25 mm: ±0,2

Les deux articulations doivent permettre un mouvement dans le même plan et le même sens de 90° avec une tolérance de 0 à +10°.

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.

Figure 2 – Doigt d'épreuve normalisé (voir 9.2, 15.5.2 et la CEI 61032 calibre d'essai B)
Standard test finger (see 9.2, 15.5.2 and IEC 61032 test probe B)