3.5.101
rated thermal output
product of the **rated output voltage** and the **rated output current**, or for polyphase **transformers**, the appropriate factor (e. g. for three-phase transformers $\sqrt{3}$) times the product of the **rated output voltage** and the **rated output current** delivered in continuous operation loaded at **power factor** 1

Note 1 to entry: If the **transformer** has more than one **output winding** or tapped **output winding** (or both), the **rated output** denotes the sum of the products of **rated output voltage** and **rated output current** for **output circuits** intended to be loaded simultaneously.

3.5.102
admissible instantaneous output
product of the **rated output voltage** and the **rated instantaneous output current**, or for polyphase **transformers**, the appropriate factor (e. g. for three-phase transformers $\sqrt{3}$) times the product of the **rated output voltage** and the **rated instantaneous output current** delivered at **power factor** 0,5

Note 1 to entry: If the **transformer** has more than one **output winding** or tapped **output winding** (or both), the **rated output** denotes the sum of the products of **rated output voltage** and **rated instantaneous output current** for **output circuits** intended to be loaded simultaneously.

3.5.103
rated instantaneous output current
output current for the specific operating conditions at the **rated output voltage** and the **rated supply frequency** at **power factor** 0,5 assigned to the **transformer** by the manufacturer

4 General requirements

This clause of IEC 61558-1:2017 is applicable.

5 General notes on tests

This clause of IEC 61558-1:2017 is applicable.

6 Ratings

This clause of IEC 61558-1:2017 is applicable except as follows:

Addition:

6.101 The **rated output voltage** shall not exceed 1 000 V AC or 1 415 V ripple-free DC and for **independent transformers** shall exceed 50 V AC or 120 V ripple-free DC.

For **independent transformers**, this output voltage limitation applies even when **output windings**, not intended for interconnection, are connected in series.

6.102 The **rated thermal output** shall not exceed:

- 25 kVA for single-phase **transformers,**
- 40 kVA for polyphase **transformers.**

Transformers without limitation of the **rated thermal output** shall be subject to agreement between the purchaser and the manufacturer.

6.103 The **rated supply frequency** and the **internal operating frequencies** shall not exceed 500 Hz.

6.104 The **rated supply voltage** shall not exceed 1 000 V AC.

Compliance with the requirements of 6.101 to 6.104 is checked by inspection of the marking.

7 Classification

This clause of IEC 61558-1:2017 is applicable except as follows:

7.8

Replacement

Control transformers shall be classified for **overvoltage category III**.

8 Marking and other information

This clause of IEC 61558-1:2017 is applicable except as follows:

8.1 c)

Replacement:

the **transformers** shall be marked with the **rated thermal output** and the **admissible instantaneous output** in volt-ampere, separated by an oblique stroke (e.g. 100/300 VA);

d)

Replacement:

Item d) is not applicable.

h)

Replacement of the content up to the first semi-colon by the following:

relevant graphical symbols shown in Table 101 that indicate the kind of **transformer**

8.11

Addition:

The symbol for linear **power supply units** shall be used in conjunction with the symbol indicating the kind of **transformer**.

11 Output voltage and output current under load

This clause of IEC 61558-1:2017 is applicable except as follows:

11.1

Replacement:

When the **transformer** is connected to the **rated supply voltage**, at **rated supply frequency**, and loaded with an impedance at **power factor** 1 resulting in the **rated thermal output** at the **rated output voltage**, the output voltage shall not differ from the rated value by more than ±5 %.

Compliance is checked by measuring the output voltage when steady-state conditions are established.

Immediately after the **transformer** is loaded with an impedance resulting in the **admissible instantaneous output** at the **rated output voltage** at **power factor** 0,5 (inductive), the output voltage measured shall not be less than 95 % of the measured voltage at the **rated thermal output**.

The output voltage measurement for the **admissible instantaneous output** should be carried out within 50 ms after applying this overload to minimise the effects of supplementary heating of the **transformer**.

For **transformers** with more than one **rated supply voltage**, the requirement is applicable for each of the **rated supply voltages**.

12 No-load output voltage

This clause of IEC 61558-1:2017 is applicable except as follows:

Addition:

12.101 The **no-load output voltage** shall not exceed 1 000 V AC or 1 415 V ripple-free DC and for **independent transformers** shall exceed 50 V AC or 120 V ripple-free DC.

For **independent transformers**, this **output voltage** limitation applies even when **output windings**, not intended for interconnection, are connected in series.

NOTE The requirement for series connection does not apply to associated or IP 00 **transformers**.

12.102 The difference between the **no-load output voltage** and the **output voltage** under load shall not be excessive.

The ratio between the **no-load output voltage** measured in Clause 12 and the **output voltage** under load measured during the test of Clause 11, expressed as a percentage of the latter voltage, shall not exceed 10 %.

The ratio is determined by Formula (1):

$$\frac{U_{\text{no-load}} - U_{\text{load}}}{U_{\text{load}}} \times 100(\%) \quad (1)$$

where

$U_{\text{no-load}}$ is the no-load output voltage, expressed in V;

U_{load} is the output voltage under load, expressed in V.

*Compliance with the requirements of 12.101 and 12.102 is checked by measuring the **no-load output voltage** at the **ambient temperature** when the **transformer** is connected to **the rated supply voltage** at the **rated supply frequency** and at the **rated thermal output**.*

13 Short-circuit voltage

This clause of IEC 61558-1:2017 is applicable.

14 Heating

This clause of IEC 61558-1:2017 is applicable except as follows:

14.1.1

Replacement of the eleventh paragraph:

***Transformers** are supplied at the **rated supply voltage** and loaded with an impedance producing the **rated thermal output**, at the **rated output voltage** and, for AC current, at the **rated power factor**. The value of the output current is measured when steady state is established. Then the supply voltage is increased by 10 % and the output current is adjusted to the same value measured previously. The output current is not adjusted for **independent transformers**. After this increase of the supply voltage, no change is made in the circuit. The test is repeated under no-load condition, if this is a more unfavourable situation.*

15 Short-circuit and overload protection

This clause of IEC 61558-1:2017 is applicable.

16 Mechanical strength

This clause of IEC 61558-1:2017 is applicable.

17 Protection against harmful ingress of dust, solid objects and moisture

This clause of IEC 61558-1:2017 is applicable.

18 Insulation resistance, dielectric strength and leakage current

This clause of IEC 61558-1:2017 is applicable except as follows:

Compliance is checked by calculation.

12 No-load output voltage

The relevant requirements for the **no-load output voltage** limitation are given in IEC 61558 Part 2 for the different types of **transformers**.

*For **transformers** incorporating a rectifier, the output voltages are measured at the input and output terminals of the rectifier if they are connected to terminals or terminations. The measurement at the input terminals of the rectifier is made if they are accessible to the user. The **output voltage** is measured at the terminals of the circuit with a voltmeter giving the arithmetic mean value, unless the effective value RMS is specifically stated (see 8.1).*

13 Short-circuit voltage

If there is a **short-circuit voltage** marking, the **short-circuit voltage** measured shall not deviate by more than 20 % from the value marked.

*Compliance is checked by measuring the **short-circuit voltage**, the **transformer** being at ambient temperature.*

14 Heating

14.1 General requirements

14.1.1 Temperature-rise test

Transformers and their supports shall not attain excessive temperature in normal use.

The manufacturer may choose the simulated load methods according to 14.1.2.1 or 14.1.2.2 instead of the direct load method that may be applied.

NOTE 1 The simulated load methods are according to IEC 60076-11:2004, 23.2.1 and 23.2.2.

Temperatures are determined under the following conditions when steady-state is established.

*The test and the measurements are made in a draught-free location having dimensions such that the test results are not influenced. If the **transformer** has a t_a rating, the test is conducted at (t_a ± 5) °C.*

NOTE 2 The heating test is carried out taking into consideration only the t_a (and not t_{amin}).

***Portable transformers** are placed on a dull black painted plywood support. **Stationary transformers** are mounted as in normal use, on a dull black painted plywood support. The support is approximately 20 mm thick, and has dimensions which are at least 200 mm in excess of those of the orthogonal projection of the specimen on the support.*

***Transformers** which are provided with integral pins intended to be introduced into fixed socket-outlets are tested in a flush-mounted socket-outlet mounted in a box on a dull black painted plywood support as indicated in Figure 2.*

*Flush type **transformers** are tested as described in 5.10.*

***Transformers** with a protection index other than IP00 are tested in their **enclosure**.*

At the beginning of the test, the windings shall be at ambient temperature.

When determining the temperature of the windings, the ambient temperature is measured at such a distance from the specimen so as not to influence the temperature reading. At this point, the ambient temperature shall not vary by more than 10 °C during the test. For t_a ***transformers*** *the test temperature equals* $\Delta t + t_a$.

For ***transformers*** *with more than one* ***input*** *or* ***output winding****, or a tapped* ***input*** *or* ***output winding****, the results to be considered are those showing the highest temperature.*

Transformers with a winding resistance less than 50 mΩ can also be measured by thermocouples. The thermocouples shall only be mounted on accessible surfaces of the transformer windings. The maximum values of Table 2 for winding temperatures shall be reduced by 10 °C for the thermocouple measurements.

Other temperatures are determined by means of thermocouples so chosen and positioned that they have the minimum effect on the temperature of the part under test.

Thermocouples used for determining the temperature of the surface of supports are attached to the back of small blackened discs of copper or brass 1 mm thick and 15 mm in diameter which are flush with the surface.

The temperature of electrical insulation (other than that of windings) is determined on the surface of the insulation at places where failure could establish a contact between ***hazardous-live-parts*** *and accessible* ***conductive parts****, or a reduction of* ***creepage distances*** *or* ***clearances*** *below the values specified in Clause 26. In addition, thermocouples shall be placed at the hottest points of the insulating material to avoid a risk of fire.*

During the test, the temperature shall not exceed the values shown in Table 2 when the ***transformer*** *is operated at its* ***rated ambient temperature*** *(25 °C or* t_a*). In those cases where the temperature in the test area differs from the* ***rated ambient temperature****, this difference shall be taken into account when applying the limits in Table 2 and when establishing the test temperatures in 27.2 and 27.5.*

14.1.2 Alternative temperature-rise test

14.1.2.1 Simulated load method

This method is applicable for an enclosed or non-enclosed or totally enclosed dry type unit with natural air or forced air cooling.

Temperature rise is established by combining the short-circuited test (load loss) and the open circuit test (no-load loss).

The temperature of the ***transformer*** *shall be stabilized with that of the test laboratory environment. The resistance of the primary and secondary windings shall be measured, these values will be used as reference values for the calculation of the temperature rise of the two windings. The ambient temperature of the test laboratory shall also be measured and registered.*

For three-phase ***transformers****, the resistance measurements shall be made between the central and an outer phase line terminals.*

The location of the measuring points (that is, the ambient temperature thermometers and sensors on the ***transformer****, if any), shall be the same for the reference and final measurements.*

14.1.3 Determination of steady-state conditions

The ultimate temperature rise is reached when the temperature rise becomes constant; this is considered to have been achieved when the temperature rise does not vary by more than 1 K per hour.

For the purpose of determining when steady-state conditions have been achieved, thermocouples shall be applied to the following surfaces:

– *For all types of transformers defined in Clause 3: centre of top yoke and as close as practicable to the innermost winding at the top of the winding, the measurement being on the centre leg of a three-phase transformer.*

Table 2 – Values of maximum temperatures in normal use

Parts[a]	**Temperature** °C
Windings, if the insulation system (i.e. bobbins and any other insulating materials that are in contact with the winding) is:	
– of class A [b]	100
– of class E [b]	115
– of class B [b]	120
– of class F [b]	140
– of class H [b]	165
– of other classes [c]	–
External **enclosures** [d,f] (which can be touched with the standard test finger) of **stationary transformers**, if of:	
– bare metal	65
– metal covered by lac or varnish	70
– other material	80
External **enclosures** [d,f] (which cannot be touched with the standard test finger) of **stationary transformers**	85
External **enclosures** [d,f], handles and the like of **portable transformers**:	
– if, in normal use, these parts are continuously held (for example for **hand held transformers**):	
• of metal	48
• of other material	48
– if, in normal use, these parts are not continuously held:	
• of metal	60
• of other material	80
Terminals for external conductors and terminals of switches	70
Insulation of internal and external wiring [e]:	
– of rubber	65
• of polyvinyl chloride	70
Parts the deterioration of which could affect safety [e]:	
– of rubber (other than insulation of wiring)	75
• of phenolformaldehyde	105
• of ureaformaldehyde	85
• of impregnated paper and fabric	85
• of impregnated wood	85
• of polyvinyl chloride (other than insulation of wiring), polystyrene and similar thermo-plastic material	65
• of varnished cambric	75

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 several knock-outs are provided and positioned on different parts of the enclosure, the knock-out which produces the most unfavourable condition will be 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 **transformers** with protection index IP20, or lower;*
- *seven days (168 h) for **transformers** with other protection index.*

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.

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 document.*

18 Insulation resistance, dielectric strength and leakage current

18.1 General

The insulation resistance, the dielectric strength and the leakage current of **transformers** shall be adequate.

Compliance is checked by the tests of 18.2 to 18.5 which are carried out immediately after the test of 17.2, in the humidity cabinet or in the room where the specimen was brought to the prescribed temperature, after reassembling those parts which may have been removed.

Reducing the overvoltage category classification by about one category lower after the secondary side of the transformer is allowed, except for auto-transformers, under the following conditions:

- an earthed screen shall be between the primary and secondary winding or the secondary circuits have to be connected to functional earthing.

18.2 Insulation resistance

The insulation resistance shall not be less than that shown in Table 13.

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

Table 13 – 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 conductive parts of **class II transformers** which are separated from **hazardous-live-parts** by **basic insulation** only	2
Between conductive 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 of class II **transformers**	7