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

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 the values shown in Table 102.*

The ratio is determined by Formula (1):

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

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.

Table 102 – Output voltage ratio

Type of transformer Rated output VA	Ratio between no-load output voltage and output voltage under load %
– up to and including 63	20
– over 63 up to and including 250	15
– over 250 up to and including 630	10
– over 630	5

*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**.*

The ratio shall not exceed the values shown in Table 102.

13 Short-circuit voltage

This clause of Part 1 is applicable.

14 Heating

This clause of Part 1 is applicable.

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