

CONFIRMED
MARCH 1982

Specification for

Voltage transformers

UDC 621.314.222

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW



Document Sharing Hub

Co-operating organizations

The Electrical Industry Standards Committee under whose supervision this British Standard was prepared consists of representatives from the following Government departments and scientific and industrial organizations:

- Associated Offices Technical Committee
- Association of Consulting Engineers*
- Association of Manufacturers of Domestic Electrical Appliances
- Association of Mining Electrical and Mechanical Engineers
- Association of Supervisory and Executive Engineers
- British Electrical and Allied Manufacturers' Association*
- British Electrotechnical Approvals Board for Household Equipment
- British Non-Ferrous Metals Federation
- British Radio Equipment Manufacturers' Association
- British Railways Board
- British Steel Corporation
- Crown Agents for Oversea Governments and Administrations
- Department of Employment (HM Factory Inspectorate)
- Department of Energy*
- Department of the Environment
- Department of Prices and Consumer Protection
- Electric Cable Makers' Confederation
- Electrical Contractors' Association
- Electrical Contractors' Association of Scotland
- Electrical Research Association
- Electricity Supply Industry in England and Wales*
- Electronic Engineering Association
- Engineering Equipment Users' Association
- Institution of Electrical Engineers
- Institution of Electrical and Electronics Technician Engineers
- Lighting Industry Federation Limited
- Ministry of Defence
- National Inspection Council for Electrical Installation Contracting
- Oil Companies' Materials Association
- Post Office
- South of Scotland Electricity Board

The Government department and scientific and industrial organizations marked with an asterisk in the above list together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

This British Standard, having been approved by the Electrical Industry Standards Committee, was published under the authority of the Executive Board on 29 August 1975

- Engineering Industries Association
- Transmission and Distribution Association (BEAMA)

© BSI 04-1999
First published November 1965
First revision August 1975

The following BSI references relate to the work on this standard;
Committee reference ELE/59
Draft for comment 72/23649 DC

ISBN 0 580 08913 4

Amendments issued since publication

Amd. No.	Date of issue	Comments
2076	August 1976	
4004	July 1982	Indicated by a sideline in the margin

Contents

	Page
Co-operating organizations	Inside front cover
Foreword	iii
Section 1. General	
1 Scope	1
2 References	1
3 Definitions	1
4 Service conditions	5
Section 2. Requirements for all voltage transformers	
5 Rated frequency	5
6 Rated secondary voltages	5
7 Rated outputs	5
8 Rated transformation ratios	6
9 Rated voltage factors	6
10 Characteristics of voltage transformers with residual voltage windings	6
11 Limits of temperature rise	6
12 Rated insulation levels	8
13 Creepage distances	9
14 Accuracy class designation	9
15 Limits of error	9
16 Marking	10
17 Test requirements	10
18 Tests	11
Section 3. Additional requirements for capacitor voltage transformers	
19 General requirements	16
20 Additional performance requirements	16
21 Test requirements	16
22 Marking	17
Section 4. Requirements for capacitors for use with capacitor voltage transformers	
23 General requirements	17
24 Test requirements	17
25 Tests	18
26 Insulation level	20
27 Marking	20
Appendix A Service conditions	21
Appendix B Guidance on the application of measuring voltage transformers	22
Appendix C Rating of voltage transformers at frequencies other than rated frequency	22
Appendix D Temperature measurements	23
Appendix E Guidance for installation and operation of capacitors	24
Appendix F Information required by the manufacturer	25
Figure 1 — Single-phase voltage transformer having one or two secondary windings without tapplings	26
Figure 2 — Single-phase voltage transformer having one or two secondary windings with tapplings	26

	Page
Figure 3 — Single-phase or 3-phase voltage transformer with one residual voltage winding	27
Figure 4 — 3-phase voltage transformer with one or two secondary windings without tapings	28
Figure 5 — 3-phase voltage transformer with one secondary winding with tapings	29
Figure 6 — Circuit for accuracy test on a transformer having a rated voltage factor of 1.5	29
Figure 7 — Circuit for accuracy test on a transformer having a rated voltage factor of 1.9	30
Figure 8 — Circuit for accuracy test on the residual voltage winding of a transformer having a rated voltage factor not exceeding 1.5	30
Figure 9 — Circuit for accuracy test on the residual voltage winding of a transformer having a rated voltage factor of 1.9	31
Figure 10 — Alternative circuit for accuracy test on the residual voltage winding of a transformer having a rated voltage factor of 1.9	31
Figure 11 — Diagrammatic arrangement of capacitor voltage transformer	32
Table 1 — Rated transformation ratios	6
Table 2 — Standard values of rated voltage factors	7
Table 3 — Characteristics of voltage transformers with residual voltage windings	7
Table 4 — Limits of temperature rise of windings	8
Table 5a — Insulation test levels for rated highest equipment voltages up to and including 72.5 kV	8
Table 5b — Insulation test levels for rated highest equipment voltages of 100 kV and above	8
Table 6 — Limits of voltage error and phase displacement for measuring voltage transformers	9
Table 7 — Limits of voltage error and phase displacement for protective voltage transformers	10
Table 8 — High-voltage winding terminal to be earthed during impulse voltage tests	14
Table 9 — Applied power frequency test voltages on primary windings (after erection on site)	15
Table 10 — Applied power frequency high voltage tests for durations exceeding one minute (after erection on site)	15
Table 11 — Selection of class of accuracy of measuring voltage transformers	22
Publications referred to	Inside back cover

Foreword

This British Standard has been prepared under the authority of the Electrical Industry Standards Committee. It is a revision of the 1965 edition, which is therefore now withdrawn, to bring it more into line with the corresponding IEC Recommendations given in Publications 186 and 186A “Voltage transformers”. It retains the requirements for 3-phase voltage transformers which are not at present covered by the IEC Recommendations.

The standard also includes requirements for capacitor dividers of capacitor voltage transformers based on the requirements of IEC Publication 358 “Coupling capacitors and capacitor dividers”.

The insulation test levels that are included in the present edition differ from those given in the IEC Publications because this subject is still under general discussion in the IEC, and it is considered that the test levels for voltage transformers should be in agreement with the values likely to be adopted for switchgear.

This standard does not at present include tests for dew-point radio interference, switching impulse withstand or partial discharges (except on capacitors for use with capacitor voltage transformers) because these subjects are still under discussion nationally and internationally.

Changes have been made to some of the appendices of the previous edition. The appendix giving correction factors for atmospheric conditions during voltage tests has been deleted as this subject is now covered by BS 923 “Guide on high-voltage testing techniques”. The appendix relating to the use of stepped range designs of capacitor voltage transformers has also been deleted, as these are no longer in use, and a new one added giving guidance for installation and operation of capacitors. The appendix giving the procedure during impulse voltage withstand tests has been deleted, as this subject is covered by BS 923.

Certification. Attention is drawn to the certification facilities described on the inside back cover of this standard.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 32, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1 Scope

This British Standard specifies the requirements for electromagnetic and capacitor voltage transformers suitable for frequencies from 15 Hz to 100 Hz, and intended for use with electrical measuring instruments and electrical protective equipment such as are covered in general by the following British Standards:

BS 37, *Electricity meters*.

BS 89, *Direct acting electrical indicating instruments*.

BS 90, *Direct acting electrical recording instruments*.

BS 42, *Electrical protective relays*.

BS 3950, *Electrical protective systems for a.c. plant*.

Although the requirements relate basically to transformers with separate windings, they are also applicable, where appropriate, to auto-transformers.

This standard also specifies requirements for capacitor dividers of capacitor voltage transformers both for the above mentioned usage and also for those having the additional function of providing a high frequency link for telecommunication transmission systems on high-voltage overhead lines.

The standard does not cover capacitor voltage transformers in which the capacitance of the high-voltage capacitor is such that outputs of 10 V A cannot be obtained, although some of the clauses may apply to such devices.

2 References

The titles of the British Standards referred to in this standard are listed on the inside back cover.

3 Definitions

For the purposes of this British Standard the following definitions apply.

3.1

accuracy class

a designation assigned to a voltage transformer, the errors of which remain within specified limits under prescribed conditions of use

3.2

actual transformation ratio

the ratio of the actual primary voltage to the actual secondary voltage

3.3

broken delta connection

the connection, in delta, of a 3-phase or three single-phase secondary winding(s) of a voltage transformer, the circuit being open-circuited at one point of the delta winding, and the two ends connected to separate terminals referred to as the residual voltage terminals

3.4

burden

the value of the impedance of the external secondary circuit, expressed in ohms (or in volt-amperes at rated secondary voltage), at the relevant power factor

3.5

capacitor divider

a three-terminal device having one terminal (primary) at a high voltage (to be measured), a second terminal (earth) at or near earth potential and the third terminal (intermediate) at an intermediate voltage

NOTE 1 The expression "intermediate terminal" is an abridged designation of "intermediate-voltage terminal".

NOTE 2 The earth terminal is also sometimes called the low-voltage terminal, a term which is more suitable when a carrier frequency coupling device is used.

3.6

capacitor element

an indivisible part of a capacitor consisting of electrodes separated by a dielectric

3.7

capacitor stack

a unit or an assembly of units (usually connected in series) intended for connection to a power line

3.8

capacitor unit

an assembly of capacitor elements in a single container with accessible connections

NOTE A common type of unit for coupling capacitors has a cylindrical housing of insulating material, and metal end flanges which serve as terminals.

Units in metal containers usually have one terminal connected to the container and the other brought out through a bushing.

3.9

capacitor voltage transformer

a voltage transformer comprising a capacitor divider unit and an electromagnetic unit so designed and interconnected that the secondary voltage of the electromagnetic unit is substantially proportional to and in phase with the primary voltage applied to the capacitor divider unit

3.10**carrier frequency coupling device**

a circuit element intended to permit the injection of carrier frequency current, and which is connected between the low-voltage terminal of a capacitor divider unit and earth. It has an impedance which is insignificant at power frequency but appreciable at the carrier frequency

3.11**composite capacitor voltage transformer**

a capacitor voltage transformer in which the capacitor divider unit is an integral component

3.12**creepage distance**

the shortest distance, following the contour along the external surface of an insulator, from the earthed flange to live metal

3.13**earthed neutral system**

a system in which the neutral is connected to earth, either solidly or through a resistance or reactance of low enough value to reduce materially transient oscillations and to permit a current sufficient for selective earth fault protection

- a) A system with *effectively earthed* neutral at a given location is a system characterized by an earthing factor at this point which does not exceed 80 %.

NOTE This condition is obtained in general when, for all system configurations, the ratio of zero-sequence reactance to positive-sequence reactance is less than 3 and the ratio of zero-sequence resistance to positive-sequence reactance is less than 1.

- b) A system with *non-effectively earthed* neutral at a given location is a system characterized by an earthing factor at this point that may exceed 80 %.

NOTE Non-effectively earthed systems include resonant earthed and resistance earthed systems where earth faults are not allowed to persist for longer than 8 h in any 24 h or a total of 125 h per annum. For other cases where there is no intentional connection to earth except through indicating, measuring or protective devices of very high impedance or where the duration of earth faults exceeds the periods referred to above, the manufacturer should be consulted. (See also Table 2.)

3.14**earthing factor (coefficient of earthing)**

the ratio, expressed as a percentage, of the highest r.m.s. line-to-earth power frequency voltage on a sound phase at the selected location during a fault to earth affecting one or more phases, to the line-to-line r.m.s. power frequency voltage which would be obtained at the selected location with the fault removed

3.15**earthed voltage transformer**

a single-phase voltage transformer which is intended to have one end of its primary winding directly earthed, or a 3-phase voltage transformer which is intended to have the star-point of its primary winding directly earthed

3.16**electromagnetic unit**

the component of a capacitor voltage transformer, connected between the intermediate-voltage terminal and the low-voltage terminal of the capacitor divider (or possibly directly connected to earth when a carrier frequency coupling device is used) which supplies the secondary voltage

NOTE An electromagnetic unit comprises essentially a transformer to reduce the intermediate voltage to the required value of secondary voltage, and an inductive reactance approximately equal, at rated frequency, to the capacitive reactance of the two parts of the divider connected in parallel ($C_1 + C_2$). The inductive reactance may be incorporated wholly or partially in the transformer. See Figure 11.

3.17**electrically exposed installation¹⁾**

an installation in which the apparatus is subject to over-voltages of atmospheric origin, e.g. an installation connected to overhead transmission lines either directly or through short lengths of cable

3.18**electrically non-exposed installation¹⁾**

an installation in which the apparatus is not subject to over-voltages of atmospheric origin, e.g. an installation connected to a cable network

3.19**full range design**

a capacitor voltage transformer which covers its rated output range without any adjustment to the setting of its electromagnetic unit

¹⁾ Apparatus may be required for installations which are semi-exposed to over-voltages of atmospheric origin, i.e. to over-voltages of a magnitude less than for an exposed installation. Such installations are usually connected to overhead transmission lines through double-winding transformers, or cable, which may reduce the amplitude of incoming over-voltages. These cases require special consideration.

3.20**intermediate-voltage capacitor (C_2)**

that part of the capacitor divider between the intermediate-voltage terminal and the low-voltage terminal

NOTE See Figure 11.

3.21**intermediate voltage (U_i)**

the voltage to earth at the intermediate-voltage terminal of the capacitor divider unit when primary voltage is applied between the primary and low-voltage terminals

NOTE See Figure 11 and 3.25.

3.22**isolated neutral system**

a system which has no intentional connection to earth except through indicating, measuring or protective devices of very high impedance

3.23**measuring voltage transformer**

a voltage transformer intended to supply indicating instruments, integrating meters and similar apparatus

3.24**non-composite capacitor voltage transformer**

a capacitor voltage transformer in which the capacitor divider unit is a component of other apparatus such as a high-voltage bushing of a circuit-breaker

3.25**open-circuit intermediate voltage (U_i)**

the intermediate voltage when the electromagnetic unit is disconnected

NOTE 1 See Figure 11 and 3.21.

NOTE 2 The value of this voltage is given by:

$$U_i = U_p \left(\frac{C_1}{C_1 + C_2} \right)$$

where U_p is the voltage applied to the primary terminal.

3.26**phase displacement**

the displacement in phase between the primary and secondary voltage vectors, the direction of the vectors being so chosen that the angle is zero for a perfect transformer

the phase displacement is said to be positive when the secondary voltage vector *leads* the primary voltage vector, and negative when it *lags* the primary voltage vector; it is usually expressed in minutes or in centiradians

NOTE This definition is strictly correct for sinusoidal voltages only.

3.27**high-voltage capacitor (C_1)**

that part of the capacitor divider between the primary terminal and the intermediate-voltage terminal

NOTE See Figure 11.

3.28**primary winding**

the winding to which the voltage to be transformed is applied

3.29**protective device**

a device incorporated in a capacitor voltage transformer for the purpose of limiting over-voltages which may appear in one or more of its components, and/or to prevent sustained ferro-resonance

NOTE The device may include a spark gap and may be located in several different ways depending upon its nature.

3.30**protective voltage transformer**

a voltage transformer intended to provide a supply to electrical protective equipment

3.31**rated burden**

the value of the burden on which the accuracy requirements of this specification are based

3.32**rated capacitance (C_N)**

the value of the capacitance at rated voltage and rated frequency for which a capacitor is designed. This definition applies

- a) to the capacitance between the terminals of a capacitor unit;
- b) to the capacitance between high-voltage and low-voltage terminals or high-voltage and earth terminals of a capacitor stack;
- c) to the resultant capacitance:

$$\frac{C_1 \times C_2}{C_1 + C_2} \text{ of a capacitor divider.}$$

3.33**rated frequency**

that frequency marked on the rating plate and on which the accuracy requirements are based

3.34**rated highest equipment voltage (U_m)**

the highest r.m.s. line-to-line system voltage for which the voltage transformer is designed, and which is marked on the rating plate

3.35
rated insulation level

that combination of voltage values, both power frequency and impulse (where applicable), which characterizes the insulation of a transformer with regard to its capability of withstanding dielectric stresses

3.36
rated output

the value, marked on the rating plate, of the apparent power (in volt-amperes, using the per phase value for 3-phase transformers) that a transformer is intended to supply to the secondary circuit at the rated secondary voltage and at the specified power factor without causing the errors to exceed the values specified

3.37
rated primary voltage

the value of the primary voltage which appears in the designation of the transformer and on which its performance is based

3.38
rated secondary voltage

the value of the secondary voltage which appears in the designation of the transformer and on which its performance is based

3.39
rated transformation ratio

the ratio of the rated primary voltage to the rated secondary voltage

3.40
rated voltage factor

the multiplying factor to be applied to the rated primary voltage to determine the maximum voltage at which a transformer shall comply with the relevant thermal requirements for a specified time, and with the relevant accuracy requirements

3.41
reference range of frequency

the range of frequency values within which a capacitor voltage transformer complies with the relevant accuracy requirements

3.42
reference range of temperature

the range of ambient temperature values within which a capacitor voltage transformer complies with the relevant accuracy requirements

3.43
residual voltage

the vector sum, in a 3-phase system, of all three line-to-earth voltages

3.44
residual voltage transformer

a 3-phase voltage transformer or a group of three single-phase voltage transformers having windings connected in broken delta so as to produce between the appropriate terminals a voltage representative of the residual voltage existing in the 3-phase voltage applied to the primary terminals

3.45
residual voltage winding

the winding of a transformer between the terminals of which is produced the residual secondary voltage

3.46
resonant earthed system (a system earthed through an arc-suppression coil)

a system earthed through a reactor, the reactance being of such value that, during a single phase-to-earth fault, the power frequency inductive current passed by this reactor substantially neutralizes the power frequency capacitance component of the earth fault current

NOTE With resonant earthing of a system, the residual current in the fault is limited to such an extent that an arcing fault in air is self-extinguishing.

3.47
secondary circuit

the external circuit supplied by the secondary winding of a transformer

3.48
secondary winding

the winding which supplies the voltage circuits of measuring instruments, meters, relays or similar apparatus

3.49
unearthed voltage transformer

a voltage transformer which has all parts of its primary winding, including terminals, insulated from earth to a level corresponding to its rated insulation level

3.50
voltage error (ratio error)

the error which a transformer introduces into the measurement of a voltage and which arises when the actual transformation ratio is not equal to the rated transformation ratio

the voltage error, expressed as a percentage, is given by the formula:

$$\text{voltage error \%} = \frac{(K_n U_S - U_p) \times 100}{U_p}$$

where

K_n is the rated transformation ratio,

U_p is the actual primary voltage, and

U_s is the actual secondary voltage when U_p is applied under the conditions of measurement.

3.51 voltage transformer

a transformer, for use with electrical measuring instruments, electrical protective. and/or control equipment, for the transformation of voltage and in which the voltage in the secondary winding, in normal conditions of use, is substantially proportional to the voltage in the primary winding and differing from it by an angle which approaches zero for an appropriate method or manner of connection

4 Service conditions

Unless otherwise specified, voltage transformers shall be suitable for use under the following service conditions.

4.1 Ambient air temperatures

	°C
Maximum	40
Daily mean, not exceeding	35
Minimum, for indoor type transformers	– 5
Minimum, for outdoor type transformers	– 20

4.2 Altitude. Up to 1 000 m above sea level.

NOTE For altitudes above 1 000 m the manufacturer should be consulted.

4.3 Atmospheric conditions. Atmospheres which are:

- | | |
|-----------------------|--------------------------|
| (a) normally polluted | } see clause 13 and A.1. |
| (b) heavily polluted | |

4.4 System earthing

- a) Isolated neutral system (see 3.22).
- b) Resonant earthed system (see 3.46).
- c) Earthed neutral system (see 3.13):
 - 1) effectively earthed neutral system;
 - 2) non-effectively earthed neutral system.

Section 2. Requirements for all voltage transformers

5 Rated frequency

Unless otherwise specified the rated frequency shall be 50 Hz.

5.1 Standard reference range of frequency.

The standard reference range of frequency shall be from 99 % to 101 % of the rated frequency for accuracy classes for measurement, and from 97 % to 103 % for accuracy classes for protection.

6 Rated secondary voltages

The standard values of rated secondary voltage are 110 V and 110/√3 V (see Table 1).

The rated voltage of windings intended to be connected in broken delta with similar windings to produce a residual voltage is 110/√3 V.

The rated residual voltage of a 3-phase protective voltage transformer having a voltage factor of 1.5 shall be 110/√3 V, and of a 3-phase protective voltage transformer having a voltage factor of 1.9 shall be (110 × 3)/√3 V.

NOTE These rated residual voltages imply nominal voltages of the individual windings constituting a broken delta connection of 110/√3 V each.

7 Rated outputs

The standard values of rated output at a power factor of 0.8 lagging, expressed in volt-amperes, are:

10, 15, 25, 30, 50, 75, 100, 150, 200,
300, 400, **500.**

The values in bold type are preferred values. The rated output of a 3-phase transformer shall be the rated output per phase.

NOTE 1 For a given transformer, provided one of the values of rated output is standard and associated with a standard accuracy class, the declaration of other rated outputs, which may be non-standard values but associated with other standard accuracy classes, is not precluded.

NOTE 2 Attention is drawn to the fact that the load taken by a resistor or reactor permanently connected to the secondary terminals of a capacitor voltage transformer and forming an integral part of the electromagnetic unit is not considered to be part of the rated output.

The rated output of a residual voltage winding shall be 25 V A, 50 V A or 100 V A.

8 Rated transformation ratios

The rated transformation ratios shall be as detailed in Table 1.

Table 1 — Rated transformation ratios

All 3-phase transformers and single-phase non-earthed transformers Line-to-line	Single-phase earthed transformers Line-to-earth
kV/V	kV/V
0.11/110	$\frac{0.11}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
0.44/110	$\frac{0.44}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
0.66/110	$\frac{0.66}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
3.3/110	$\frac{3.3}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
6.6/110	$\frac{6.6}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
11/110	$\frac{11}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
16.5/110	$\frac{16.5}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
22/110	$\frac{22}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
33/110	$\frac{33}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
44/110	$\frac{44}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
66/110	$\frac{66}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
88/110	$\frac{88}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
—	$\frac{110}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
—	$\frac{132}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
—	$\frac{165}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
—	$\frac{220}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
—	$\frac{275}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
—	$\frac{330}{\sqrt{3}} / \frac{110}{\sqrt{3}}$
—	$\frac{396}{\sqrt{3}} / \frac{110}{\sqrt{3}}$

9 Rated voltage factors

The voltage factor is determined by the maximum operating voltage which, in turn, is dependent on the system and the voltage transformer primary winding earthing conditions.

The standard voltage factors appropriate to the different earthing conditions are given in Table 2, together with the permissible duration of maximum operating voltage (i.e. rated time).

10 Characteristics of voltage transformers with residual voltage windings

The characteristics of voltage transformers having residual voltage windings shall be as detailed in Table 3.

11 Limits of temperature rise (see Appendix D)

Unless otherwise specified below, the temperature rise of a voltage transformer at the specified voltage, at rated frequency and at rated burden, or at the highest burden if there are several rated burdens, at any power factor between 0.8 lagging and unity, shall not exceed the appropriate values given in Table 4.

The values given in Table 4 are based on the service conditions given in clause 4.

If ambient temperatures in excess of the values given in 4.1 are specified, the permissible temperature rise given in Table 4 shall be reduced by an amount equal to the excess ambient temperature.

If a transformer is specified for service at an altitude in excess of 1 000 m and tested at an altitude below 1 000 m, the limits of temperature rise given in Table 4 shall be reduced by the following amounts for each 100 m that the altitude at the operating site exceeds 1 000 m:

- (a) oil-immersed transformers: 0.4 %
- (b) dry-type transformers: 0.5 %

The temperature rise of the windings is limited by the lowest class of insulation either of the winding itself or of the surrounding medium in which it is embedded. The maximum temperature rises of the insulation classes are as given in Table 4.