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Edition 4

SOUTH AFRICAN NATIONAL STANDARD

Distribution transformers

WARNING – Can only be used in conjunction with SANS 60076-1

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Table of changes

Change No.	Date	Scope

Foreword

This South African standard was approved by National Committee SABS SC 67E, *Electricity distribution systems and components – Electricity distribution,* in accordance with procedures of the SABS Standards Division, in compliance with annex 3 of the WTO/TBT agreement.

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This document supersedes SANS 780:2004 (edition 3.2).

Annex C forms an integral part of this document. Annexes A, B and D are for information only.

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Contents

Page

Foreword

1 Scope 3

2 Normative references 3

3 Definitions and abbreviations 5

4 Rating 5

5 Requirements for transformers that have a tapped winding 6

6 Connection and phase displacement symbols for three-phase transformers 8

7 Rating plates 8

8 Miscellaneous requirements 8

9 Tolerances 19

10 Tests 20

11 Marking 23

Tables 1-9 24-29

Figures 1-6 29-33

Annex A (informative) Guide to purchasers on preparing an enquiry 34

Annex B (informative) Recommendations with regard to responsibility for testing 40

Annex C (normative) Non-preferred fittings 41

Annex D (informative) Example of a Routine Test Report 45

Bibliography 46

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Distribution transformers

1 Scope

1.1 This standard specifies requirements for single-phase and three-phase distribution transformers of the oil-immersed type, that

a) are category-sized in accordance with SANS 60076-1 up to and including 3 150 kVA,

b) have rated maximum voltages (U_m) that do not exceed 36 kV,

c) have uniformly insulated windings,

d) have a high-voltage and a low-voltage winding or, in the case of an auto-transformer, a series and a common winding and, in each case, if necessary, a stabilizing winding or an auxiliary winding, and

e) are suitable for off-circuit tap changing only.

NOTE Although distribution transformers are generally designed to receive power at a voltage that exceeds 3,3 kV and to deliver power to systems that have a nominal voltage of 230/400 V or 525 V, this standard covers transformers that have any combination of rated primary and secondary voltages.

1.2 This standard is not applicable to transformers that have more than two windings, other than those referred to in 1.1(d).

1.3 This standard applies to distribution transformers that are designed for use, at full continuous rating, under the conditions specified in SANS 60076-1, and also under the following conditions:

a) at an altitude that does not exceed 1 800 m;

b) at a system voltage frequency of 50 Hz; and

c) under the conditions to which the electrical installations being served could be exposed.

NOTE Requirements that have to be specified by the purchaser and those that have to be agreed upon by the manufacturer and the purchaser are listed in annex A.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced documents (including any amendments) applies. Information on currently valid national and international standards can be obtained from the SABS Standards Division.

IEC 60085, *Electrical insulation – Thermal evaluation and designation.*

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ISO 8501-1, *Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings.*

NRS 012, *Cable terminations and live conductors within air-insulated enclosures (insulation co-ordination) for rated a.c. voltages of 7,2 kV and up to and including 36 kV.*

SANS 32/EN 10240, *Internal and/or external protective coatings for steel tubes – Specification for hot dip galvanized coatings applied in automatic plants.*

SANS 121/ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods.*

SANS 555, *Unused and reclaimed mineral insulating oils for transformers and switchgear.*

SANS 1029, *Miniature substations.*

SANS 1037, *Standard transformer bushings.*

SANS 1091, *National colour standard.*

SANS 1507-1, *Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 1: General.*

SANS 1507-2, *Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 2: Wiring cables.*

SANS 1507-3, *Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 3: PVC distribution cables.*

SANS 1507-4, *Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 4: XLPE distribution cables.*

SANS 1507-5, *Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 5: Halogen-free distribution cables.*

SANS 1507-6, *Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 6: Service cables.*

SANS 2063/ISO 2063, *Thermal spraying – Metallic and other inorganic coatings – Zinc, aluminium and their alloys.*

SANS 2808/ISO 2808, *Paints and varnishes – Determination of film thickness.*

SANS 10064, *The preparation of steel surfaces for coating.*

SANS 60076-1:2008/IEC 60076-1:2000, *Power transformers – Part 1: General.*

SANS 60076-2/IEC 60076-2, *Power transformers – Part 2: Temperature rise.*

SANS 60076-3/IEC 60076-3, *Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air.*

SANS 60076-5:2006/IEC 60076-5:2006, *Power transformers – Part 5: Ability to withstand short circuit.*

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SANS 60076-7/IEC 60076-7, *Power transformers – Part 7: Loading guide for oil-immersed power transformers.*

SANS 60076-10/IEC 60076-10, *Power transformers – Part 10: Determination of sound levels.*

SANS 60076-13/IEC 60076-13, *Power transformers – Part 13: Self-protected liquid-filled transformers.*

SANS 60137/IEC 60137, *Insulated bushings for alternating voltages above 1 000 V.*

SANS 60815-1/IEC/TS 60815-1, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles.*

SANS 60815-2/IEC/TS 60815-2, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 2: Ceramic and glass insulators for a.c. systems.*

SANS 60815-3/IEC/TS 60815-3, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 3: Polymer insulators for a.c. systems.*

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this document, the definitions given in SANS 60076-1 apply.

3.2 Abbreviations

BIL: basic insulation level

CSP: complete self-protecting

HV: high voltage

LV: low voltage

SWER: single wire earth return

4 Rating

4.1 Rated power

The requirements of SANS 60076-1 apply.

4.2 Loading cycle

Transformers shall be capable of performing a loading cycle as specified in SANS 60076-7.

4.3 Preferred values of rated power

The rated power of a transformer shall be as required (see annex A) and shall preferably be one of the standard values given in column 2 of table 1.

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4.4 Operation at higher than rated voltage and/or at disturbed frequency

The requirements of SANS 60076-1 apply.

4.5 Rating of the low-voltage neutral terminal

Unless otherwise required (see annex A), the rating of the low-voltage neutral terminal shall be at least 50 % of the rated current of the line terminals in the case of transformers with a power rating exceeding 630 kVA. In the case of a transformer that has a rating of 630 kVA or lower, the rating of the neutral bushing shall be the same as that of the line terminals. In the case of a miniature substation transformer, the rating of the neutral terminal shall be the same as that of the line terminals.

4.6 Basic insulation level

Transformer windings and connected parts shall be designed to the insulation level assigned by the user in accordance with table 2.

5 Requirements for transformers that have a tapped winding

5.1 General – Notation of tapping range

The requirements of SANS 60076-1 apply.

5.2 Tapping voltage – Tapping current. Standard categories of tapping voltage variation. Maximum voltage tapping

The requirements of SANS 60076-1 apply. (See annex A.)

5.3 Tapping power. Full-power tappings – Reduced-power tappings

The requirements of SANS 60076-1 apply.

5.4 Specification of tappings in enquiry and order

The requirements of SANS 60076-1 apply.

5.5 Specification of short-circuit impedance

The requirements of SANS 60076-1 apply.

5.6 Load loss and temperature rise

5.6.1 The requirements of SANS 60076-1 apply with the following additions:

Component loss tolerances shall be in accordance with table 1 of SANS 60076-1:2008; and

a) the losses as agreed upon between the manufacturer and the purchaser (see annex A); or

b) the appropriate component loss values given in column 3 or 4 or 5 (as relevant) and column 6 of table 1, except that,

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1) if the rated no-load secondary voltage differs from one of the appropriate values given in column 1 of table 1 by more than 5 % of that value, the appropriate component loss value given in column 6 of table 1 shall be increased by 10 %; and

2) in the case of a tapped dual-ratio transformer (i.e. a transformer that has a high-voltage winding that can be connected for either one of two rated voltages without affecting phase displacement), the appropriate component loss values given in column 3 or 4 or 5 (as relevant), and column 6 of table 1 shall each be increased by 10 %.

NOTE The losses in table 1 will be subject to periodic review to ensure that the capitalized transformer losses are not excessive.

5.6.2 The pressure build-up during the temperature-rise test shall not exceed 20 kPa.

5.7 Off-circuit tapping switch

The requirements of SANS 60076-1 apply with the following additions:

When an off-circuit tapping switch is fitted,

a) it shall be a ganged switch that is operated by means of an external handle;

b) the switch shall be positively located in each operating position;

c) facilities shall be provided for the use of a padlock to prevent unauthorized operation of the switch;

d) each position of the switch shall be indicated by means of a number displayed in legible and indelible marking; and

e) the numbers referred to in (d) shall be given on the diagram plate.

5.8 External tapping connections

5.8.1 When external tapping connections are provided (see table 3), they shall be brought out by means of bushings on the low-voltage side.

5.8.2 The following tapping connections shall be provided:

a) MV to single-phase, LV: 240 V secondary, 3 LV taps, 0 %, +2,5 %, +5 % (only boost taps);

b) MV to dual phase, LV: 480/240 V secondary, 5 MV taps, -5 %, -2,5 %, 0 %, +2,5 %, +5 %;

c) MV to three-phase LV: 420 V secondary, 5 MV taps, -5 %, -2,5 %, 0 %, +2,5 %, +5 %;

d) MV to 19 kV SWER: 19 kV secondary, 5 MV taps, -5 %, -2,5 %, 0 %, +2,5 %, +5 %.

NOTE MV includes 3,3 kV, 6,6 kV, 11 kV, 22 kV and 33 kV.

5.8.3 Tapped dual-ratio transformers (i.e. transformers that have a high-voltage winding that can be connected for either one of two rated voltages) shall, when connected for the higher rated voltage, comply with the requirements of 5.6.

5.8.4 The tapping range, when the transformer is connected for the lower rated voltage, using the same tapping connections on the same phase windings as for the higher ratio, shall be in accordance with the design. The tapping range at the lower rated voltage shall be as stated by the manufacturer.

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6 Connection and phase displacement symbols for three-phase transformers

6.1.1 Subject to the provisions of 6.1.2, current-carrying connections to bushings shall be sufficiently flexible to prevent strain on the bushings and fracture of the connections during transportation.

6.1.2 The design and construction of current-carrying connections shall be such that contact between phase conductors, and between any phase conductor and a neutral conductor or any earthed metal, is not possible under short-circuit conditions.

6.1.3 Unless otherwise required (see annex A), the transformer shall be marked by the Vector symbol, Dyn11 or Yzn11.

7 Rating plates

7.1 Information to be given in all cases

The requirements of SANS 60076-1 apply with the following addition:

Month of manufacture.

7.2 Additional information to be given when applicable

The requirements of SANS 60076-1 apply.

8 Miscellaneous requirements

8.1 Dimensioning of neutral connection

The requirements of SANS 60076-1 apply including the requirements in 8.14.

8.2 Oil preservation system

The requirements of SANS 60076-1 apply including of the requirements in 8.9, 8.10 and 8.17.

8.3 Load rejection on generator transformers

The requirements of SANS 60076-1 are not applicable.

8.4 Standard dimensions of three-phase transformers

The overall dimensions of a three-phase transformer shall not exceed the applicable values given in table 4 or table 5.

8.5 Constructional requirements

8.5.1 Unless otherwise agreed upon (see annex A), constructional details and fittings shall comply with the requirements given in table 3 and in the related subclauses listed in table 3.

8.5.2 All fittings (or their extensions or terminations) to which access might be required, shall be mounted on the fitting-end of a transformer or adjacent to it if there is insufficient space on the fitting-end (i.e. on one of the short sides of the tank).

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NOTE On both an outdoor and an indoor transformer, the fitting-end shall be the left end when the transformer is viewed from the high-voltage side.

8.5.3 A transformer shall be so designed and constructed as to have an audio-sound level, measured in accordance with SANS 60076-10, which does not exceed the values given in table 6.

8.6 Cores

8.6.1 Earthing of magnetic circuit

The magnetic circuit shall be earthed to the core-clamping structure, at one point only, through a removable connection that is in an accessible position at the top of the core structure.

8.6.2 Core-clamping structures

Clamping bolts, if fitted, shall be effectively locked. Core-clamping structures shall be of metal or other acceptable material and shall clamp the core effectively. The core-clamping structure shall be insulated from the core and this insulation shall be able to withstand an r.m.s. test voltage of 2 kV at 50 Hz for 60 s, or shall have an insulation resistance of at least 500 MΩ when measured at a d.c. voltage of 2 kV.

8.7 Core-lifting lugs

Core-lifting lugs or other means shall be provided for lifting the core, and these shall be so positioned that, during lifting, no stress is imposed on any clamping bolt or its insulation.

8.8 Windings

8.8.1 Design and construction of transformers

A transformer shall be so designed and constructed as to withstand, without sustaining any damage, the thermal and dynamic effects of an external short-circuit under the conditions specified in SANS 60076-5.

8.8.2 Clamping of windings

Except in the case of small, single-phase transformers, which shall have solidly bonded windings, it shall be possible to so clamp the windings that the clamping forces are distributed over the windings and that adjustment of the pressure and the taking up of shrinkage is possible. A clamping arrangement shall be capable of withstanding any axial force that could arise during an external short-circuit. In the case of a transformer that has at least one winding, the conductor(s) of which cover the full height of the other winding(s) (i.e. where axial forces during a short-circuit are insignificant), axial clamping of the windings is not required.

8.8.3 Treatment of windings

All insulation of windings shall have been treated to ensure that no appreciable shrinkage in service will occur. Windings shall not be impregnated with varnish.

8.9 Tank and tank cover

8.9.1 General

Distribution transformers shall be free breathing or sealed and may have rigid or corrugated tanks.

NOTE Free-breathing transformers should be fitted with a conservator.

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8.9.2 Tank construction

The transformer tank shall be of welded construction. Radiators shall not obstruct the connection path of cables.

NOTE In places where welds are not continuous and the junction between the two parts could collect water, a gap of at least 3 mm should be left.

Means shall be provided, inside the tank, for locating the core and the windings at the top and the bottom of the tank. In cases where the core and windings are attached to the tank cover, they shall rest on the tank base plate when the transformer is fully assembled.

8.9.3 Sealed transformers

A sealed transformer shall be so designed that when it is filled with oil to the correct level, the internal tank pressure does not rise to more than 20 kPa during the normal temperature-rise test.

8.9.4 Rigid tanks

A sealed transformer that has a rigid tank with a gas cushion shall have an expansion space that is filled with dry air or dry, inert gas.

NOTE To maintain the pressure below 20 kPa, the volume of the expansion space should be approximately 15 % of the volume of the oil when the oil and the dry air or gas are at ambient pressure and a temperature of 20 °C.

8.9.5 Corrugated tanks

All corrugated panels used on fully or partially corrugated tanks shall have been type tested in accordance with 10.3.3.

8.9.6 Tank cover

8.9.6.1 The tank cover shall be so constructed as to prevent the accumulation of moisture. The thickness of the cover and, when applicable, of the flange, and the spacing of cover bolts shall be such that a leakproof joint is provided.

8.9.6.2 The tank cover of a transformer, other than a sealed transformer, shall be bolted to the tank. All gasketed cover joints shall be below cold oil level for transformers above 500 kVA. This is to prevent the ingress of moisture through undetected leaks.

8.9.6.3 The tank cover of a sealed transformer shall normally be welded. If so agreed upon (see annex A), the cover may be bolted. A label that gives the precautions to be taken on opening a sealed transformer shall be attached to the transformer.

8.9.6.4 Where a Buchholz relay is to be fitted to the tank, the tank cover shall be constructed in such a way that the gasses will rise to the entrance of the pipe to which the Buchholz relay is fitted.

8.9.7 Strength of tank and effectiveness of sealing

8.9.7.1 Strength of tank

When determined in accordance with 10.4.3, the permanent deflection of each panel, or stiffener (or both) of the transformer tank and, when relevant, of the conservator (measured after the application of a vacuum and pressure as described in 10.4.3, and not caused by the relieving, during the test, of fabrication stresses), shall not exceed the limit given in column 2 of table 7 in relation to the minor dimension of the panel given in column 1.

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8.9.7.2 Effectiveness of sealing

When tested in accordance with 10.3.3, the tank and, when relevant, the conservator, shall withstand the appropriate pneumatic pressure without any leakage of oil, air or gas.

8.9.8 Drain valve

Where applicable, a shouldered and gasketed drain valve shall be provided at the lowest practicable point on the main tank. It shall be positioned on the fitting end.

8.9.9 Filter valve

Where applicable, a shouldered and gasketed filter valve shall be positioned in relation to the conservator pipe that enters the main tank, or the oil-filling pipe if no conservator is fitted, so as to ensure a reasonable cross-flow of oil during filtration. The filter valve shall be flanged and its flange shall be bolted to the tank. The valve shall be fitted with a blanking plug or cover on the outlet, to exclude dirt and moisture. The valve shall be of a corrosion-resistant material.

8.9.10 Oil-filling pipe

If the transformer is not fitted with a conservator and is not sealed, an oil-filling pipe of diameter at least 25 mm, and fitted with a gasketed blanking plate, shall be fitted on the tank cover.

8.9.11 Pressure relief

When specified (see annex A), a suitable pressure-relief device shall be fitted for the release of excessive pressure. The function of the pressure relief device shall be specified. The manufacturer shall state the type and position of the device.

NOTE Consideration should be given to the use of pressure-relief devices used for slow or gradual pressure-relief over time and those used for sudden pressure-relief associated with an internal transformer fault. The latter type should be positioned so as to minimize the risk of injury associated with oil that escapes from the tank and is typically applied to larger transformers of rating above 500 kVA.

8.10 Conservator

8.10.1 General

The strength of the conservator and the effectiveness of its sealing are covered in 8.9.7.

8.10.2 Positioning (pole-mounted transformers only)

Where a conservator is required (see annex A), the purchaser shall specify the limiting dimensions.

NOTE Conservators on pole-mounted transformers are not preferred.

8.10.3 Construction

8.10.3.1 When the overall height of a transformer and conservator exceeds 1 800 mm, the conservator shall be so mounted that it can easily be removed (i.e. without disturbing the cover bolts).

8.10.3.2 Each conservator shall have an oil-filling pipe of diameter at least 25 mm, fitted with a gasketed blanking plate or a shouldered plug with a gasket. Either a drain valve of a corrosion-resistant material, or an oil-tight gasketed-shouldered plug, or a pipe with a screwed cap shall be provided.

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8.10.3.3 The oil-filling pipe shall be at the end of the conservator opposite to the end at which the drain valve or the plug of the conservator is situated.

8.10.3.4 The pipe that connects the conservator to the main tank shall be brought out from the highest point of the cover of the main tank.

8.10.4 Oil levels and conservator capacity

8.10.4.1 The capacity of the conservator, i.e. the volume of the conservator between the minimum oil level and the opening of the conservator breathing pipe, shall be at least 8 % of the total oil capacity of the transformer.

8.10.4.2 The pipe from the main tank shall protrude at least 25 mm into the conservator.

8.10.4.3 The minimum level of the oil at 10 °C in the conservator shall be at least 10 mm above the sump pipe.

8.11 Gaskets

Sealing gaskets shall be manufactured of a material that is chemically resistant to the insulating medium for which the transformer is designed. If synthetic rubber is used in the manufacture of seals, steel stops shall be provided to prevent over-compression of the gasket.

8.12 Bushings, cable boxes and terminal arrangement

8.12.1 Bushings

8.12.1.1 Open bushings shall comply with the relevant requirements of SANS 1037 and SANS 60137.

8.12.1.2 Bushings within cable boxes shall comply with the relevant requirements of NRS 012 and SANS 60137.

8.12.1.3 All bushings other than bushings intended for cable boxes and for indoor and enclosed installations (for example a miniature substation), shall be of the outdoor type.

8.12.1.4 Bushings shall comply with the following requirements:

a) outdoor MV bushings shall be clamped at the base of the bushing;

b) stem sealing washers shall comply with the requirements of SANS 1037;

c) taking into consideration specific environmental and service conditions, outdoor bushings shall comply with the requirements of the relevant part of SANS 60815;

d) MV bushings shall have a stem of diameter 12 mm;

e) LV bushings of 100 kVA or smaller transformers shall have a stem of diameter 12 mm; and

f) on a fully threaded stem, the nut used for the sealing of bushings shall be one size larger than that used for the fastening of conductors.

NOTE See 4.5 for the requirements for the current rating of neutral bushings.

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8.12.2 Bushing clearances

8.12.2.1 In the case of an open bushing, the minimum external air clearances, in millimeters, between the live metal parts of a bushing and the corresponding parts of an adjacent bushing and any earthed metal shall be

a) 1,3 times the numerical value of the appropriate lightning impulse test voltage given in column 3 of table 2 in the case of non-exposed installations,

b) twice the numerical value of the appropriate lightning impulse test voltage given in column 4 of table 2 in the case of exposed installations; or

c) such that the lightning impulse test voltage, as specified in table 2, can be applied to a transformer in accordance with SANS 60076-3 without the occurrence of flashover or breakdown.

8.12.2.2 In the case of a bushing within cable boxes, the clearance shall comply with the requirements of NRS 012.

NOTE The application of insulating tape to the live metal parts does not absolve the manufacturer from compliance with the requirements for minimum clearances.

8.13 Cable boxes

8.13.1 An MV cable box shall be an air-filled enclosure in accordance with the requirements of NRS 012. The type of arrangement (i.e. type 1, 2, 3 or 4) in accordance with NRS 012 shall be specified (see annex A).

8.13.2 An LV cable box bushing shall be capable of accommodating one cable conductor for each line and neutral terminal. In a case where more than one conductor is required, bushing flags shall be used. The purchaser shall specify the number and type of connection required (see annex A). (See SANS 1037 and SANS 60137.)

8.14 Arrangement of terminals

8.14.1 In the case of side-mounted bushings on a non-rectangular tank, the LV bushings of a two-winding transformer shall be spaced at least 90° from the MV bushings.

8.14.2 If LV bushings are mounted on a side other than opposite to the MV bushings, some form of protection (as agreed upon between the purchaser and the manufacturer (see annex A)) shall be provided against accidental contact of a broken MV overhead line connection.

8.14.3 Unless otherwise agreed upon between the purchaser and the manufacturer (see annex A), bushings shall be side mounted.

8.14.4 With the exception of the terminal arrangement on the low-voltage side of miniature substation transformers (see SANS 1029), the arrangement of both sets of terminals, when viewed from the high-voltage side, shall be in alphabetical order from left to right and, in cases where a neutral terminal is fitted, it shall be on the extreme left, adjacent to terminal "A" or "a".

8.14.5 In the case of a single-phase transformer, the terminal's lower case identifying subscript numbers shall be arranged in descending order from left to right (see figure 1).

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8.15 Surge arrester brackets

Where the mounting of an MV surge arrester is required on a transformer fitted with outdoor bushings (see annex A), suitable brackets shall be fitted adjacent to the MV bushings.

The brackets shall allow sufficient clearance from the tank such that the tank does not interfere with the operation of the surge arrester. Each bracket shall have a hole of diameter 14 mm for mounting the surge arrester. (See figure 2 for dimensions.)

The surge arrester bracket shall be mounted high enough on the transformer tank such that the bottom of the surge arrester does not extend below the base of the tank.

8.16 Dehydrating breathers and breather pipes

A dehydrating breather, when used, shall be of a transparent material or shall have a window of a transparent material to allow the condition of the desiccant to be inspected from a reasonable distance. Oil and ultraviolet radiation shall not affect the transparent material.

The breather shall be fitted with an oil cup that bears a mark to indicate the normal oil level, and that is so mounted as to prevent direct contact between the desiccant and the air outside the transformer.

If the breather is of the cartridge type, the cartridge shall be readily removable from its housing without the use of tools.

The dry mass of the desiccant shall be at least 1 kg for every 3 000 L of oil in the transformer.

The breather shall be located on the fitting end of the tank, remote from the high-voltage side and, where practicable, at a height of approximately 1,5 m above the base level of the transformer.

8.17 Oil-level gauge

8.17.1 Positioning

8.17.1.1 In the case of a transformer with a conservator, an oil-level gauge shall be provided on the conservator.

8.17.1.2 When required (see table 3) in the case of a sealed transformer, the oil-level gauge shall be mounted on the transformer tank.

8.17.1.3 The oil-level gauge shall be visible from the fitting-end of the transformer or, in the case of a conservator, from either the fitting-end or the low-voltage side.

8.17.2 Types of gauge

Where required, the oil level shall be indicated by a column type gauge or a series of gauges with overlapping ranges. The gauge(s) shall have a transparent column(s) of a suitable material and shall be securely attached to the tank or, when relevant, to the conservator.

8.17.3 Materials and design

Oil and ultraviolet radiation shall not affect the material used in the construction of the oil-level gauge.

An oil-level gauge shall not contain glass tubes or fragile plastic tubes.

The oil in an oil-level gauge shall not be in contact with the outside air.

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8.17.4 Oil-level indication

8.17.4.1 The oil level shall remain visible or legible even when the temperature of the oil in the tank is below -10 °C. The correct oil level (at a temperature of 20 °C) shall be clearly indicated. The gauge (or series of gauges) shall cover the entire range between the minimum and maximum oil levels. (See also 8.10.4.)

8.17.4.2 The oil-level indication when the transformer delivers rated power under steady conditions with the ambient air temperature at 20 °C, shall not cover more than 80 % of the full range of the gauge.

8.18 Earthing terminals

Earthing terminals shall be fitted. They shall comprise a stainless steel boss welded to the tank and fitted with a 12 mm stainless steel bolt. One terminal shall be on the low-voltage side of the tank, directly below the neutral terminal, and one on the high-voltage side of the tank, directly below the centre bushing.

Earthing terminals shall be positioned a least 50 mm above the base level of the transformer, and at least 50 mm from any cooling tube. The LV earthing terminal shall be between 250 mm and 300 mm below the neutral bushing.

8.19 Pole-mounting brackets

When pole mounted, a transformer shall have two brackets welded to its tank (see table 3). The arrangement and dimensions of the brackets are given in figure 3. The centres of the top and bottom brackets shall be 400 mm apart.

8.20 Underbase

8.20.1 General

8.20.1.1 The underbase of a miniature substation transformer shall be suitable for mounting on a base that complies with the requirements of SANS 1029.

8.20.1.2 The underbase for a transformer shall be as indicated in table 3.

8.20.2 Flat underbase

The nominal thickness of a flat underbase shall be at least equal to the appropriate minimum value given in column 2 of table 8.

8.20.3 Skid underbase

A skid underbase shall consist of channel, angle or bar runners or of flanges formed by folding the long edges of the tank base downwards and horizontally.

8.20.4 Fixing holes

Transformers for pole-platform mounting shall have fixing holes, each of diameter 22 mm (see annex A). The holes shall be arranged symmetrically in relation to the transformer's centre of gravity. Fixing hole centres on the long side of the base shall be 400 mm apart. In the transverse direction, fixing hole centres shall be 350 mm, 400 mm or 450 mm apart. (See figure 4 and table 3.)

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8.20.5 Mounting holes

Where specified in schedule A (see annex A), ground-mounted transformers shall be fitted with 22 mm mounting holes at or adjacent to each corner of the tank and in or close to the underbase, as indicated in table 3.

8.21 Jacking pads

Transformers that exceed 630 kVA shall be fitted with four jacking pads, each of which shall have a usable area of length and width at least 150 mm. These pads shall be located at a height of at least 300 mm above the base level and as near as possible to the corners of the tank. The jacking pads shall be so designed and constructed as to support the transformer during loading and off-loading operations.

In the case of jacking pads for transformers of 630 kVA or less, the number, size and height of the pads shall be as agreed upon (see annex A).

8.22 Lifting lugs

8.22.1 Lifting lugs shall be so fitted and positioned as to permit the complete assembled transformer (filled with oil) to be lifted vertically without the aid of a sling spreader.

8.22.2 Lifting lugs fitted on a removable conservator and on a detachable radiator shall be appreciably smaller than those fitted on the transformer tank.

8.22.3 The lifting lug hole shall be of diameter at least 30 mm.

8.22.4 A safety factor of at least 2,5 per lug shall apply.

8.23 Protection against corrosion

8.23.1 General

The interior and exterior surfaces of a tank, the tank cover and, when fitted, the conservator (see annex A) shall either have been abrasive blast-cleaned or pickled, rinsed and dried (in all instances in accordance with the procedures outlined in SANS 10064). Immediately before coating, both surfaces shall be free from rust, grease, oil and moisture. Abrasive blast cleaning shall only be used where the steel plate is of thickness 3 mm or more.

Special attention shall be given to preparing the surfaces of the welded areas of the covers and tank rims of sealed transformers. All spatter, slag and flux shall be removed, whereupon the areas shall immediately be cleaned back to bare metal. The exterior coating shall be applied in accordance with either 8.23.3 or 8.23.4, as appropriate to the environment where the transformer is required to operate.

NOTE SANS 10064 recommends that after the surfaces have been blast-cleaned, a coating be applied before contamination or oxidation of the surfaces can occur. As a guideline, a coating should be applied within 4 h of blast-cleaning.

8.23.2 Coating of interior surfaces

The interior surfaces of the tank, cover and cooling equipment shall be clean, dry and free of corrosion immediately before filling the transformer with oil. If there is a delay exceeding 4 h before filling, the interior surfaces shall be temporarily protected from corrosion by varnishing, oiling or applying a corrosion preventative.

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8.23.3 Coating of exterior surfaces of transformers for use in non-corrosive environments

8.23.3.1 The exterior surfaces of a transformer shall be prepared for coating either by

a) abrasive blast-cleaning to grade Sa 2½ of ISO 8501-1, to achieve a blast profile of 50 µm to 75 µm, or

b) phosphoric acid etch.

8.23.3.2 One of the coating systems given in (a) and (b) shall be selected, depending on the coating process used.

a) In the case of flow-coating or airless spray, a primer of phenolated alkyd anti-corrosive primer applied to a dry film thickness of 50 µm to 55 µm, followed by a finishing coat of air-dry quick drying alkyd gloss finish applied to a dry film thickness of 50 µm to 55 µm, followed by a final coat of air-dry quick drying gloss finish, applied by airless or conventional spray upon completion of assembly, to a dry film thickness of 20 µm to 25 µm.

b) In the case of conventional spray, either

   a twin-pack urethane primer applied to a dry film thickness of 70 µm to 80 µm, followed by a finishing coat of twin-pack recoatable polyurethane applied to a dry film thickness of 40 µm to 50 µm,

   or

   a primer of twin-pack surface-tolerant epoxy containing micatious iron oxide (MiO), applied to a dry film thickness of 70 µm to 80 µm, followed by a topcoat of twin-pack recoatable polyurethane applied to a dry film thickness of 40 µm to 50 µm.

8.23.3.3 Unless otherwise specified (see annex A), the colour of the finishing coat shall match colour C12 "Avocado" of SANS 1091. The paint manufacturer's specifications with regard to mixing and application of the finishing coat shall be followed.

8.23.4 Coatings of exterior surfaces of transformers for use in corrosive environments

8.23.4.1 The exterior surfaces of a transformer shall be prepared for coating by abrasive blast-cleaning to grade Sa 3 of ISO 8501-1, to achieve a blast profile of 50 µm to 75 µm.

8.23.4.2 Unless otherwise specified (see annex A), the exterior surfaces shall be coated by either

a) hot-dip galvanizing, in accordance with SANS 32 and SANS 121, or

b) zinc metal spraying to a dry film thickness of 50 µm to 75 µm, in accordance with SANS 2063.

8.23.4.3 One of the coating systems given in (a) and (b) shall be selected, depending on the coating process used.

a) In the case of flow-coating or airless spray, a primer of phenolated alkyd anti-corrosive primer applied to a dry film thickness of 50 µm to 55 µm, followed by a finishing coat of air-dry alkyd gloss finish applied to a dry film thickness of 50 µm to 55 µm, followed by a final coat of air-dry alkyd gloss finish, applied by airless or conventional spray upon completion of assembly, to a dry film thickness of 25 µm to 35 µm.

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b) In the case of conventional spray, a twin-pack surface-tolerant epoxy primer containing micatious iron oxide (MiO), applied to a dry film thickness of 70 µm to 80 µm, followed by a top coat of twin-pack recoatable polyurethane applied to a dry film thickness of 40 µm to 50 µm with a solids minimum volume fraction of 42 %.

8.23.4.4 Unless otherwise specified (see annex A), the colour of the finishing coat shall match colour G35 "Navy light grey" of SANS 1091. The paint manufacturer's specifications with regard to mixing and application of the finishing coat shall be followed.

8.23.5 Coatings of exterior surfaces of transformers that use 3CR12

8.23.5.1 The exterior surfaces of a transformer that uses 3CR12 shall be prepared for coating by abrasive blast-cleaning to grade Sa 2½ of ISO 8501-1, to achieve a blast profile of 50 µm to 75 µm.

8.23.5.2 The exterior surfaces shall be coated as follows by means of an airless spray:

one coat of polyamide cured epoxy strontium chromate primer applied to a dry film thickness of 20 µm to 25 µm, followed by an undercoat of polyamide cured epoxy applied to a dry film thickness of 20 µm to 30 µm, followed by a two-component high solids polyurethane applied to a dry film thickness of 30 µm to 40 µm. Alternatively, a primer with at least similar properties may be considered.

8.23.5.3 Unless otherwise specified (see annex A), the colour of the finishing coat shall match colour G35 "Navy light grey" of SANS 1091. The paint manufacturer's specifications with regard to mixing and application of the finishing coat shall be followed.

8.23.6 Other coatings

If any other coating or coating system is used, its properties shall be detailed on a data sheet and it shall have been tested and evaluated by the testing facility to ensure that its performance is at least equal to that of the systems specified in 8.23.3 to 8.23.5 (inclusive).

8.24 Physical and electrical requirements

8.24.1 Insulating materials

Solid insulating materials shall be of the appropriate type and temperature class (see annex A). Their properties and thermal classes shall comply with those recommended in IEC 60085.

A liquid insulant shall be a mineral oil that complies in all respects with the requirements of SANS 555. Oil shall contain no detectable polychlorinated biphenyls (PCBs).

8.24.2 Methods of cooling

The methods of cooling a transformer shall be those represented by the symbol group ONAN (oil natural air natural) (see annex A).

8.24.3 Temperature rise

The temperature rise shall be in accordance with SANS 60076-2.

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8.25 Complete self-protecting (CSP) features

8.25.1 Overload protection

In the case of a transformer of 200 kVA or less, if so required (see annex A), the manufacturer shall install a circuit-breaker that shall protect the transformer from LV faults and over-temperature. This breaker shall be a thermal analogue of the transformer winding and shall trip under the following conditions:

a) when the winding hot-spot temperature exceeds 140 °C; or

b) when there is a current of 10 times the rated current ± 10 % within 1,5 s; or

c) when there is a current of 20 times the rated current ± 10 % within 0,3 s.

It shall be possible to reset the breaker from ground level with a link stick. The preferred convention is "up-circuit-breaker open; down-circuit-breaker closed", and it shall be used unless otherwise agreed upon (see annex A).

A mechanical indicator shall be provided to indicate, for example by means of an "off" label, whether the breaker has been manually opened or whether it has tripped.

8.25.2 Medium-voltage fuses

When so required (see annex A), the manufacturer shall install medium-voltage fuses. These fuses shall be able to withstand in-rush currents and to discriminate under all conditions.

8.26 No-load voltages

The number of phases, the rated primary voltage and the rated secondary no-load voltage shall be as required (see annex A).

The primary voltage and secondary no-load voltages shall be stated on the rating plate.

Unless system conditions warrant otherwise, the rated no-load voltage of the secondary winding shall be equal to the appropriate system nominal voltage increased by 5 %. For example, a transformer that receives power at 11 kV and supplies power to a 3,3 kV system shall be rated at 11 000/3 450 V. Similarly, a transformer that receives power at 525 V and supplies power to a 400/230 V system shall be rated at 525/420 V.

NOTE A rated no-load voltage of the secondary winding equal to the appropriate nominal system voltage can endanger rotating machines because of undervoltage conditions when the transformer is loaded.

8.27 Impedance voltage

The impedance voltage at the principal tapping of a transformer (other than an auto-transformer) as determined in accordance with SANS 60076-1 shall, unless otherwise required (see annex A), be the value declared by the manufacturer (subject to the relevant tolerance given in SANS 60076-1), which shall be within the appropriate range given in column 2 of table 9. The declared value shall be stated on the test report.

9 Tolerances

The requirements of SANS 60076-1 apply.

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10 Tests

10.1 General requirements for routine, type and special tests

The requirements of SANS 60076-1 apply.

10.2 Routine tests

10.2.1 Routine tests and inspections shall be performed before the transformer leaves the factory, and reported in accordance with annex B (see annex A).

10.2.2 Measurement of paint thickness shall be performed in accordance with SANS 2808 to determine the dry film thickness of the coatings at several points around the perimeter of the tank, the conservator (if any), cable boxes, terminal boxes, radiator headers and radiator tubes (if provided), preferably where the surface is exposed to airborne moisture and pollution or where it is likely to come into contact with soil or vegetation.

10.2.3 Effectiveness of sealing shall be verified by applying a pressure of 20 kPa for a period of 6 h in the case of transformers that have a rating of 500 kVA or less, and 12 h in the case of transformers that have a rating exceeding 500 kVA. Examine the transformer for oil, air or gas leaks.

10.3 Type tests

10.3.1 Temperature-rise test

Fit a pressure gauge to the transformer to measure the pressure build-up during the temperature-rise test.

10.3.2 Dielectric type tests

10.3.2.1 The dielectric type tests in SANS 60076-3 apply, with the addition of the procedures in 10.3.2.2 and 10.3.2.3.

10.3.2.2 Apply impulses to all the medium-voltage line terminals simultaneously. Earth low-voltage terminals, the neutral terminal and the tank of the transformer through a shunt to ground. Insulate the tank from the ground. The test sequence consists of one impulse at 60 % of the full test voltage and two impulses at 100 % of the full test voltage. Measure the currents between the tank and earth return circuit.

The results from the impulse tests completed at 100 % and 60 % of the full test voltage shall have the same wave shape.

10.3.2.3 Apply impulses to all the low-voltage and neutral terminals simultaneously. Earth medium-voltage terminals and the tank of the transformer through a shunt to ground. Insulate the tank from the ground. The test sequence consists of one impulse at 60 % of the full test voltage and two impulses at 100 % of the full test voltage. Measure currents between the tank and earth return circuit.

The results from the impulse tests completed at 100 % and 60 % of the full test voltage shall have the same wave shape.

NOTE Deviations in the two tests might be due to flashovers somewhere in the winding to ground. This constitutes a failure (see annex A.)

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10.3.3 Corrugated tank fatigue test

10.3.3.1 Apply 11 000 pressure cycles by raising the internal pressure of the transformer to the value specified below, followed by a total release of pressure to complete one cycle. In the case of panels of depth less than 260 mm, the required sequence is as follows:

a) 4 000 cycles at 15 kPa;

b) 4 000 cycles at 20 kPa; and

c) 3 000 cycles at 25 kPa.

10.3.3.2 In the case of larger panels, the sequence shall be agreed upon (see annex A) with the basis for acceptance being

a) a variation of less than 20 % in the distance between the panels when subjected to the last 3 000 cycles at 25 kPa (this measurement is taken with the tank pressurized at 25 kPa), and

b) no trace whatsoever of an oil leak.

10.3.4 Thermal trip test (CSP transformers)

SANS 60076-13 apply, with the addition of the following:

Ensure that the circuit-breaker under test is in the closed position and immersed in a container filled with transformer oil. Gradually heat the container and its contents from ambient temperature. Install a thermometer as close as possible to the circuit-breaker contacts to measure the oil temperature. Increase the temperature until the circuit-breaker trips. Check whether the circuit-breaker trips when the oil temperature exceeds a temperature that corresponds with a calculated winding hot-spot temperature of 140 °C and taking into account the tolerances specified by the circuit-breaker manufacturer.

NOTE The oil should be stirred frequently to ensure a uniform temperature throughout.

10.3.5 Short-circuit trip test and transformer short-circuit withstand test (CSP transformers)

With the transformer (as equipped for service) at ambient temperature and with the circuit-breaker closed, apply an appropriate voltage such that when a short-circuit is applied to the LV terminals, the following values of current and tripping are achieved:

a) at 10 times the rated current in the LV windings, the circuit-breaker trips within 1,50 s ± 0,15 s;

b) at 20 times the rated current in the LV windings, the circuit-breaker trips within 0,30 s ± 0,03 s.

NOTE The maximum current circulation time will be determined by the time it takes the circuit-breaker to trip, and could be shorter than required in terms of SANS 60076-5.

10.4 Additional modifications — Special tests

10.4.1 Short-circuit withstand test

In the case of transformers of rating 500 kVA and below (excluding transformers with metal foil windings) the additional requirements and acceptance criteria given in (a) to (g) with respect to the value of the symmetrical short-circuit current given in 4.1.2 of SANS 60076-5:2006 apply.

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a) Use the resistance value at 20 °C to calculate the short-circuit currents to be applied to the transformer.

b) Use a voltage of 115 % of U_n (i.e. 5 % above U_m and 15 % above U_e) to calculate the short-circuit currents to be applied to the transformer.

c) Only pre-set short-circuit testing is allowed.

NOTE It is a "normal" condition for a transformer to have a short circuit on its terminals when power is closed to the transformer or when auto-reclose operations occur. This test is aimed at emulating this condition.)

Where preset testing is not possible, alternatives might be discussed with the purchaser before testing. The aim of the discussion would be to find an equivalent alternative means of testing.

d) A single-phase transformer will be required to withstand at least three short circuits on low, middle and high tap settings with not less than nine short-circuit tests per transformer. Test a three-phase transformer in accordance with SANS 60076-5 (use a minimum of nine short-circuit tests).

NOTE A transformer is subject to many short circuits in its operational life, especially a transformer used for electrification with long feeders and many customers. A single customer transformer has fewer faults but the fault most of the time will be close to the transformer terminals i.e. high fault currents.

e) Inspect all transformers after testing, and report any mechanical deformation of the windings, winding supports, LV and HV leads or any other part of the transformer in the test report. Deformation due to short-circuit mechanical forces is not acceptable unless it could be shown that the deformation is minimal and would not cause increased electrical, mechanical, thermal or any other stresses.

f) A total change in the inductance per phase (from the first to the last test) shall not exceed 2,0 %. Repeat testing on a particular tap setting until the change in inductance after each successive test stabilizes to less than 0,25 % of the inductance of the winding. (This implies that more than nine tests would be applied in such a case.)

The supplier has to demonstrate that a change greater than 1,0 % is of a non-detrimental self-limiting nature.

g) A limited number of radial dimensional changes in non-circular concentric winding transformers are recognized as potentially acceptable. The total change in the inductance per phase (from the first to the last test) shall not exceed 4,0 %. Testing on a particular tap setting shall be repeated until the change after each successive test (on this tap setting) stabilizes to less than 0,25 % of the inductance of the winding. (This implies that more than nine tests would be applied in such a case.)

10.4.2 Determination of sound levels

If so required, determination of sound levels to prove compliance with table 6 shall be performed in accordance with SANS 60076-10.

10.4.3 Tank stiffness test

Measure the tank stiffness in relation to a reference point, the permanent deflection of tank panels or stiffeners (or both) of the transformer tank and, where relevant, the conservator, caused (in each case) by the vacuum and pressure applications described below. If the deflection exceeds the relevant limit given in table 7, repeat the test and verify whether the excess was caused only by relieving of fabrication stresses.

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Perform vacuum application with the tank and the conservator (where relevant) empty of oil, the internal pressure reduced to 10 kPa below ambient pressure or, when relevant, the pressure at which the manufacturer requires the transformer to be filled if this pressure is lower than 10 kPa below ambient pressure. Gradually increase the pressure to ambient level.

Apply pressure where all the fittings that are normally in contact with oil are in place (including pressure-limiting devices made inoperative) and with disconnecting chambers, where fitted, empty of oil and open for inspection. Subject the interior of the transformer, complete with its normal complement of oil, to a pressure of 35 kPa measured at the top of the conservator or, if no conservator is fitted, at the top of the tank. Gradually decrease the pressure to ambient level.

11 Marking

The appropriate terminal designation assigned to the windings (and to external tapping connections, when relevant), shall be given in legible and indelible marking on, or adjacent to, the terminal with which it is associated.

The high-voltage winding of a phase shall be designated by a capital letter and the low-voltage winding of the same phase by the corresponding lower-case letter. Subscript numbers shall be assigned to single-phase transformers (where applicable) to distinguish between the ends of a winding and tappings brought out from the winding, as shown in figures 4, 5 and 6.

The markings shall be on brass, stainless steel or anodized aluminium plates that are permanently secured to the tank, each in a position that clearly indicates the sequence of the terminal with which it is associated.

NOTE 1 In the case of cable boxes, the terminal markings should be visible both when the covers are fitted and with the cover removed.

NOTE 2 Where identical cover plates are used for HV and LV cable boxes, the terminal markings appropriate to the HV side and LV side should be on separate plates that are not attached to the cable box cover plates.

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Table 1 — Standard power ratings and standard component losses of dual-ratio transformers (other than auto-transformers)

1	2	3	4	5	6
Rated no-load secondary voltage	**Rated power**	**Component losses**			
		No-load loss W			**Load loss**
V	kVA	Up to 12 kV	24 kV	36 kV	W
121 or 242, single-phase	5	40	–	–	160
	16	80	100	–	400
	25	110	140	160	530
	50	180	220	250	900
420 or 550, three-phase	16	95	120	–	410
	25	120	150	170	570
	50	180	220	250	1 000
	100	300	360	400	1 700
	200	520	600	650	2 700
	315	720	840	890	3 800
	500	1 100	1 180	1 230	5 400
	630	1 300	1 400	1 450	6 400
	800	1 600	1 650	1 700	8 000
	1 000	1 900	1 950	2 000	9 500
	1 250	2 250	2 300	2 350	11 000
	1 600	2 750	2 770	2 820	13 500
	2 000	3 250	3 250	3 300	16 000
3 300 or 3 450, three-phase	2 500	3 800	3 800	3 800	19 000
	3 150	4 500	4 500	4 500	22 000

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Table 2 — Standard insulation levels for windings and connected parts

1	2	3	4	5	6
Highest r.m.s. voltage U_m for equipment	**Nominal system r.m.s voltage U_m**	**Insulation level**			
		Lightning impulse test voltage, peak kV		**Power-frequency test r.m.s. voltage** kV	
kV	kV	**List 2[a]**	**List 3[b]**	**Separate source voltage withstand**	**Induced voltage withstand**
≤ 1,0		25	30	2,5	Twice the rated voltage at principal tapping
3,6	3,3	40	60	16	
7,2	6,6	60	75	22	
12	11	75	95	28	
24	22	125	150	50	
36	33	170	200	70	

[a] List 2 values apply to transformers designed for non-exposed installations (such as those connected to cable networks).

[b] List 3 values apply to transformers designed for exposed installations.

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Table 3 — Applicability of constructional details and fittings

1	2	3	4	5	6	7	8	9	10	11	12	13
Item No.	Subclause No.	Description	Sealed transformers						Free-breathing transformers			
			Single-phase	Three-phase								
			Power rating kVA									
			1-25	5-50	100	200-315	500-630	> 630	100-315	500-630	800	> 800
1	5.7	Off-circuit tapping switch	0	+	+	+	+	+	+	+	+	+
2	5.8	External tapping connections	+	0	0	0	0	0	0	0	0	0
3	8.10.3.2	Drain plug Drain valve: 12 mm 25 mm	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	+ X 0	0 0 X	0 0 X	0 0 X
4	8.9.10	Oil-filling pipe	0	0	0	0	0	0	X	X	X	X
5	8.10	Conservator	0	0	0	0	0	0	+	+	+	+
6	8.16	Dehydrating breathers and breather pipes	0	0	0	0	0	0	X	X	X	X
7	8.17	Oil-level gauge	0	0	0	0	+	X	X	X	X	X
8	8.19	Pole-mounting brackets	X	X	X	0	0	0	0	0	0	0
9	8.20.2	Flat underbase	+	X	+	+	+	+	+	+	+	+
10	8.20.3	Skid underbase	+	+	+	X	X	X	X	X	X	X
11	8.20.4	Fixing holes	X	X	X	X	0	0	X	0	0	0
12	8.20.5	Mounting holes	0	0	0	X	X	X	X	X	X	X
13	8.21	Jacking pads	0	0	0	0	0	X	0	0	X	X

NOTE The symbols "0", "X" and "+" used in this table have the following meanings:

0 Not applicable.
X Applicable.
+ If required (see annex C).

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Table 4 — Maximum overall dimensions of three-phase transformers of rated voltage (primary winding) 22 kV or less

1	2	3	4	5
Rated power kVA	**Maximum overall dimensions** mm			
	Length	**Width[a] (when relevant, including outdoor terminals)**	**Free-breathing transformer**	**Sealed transformer**
			Height with conservator	**Height**
25	1 000	850		1 200
50	1 100	950		1 300
100	1 300	1 000		1 500
200	1 400	1 100		1 600
315	1 400	1 100		1 600
500	1 800	1 400		1 600
630	1 900	1 800	2 200	2 100
800	2 200	1 950	2 400	2 200
1 250	2 550	1 950	2 400	2 300
2 000	3 200	2 400	3 200	2 800

[a] Transformers supplied with cable boxes may be up to 500 mm wider and up to 400 mm longer than the appropriate dimensions specified in the table.

Table 5 — Maximum overall dimensions of three-phase transformers of rated voltage (primary winding) 11 kV or less, for use in limited space indoor applications

1	2	3	4	5
Rated power kVA	**Maximum overall dimensions** mm			
	Length	**Width[a] (when relevant, including outdoor terminals)**	**Free-breathing transformer**	**Sealed transformer**
			Height with conservator	**Height**
25	1 000	850	1 400	1 200
50	1 100	950	1 500	1 300
100	1 300	1 000	1 500	1 300
200	1 400	1 100	1 950	1 600
315	1 400	1 100	1 950	1 600
500	1 800	1 200	2 200	1 600
630	2 000	1 400	2 200	2 100
800	2 000	1 400	2 400	2 200
1 250	2 000	1 400	2 400	2 300

[a] Transformers supplied with cable boxes may be up to 500 mm wider and up to 400 mm longer than the appropriate dimensions specified in the table.

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Table 6 — Maximum limits of transformer audio-sound levels

1	2
Rated power kVA	**Maximum audio-sound level** dB(A)
5 to 200	48
315	50
500	52
630	53
800	54
1 250	56
2 000	58
2 500	59
3 150	60

Table 7 — Permanent deflection limits of panels of transformer tanks and conservators

1	2
Minor dimension of panel *L* mm	**Maximum permanent deflection** mm
$L \leq$ 950	3
950 $< L \leq$ 1 300	4
1 300 $< L \leq$ 1 650	6
1 650 $< L \leq$ 2 000	8
2 000 $< L \leq$ 2 300	10
2 300 $< L \leq$ 2 700	12
2 700 $< L \leq$ 3 000	14
3 000 $< L$	16

Table 8 — Minimum nominal thickness of flat underbase

1	2
Rated power of transformer *P* kVA	**Minimum nominal thickness** mm
$P <$ 100	4,5
100 $< P \leq$ 315	6,0
315 $< P \leq$ 1 250	8,0
1 250 $< P \leq$ 3 150	10,0

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Table 9 — Standard ranges of impedance voltages (percentage of rated no-load voltage) of transformers (other than auto-transformers)

1			2
Rated power *P* kVA			**Range of declared impedance voltage at the principal tapping** %
		P	< 200	3,0 to 4,5
200	≤	*P*	< 500	4,0 to 5,0
500	≤	*P*	< 1 250	4,5 to 5,5
1 250	≤	*P*	< 3 150	5,0 to 6,5

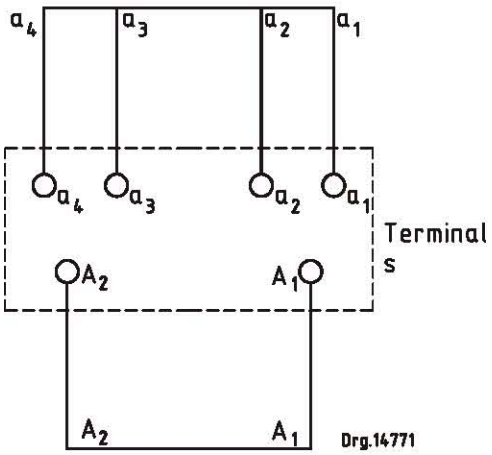

Figure 1 — Single-phase winding connection with 100 %, 102,5 % and 105 % external tapping connections

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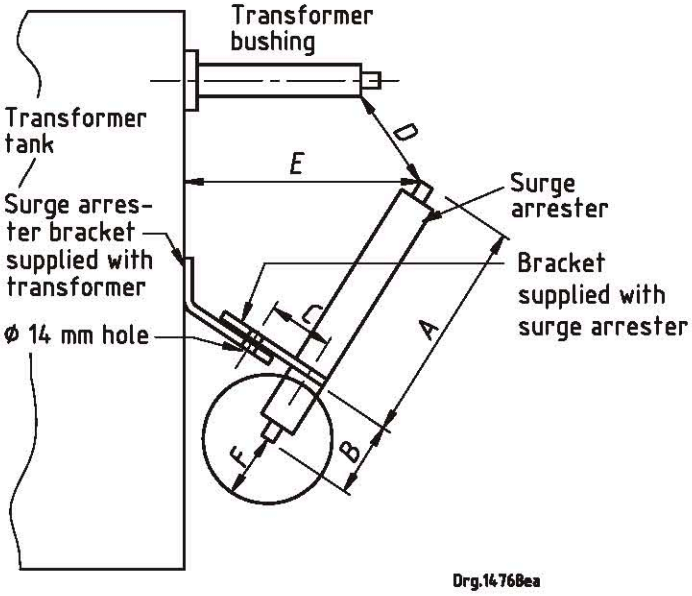
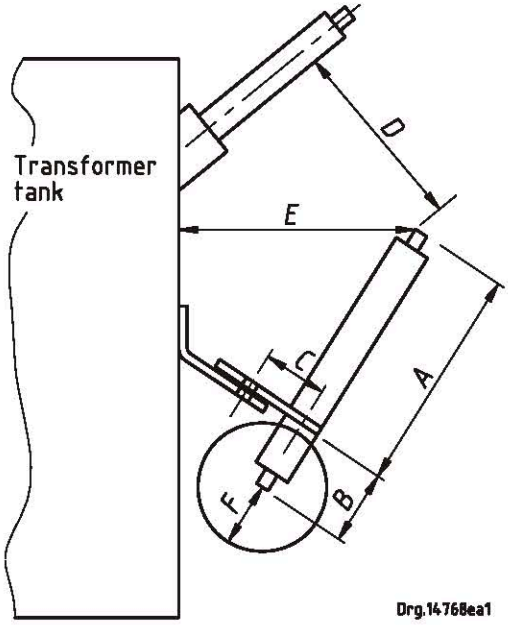
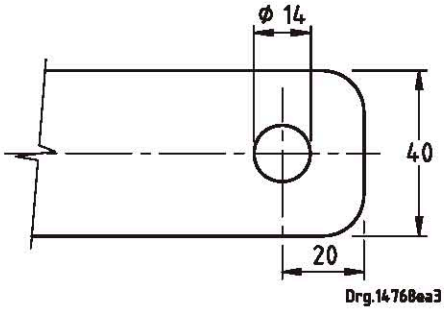


a) Horizontal transformer bushing surge arrester clearances



b) Tilted transformer bushing surge arrester clearances



c) Transformer bracket for surge arrester

1	2	3	4
Parameter	**Dimension** mm		
	Rated voltage of transformer		
	11 kV	22 kV	33 kV
A	200-300	300-400	370-570
B (max.)	75	75	75
C (min.)	130	130	130
D (min.)	200	200	200
E (min.)	190	300	400
F (min.)	150	150	150

Key

Parameters A, B and C are given values specified by the surge arrester manufacturer.

D shortest distance between the surge arrester line terminal and the transformer bushing.
E shortest distance between the surge arrester line terminal and any earthed metal.
F radius is clear of any object.

Transformers shall be designed to comply with parameters D, E and F.

The construction of the bracket may vary between manufacturers, but the interfacing dimensions shall be as shown.

Radius *F* shall be clear of any objects.

Figure 2 — Surge arrester bracket supplied with transformer — Dimensions

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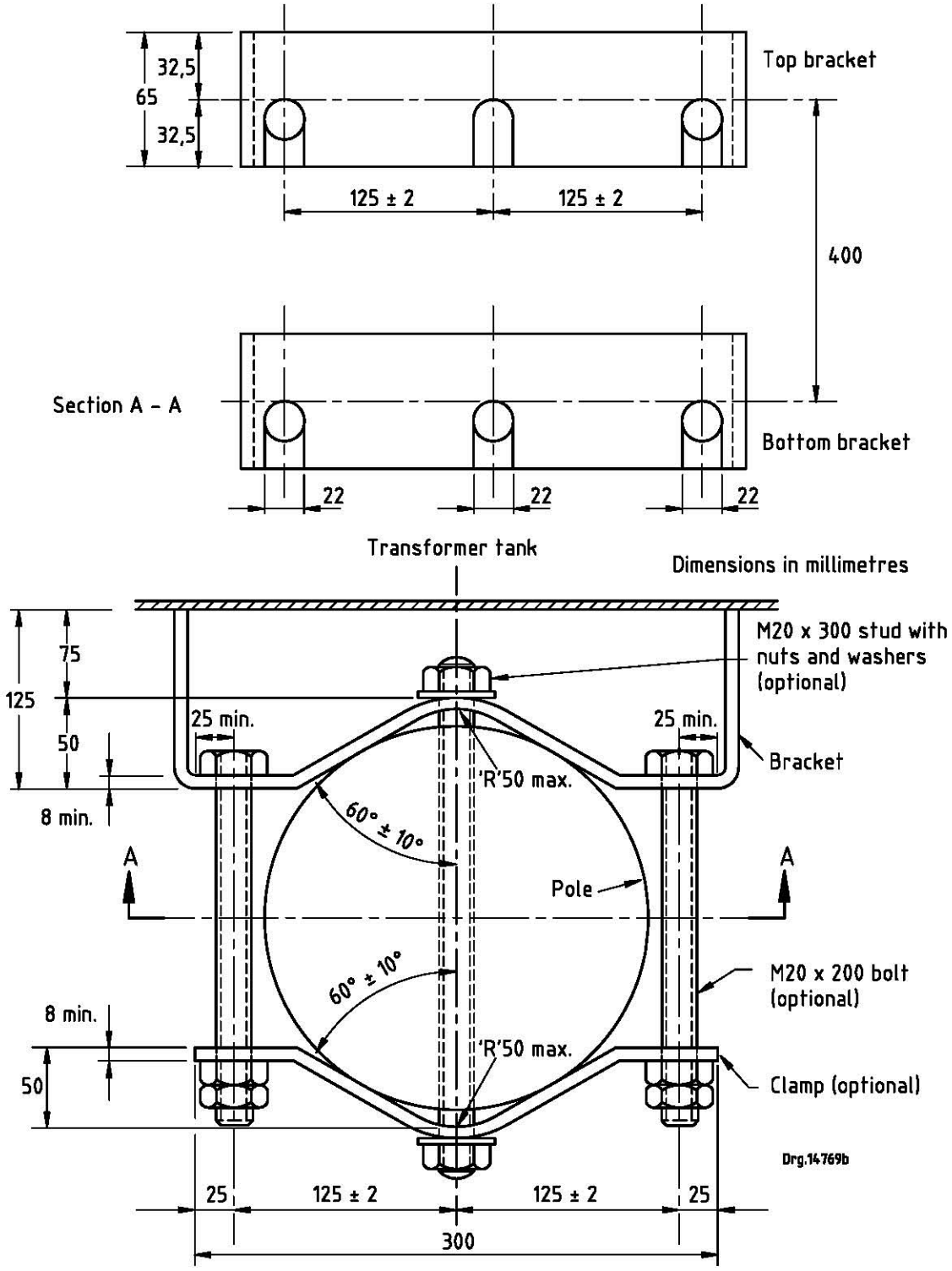

NOTE Dimensions are subject to a tolerance of +1 mm unless otherwise stated.

Figure 3 — Pole-mounting clamping arrangement

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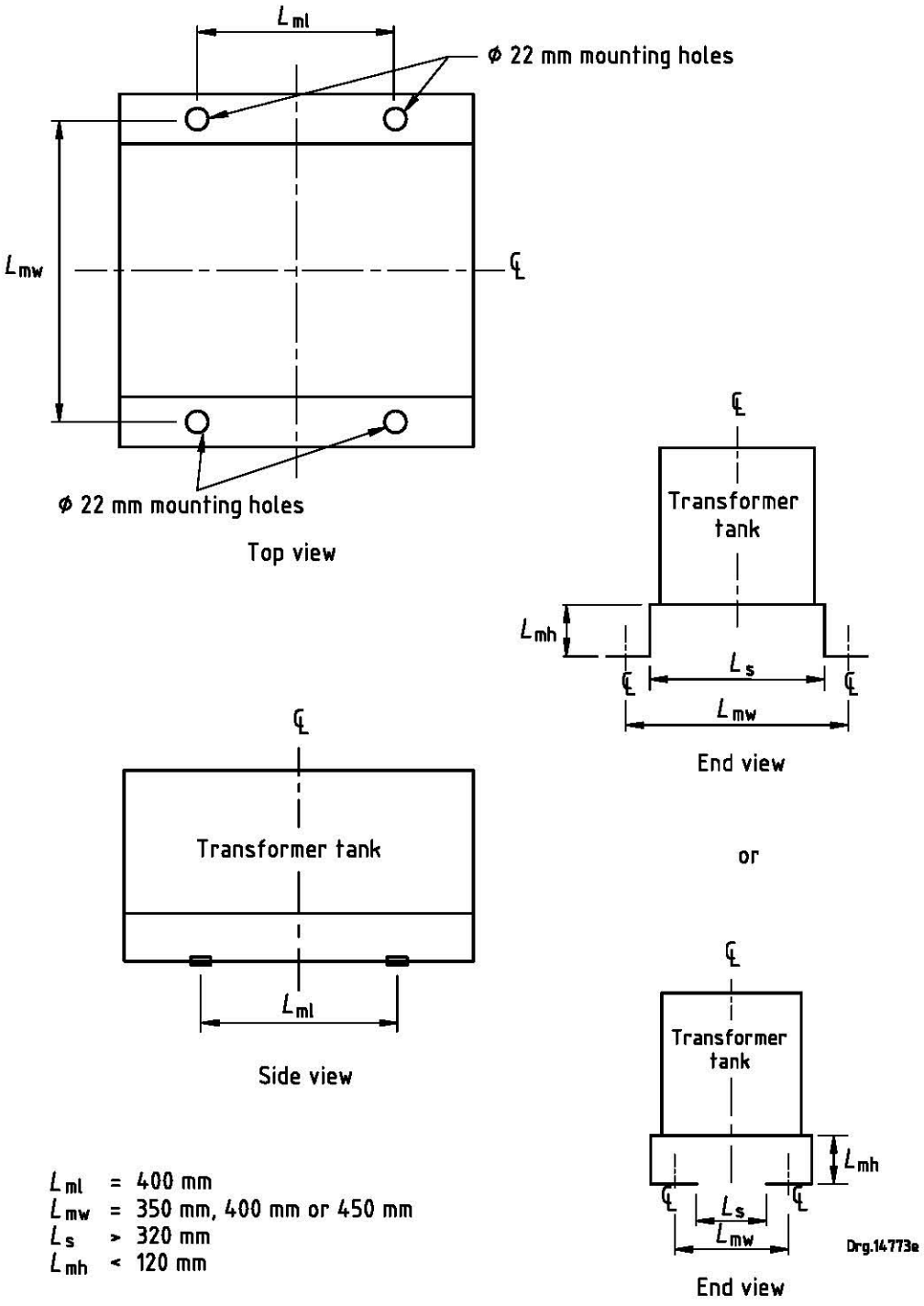

Figure 4 — Transformer mounting hole arrangement

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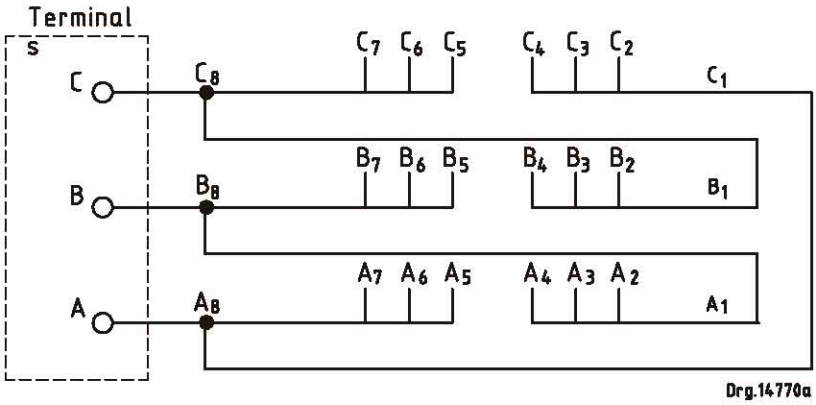
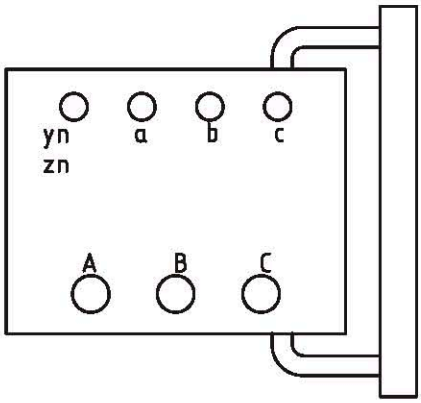
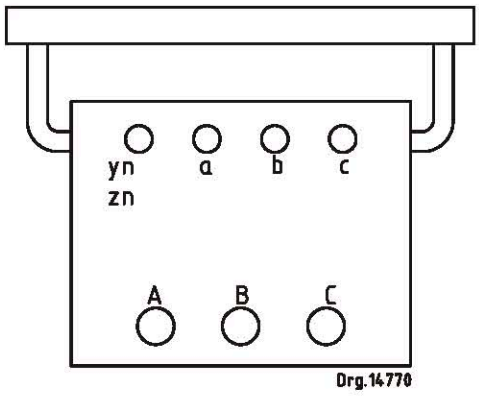


Figure 5 — Typical three-phase delta-connecting windings with tappings





Need to add MV with yn for clarity

Figure 6 — Terminal markings

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Annex A
(informative)

Guide to purchasers on preparing an enquiry

A.1 General

A model form is given in this annex to provide the purchaser with a convenient aid to purchasing. The use of this form is intended to obviate the need for preparing a detailed technical specification.

The purchaser need only specify compliance with this standard, provide the tenderers with details of his particular requirements, and set out the information he requires the tenderer to provide, as indicated below.

The model form in this annex provides the purchaser with a schedule A and a schedule B. In his enquiry, the purchaser should provide a schedule A and a schedule B for each type of transformer ordered.

A.2 Schedules

A.2.1 Schedule A

Schedule A lists the requirements to be specified by the purchaser in enquiries and orders. These requirements include references to the relevant clauses in this standard to assist in compiling the schedules.

Where the text of any referenced standard stipulates that the purchaser shall indicate his requirements, these requirements should also be specified in schedule A.

The purchaser should set out his particular requirements and choices in his own schedule A.

A.2.2 Schedule B

The tenderer should fill in schedule B. By doing this, the tenderer will be stating compliance with this standard and will be providing the information the purchaser has requested.

NOTE 1 Where this standard allows the purchaser to make a choice, schedule A lists the preferred items/values/quantities. In the interests of standardization, purchasers are encouraged not to deviate from these preferences.

NOTE 2 When completed, these schedules become normative annexes to the enquiry specification.

A.3 Commercial conditions

A purchaser will furthermore need to indicate the commercial conditions applicable and draw up a price schedule. Requirements with regard to delivery, storage, packing and marking should be attended to in this part of the enquiry.

In general, the present value of the energy losses of the transformer over its expected lifetime should be added to the initial cost of the transformer in order to enable the purchaser to select the most cost-effective supplier.

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A.4 Quality verification

This standard does not cover the purchaser's possible requirements in respect of aspects such as quality verification, quality control and inspections, since each purchaser needs to consider, among other things, the criticality of the application of each component and his own policy towards these matters. Purchasers are referred to SANS 9001 for guidance in this regard.

A.5 Testing

Attention should be paid to the subject of tests, and their related costs. Tests should be done by a competent party and tenderers should be requested to provide assurances in this regard. Price schedules should be drawn up and covering letters so worded that the costs of all services, such as tests, delivery and spares, are declared and provided for in the tender.

When sample testing is to be undertaken for type tests, or routine tests (or both), the number of samples used and the frequency of sampling should be agreed upon with the supplier.

A.6 Revision of standards used as normative references

As has been indicated, this standard is based on a set of defined standards that might have been revised or amended. It can be expected that most purchasers would, in principle, wish to use the latest editions of these standards.

A.7 Model form for schedules A and B

The model form (see table A.1) is provided as a convenient aid to purchasing. Guidance on preparing an enquiry with the aid of this form is given in clause A.2.

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Table A.1 — Model form for schedules A and B

Schedule A: Purchaser's specific requirements
Schedule B: Particulars of equipment to be supplied

Part 1 — Preferred fittings

1	2		3	4
Subclause of SANS 780	**Description**		**Schedule A**	**Schedule B**
	Number of units required a) firm b) optional			 xxxxxxxxxx xxxxxxxxxx
4	Nominal rating		.....	xxxxxxxxxx
	Rating of low-voltage neutral terminal, if other than as specified	kVA	.....	xxxxxxxxxx
4.5	Primary voltage	V	.....	xxxxxxxxxx
	Secondary voltage	V	.....	xxxxxxxxxx
	Number of phases		Single-phase Three-phase	xxxxxxxxxx
4.6	Insulation level			
	a) medium-voltage b) low-voltage	kV kV	xxxxxxxxxx xxxxxxxxxx	....
5.2	Tappings		YES/NO	xxxxxxxxxx
5.6	Losses, if other than as specified a) no-load losses b) load losses	 W W		 ....
6.1.3	Vector symbol, if other than as specified		.....	.....
8.4	Dimensions a) overall height b) overall length c) overall width Total mass	 mm mm mm kg	 xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx	 ....
8.5	Constructional details and fittings (see table 3)		.....	xxxxxxxxxx
8.9	Tank type		Sealed/ free-breathing	xxxxxxxxxx Plain/radiators/ corrugated
8.9.4	Expansion space	%	xxxxxxxxxx	.....
8.9.6	Tank cover of sealed transformer to be bolted, if so agreed		YES/NO	.....
8.9.11	Pressure-relief device		YES/NO	
8.10	Conservator		YES/NO	xxxxxxxxxx

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Table A.1 *(continued)*

1	2		3	4
Subclause of SANS 780	**Description**		**Schedule A**	**Schedule B**
8.13.1	The type of arrangement required in an air-filled arrangement		xxxxxxxxx	.....
8.13.2	Number and type of connection required		.....	xxxxxxxxxxx
8.14	Terminations		Cable-box or outdoor	xxxxxxxxxx
	Medium-voltage bushings			
	a) material		xxxxxxxxxxx	.....
	b) creepage distance	mm	xxxxxxxxxxx	.....
	BIL	kV		
	Low-voltage bushings			
	a) material		xxxxxxxxxx	.....
	b) creepage distance	mm	xxxxxxxxxx	.....
	BIL	kV		
	Number of conductors per terminal		xxxxxxxxxx	.....
	Position of bushings		xxxxxxxxxx	.....
8.14.2	The form of protection against accidental contact with an MV overhead line connection		.....	.....
8.14.3	The mounting position of bushings		.....	xxxxxxxxxxx
8.15	Mounting of an MV surge arrester on a transformer with outdoor bushings		.....	xxxxxxxxxx
8.16	Breather type		xxxxxxxxxx	.....
8.17	Oil-level gauge (> 400 kVA sealed)		YES/NO	xxxxxxxxxx
8.20	Underbase		Flat/skid	xxxxxxxxxx
8.20.4	Fixing hole spacing details		xxxxxxxxxx	.....
8.20.5	Ground-mounted transformers		xxxxxxxxxx	.....
8.21	Details of jacking pads for transformers smaller than 630 kVA		xxxxxxxxxx	.....
8.23	Corrosive environment		High/low	xxxxxxxxxx
	Colours of finishing coats, if different from standard		.....	.....
			.....	.....
8.24.1	Insulating material, if other than as specified		.....	.....
8.24.2	Cooling method		ONAN/LNAN	xxxxxxxxxx
			.....	.....
8.25.1	Overload protection	%	YES/NO	xxxxxxxxxx
	Open/close convention, if other than as specified		.....	.....
8.25.2	MV fuses		YES/NO	xxxxxxxxxx
8.26	Number of phases, rated primary and secondary no-load voltages		xxxxxxxxxx	.....
8.27	Impedance voltage, if other than as specified		.....	.....

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Table A.1 *(continued)*

1	2	3	4
Subclause of SANS 780	**Description**	**Schedule A**	**Schedule B**
10	Tests		
10.2	Number of copies of routine test results to be provided	.....	xxxxxxxxxx
10.3	Details of previous type-test results	xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx	....
	Type-test certificate serial numbers and dates	xxxxxxxxxx xxxxxxxxxx	....
10.3.3	The sequence of panels of depth exceeding 260 mm in the corrugated tank fatigue test	xxxxxxxxxx	.....
10.4.1	Short-circuit withstand test required	YES/NO	xxxxxxxxxxx
10.4.2	Sound level determination required	YES/NO	xxxxxxxxxxx

Part 2 — Optional fittings (complete only if such fittings are required)

1	2	3	4
Subclause of SANS 780	**Description**	**Schedule A**	**Schedule B**
C.1	Current transformers a) type required (mounting details) b) ratio	YES/NO	xxxxxxxxx xxxxxxxxxx xxxxxxxxxx
C.2	Gas-actuated and oil-actuated relay Type	YES/NO	xxxxxxxxxx .....
C.3	Thermometer pockets	YES/NO	xxxxxxxxxx
C.4	Indicating thermometer	YES/NO	xxxxxxxxxx
C.4.2	Type of indicating thermometer	.....	.....
C.4.4	Alarm contacts details	.....	.....
C.6	Wheels and axles, if required	YES/NO	xxxxxxxxxx

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Table A.1 *(concluded)*

Part 3 — Particulars of transformer for parallel operation (complete only if such fittings are required)

1	2		3	4
Subclause of SANS 780	**Description**		**Schedule A**	**Schedule B**
	Turns ratio of windings at rated voltage		.....	xxxxxxxxxx
	Turns ratio corresponding to tappings		.....	xxxxxxxxxx
	Tapped winding		MV/LV	xxxxxxxxxx
	Load loss at rated current corrected to a reference temperature of 75 °C	W	.....	xxxxxxxxxxx
	Impedance voltage related to the principal tapping	%	.....	xxxxxxxxxxx
	Internal winding connection symbol		.....	xxxxxxxxxxx

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Annex B
(informative)

Recommendations with regard to responsibility for testing

B.1 This standard is based on the understanding that the manufacturer conducts routine tests on every transformer before it is dispatched and that the costs of the routine tests are included in the selling price of the transformer.

B.2 Unless otherwise agreed upon between the supplier and purchaser at the time of accepting an order (see annex A), routine tests are to be conducted at the manufacturer's works and, if so desired by the purchaser, can be conducted as acceptance tests in the presence of the purchaser or his authorized representative (see annex D.)

B.3 The date and time of testing is to be decided on by the manufacturer, who should give adequate notice to the purchaser or his authorized representative. The results of the tests carried out at the appointed time should be used as criteria for acceptance, whether or not the purchaser or his representative was present during the tests.

NOTE The manufacturer can be regarded as having given adequate notice if

a) the purchaser or his authorized representative has been informed, by registered post, of the date and time of testing (such information should reach him at least one week before that date) and the manufacturer has received acknowledgement of receipt of the information, and

b) in the event of a change of date or time of testing, the purchaser or his authorized representative has been informed of the new date or time.

B.4 The cost of routine tests that are not conducted at the manufacturer's works and that are a repetition of the manufacturer's routine tests, and also the cost of routine tests, which, after agreement between supplier and purchaser, are conducted on a date later than the date initially decided upon and communicated by the manufacturer, should be borne by the purchaser.

B.5 Type and special tests as required in this standard should be done by the manufacturer on each design. To avoid the costs incurred by the repetition of type and special tests on every lot of transformers offered for test, a certified record of the results of such tests conducted on a transformer from a previous lot may be submitted and, if acceptable, one or more of these tests may be omitted, provided that the certified record gives the date and method of testing, the serial number, the year of manufacture (if different from the year of test), and all relevant details of the transformer tested. Details of any differences in construction and rating between the transformer to which the record applies and the transformers in the lot offered for test should be made available.

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Annex C
(normative)

Non-preferred fittings

C.1 Current transformers

C.1.1 Mounting

When so required (see annex A), a current transformer shall be provided and it may be mounted

a) in the main tank of the transformer, or

b) in the case of a low-voltage neutral current transformer, in a weather-proof box on the tank side or end, or

c) in the case of a low-voltage current transformer for an indoor or an enclosed installation (for example, a miniature substation transformer), direct on the bushing stems on the outside of the tank.

C.1.2 Short-circuit withstand

A current transformer shall be capable of withstanding the thermal and dynamic effects of the same overcurrents that the associated winding of the power transformer is required to withstand (see 10.4.1).

C.1.3 Insulation level

A current transformer shall have an insulation level at least equal to that of the section of the winding with which it is associated (see table 2).

C.1.4 Secondary terminal box

The secondary and tapping leads of a current transformer, other than one mounted externally on the low-voltage bushing stems (in the case of enclosed and indoor installations), shall be brought out to an air-insulated, weatherproof, and vermin-proof secondary terminal box with a bottom gland plate that complies with the requirements of C.5.1.

C.2 Gas-actuated and oil-actuated relays

A gas-actuated and an oil-actuated relay, when required (see annex A), shall be of the double-element type and shall be fitted with both alarm and tripping contacts, as described in C.4.4.

All pockets, bushing turrets and, subject to the provisions in clause C.1, chambers that are liable to entrap gas, shall be connected to the transformer tank or, at a point below the relay, to the pipe that connects the tank to the relay. The angle of inclination, with respect to the plane of the transformer base, of each pipe from the tank, pockets, chambers and bushing turrets (if any) to the relay shall be between 5° and 7°.

If the gas release cock on the relay is

a) higher than 2 m above the transformer base level, or

b) in a position that exposes the operator to the risk of contact with live parts,

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a gas release cock connected to the relay by small-bore non-ferrous tubing shall be provided on the fitting-end of the transformer, at 1,5 m above this base level.

The viewing window of the relay shall be readily visible from the ground when viewed from the low-voltage side or from either end of the transformer.

C.3 Thermometer pockets

C.3.1 A thermometer pocket, when so required (see annex A), shall be of a material that has high thermal conductivity and shall

a) have an internal diameter of at least 12 mm,

b) extend to a depth of 75 mm to 125 mm below the cover in the case of a transformer fitted with a conservator, and to 50 mm below the cold oil level in the case of a transformer not fitted with a conservator,

c) be located on the low-voltage side at or near the fitting-end of the tank, and

d) be fitted with a cover or a captive screw cap.

C.3.2 In the case of a transformer that is not fitted with a conservator, the thermometer pocket, if mounted on the side of the tank, shall be so inclined as to allow it to be filled with sufficient oil to cover the temperature sensor of the thermometer.

C.4 Indicating thermometers

C.4.1 Positioning

An indicating thermometer, when so required (see annex A), shall be situated close to the thermometer pocket. The thermometer shall be readable from the fitting-end of the tank and the temperature-sensitive part shall be so positioned in the thermometer pocket (see C.3) as to indicate the top oil temperature.

C.4.2 Type

Unless otherwise required (see annex A), an indicating thermometer shall have a dial of diameter approximately 100 mm, or shall be of the edge-reading type and, in either case, shall have a maximum temperature indicator that can be reset. The instrument shall be graduated in degrees Celsius.

C.4.3 Mounting

A thermometer that has a snap-action and a pointer indication that does not involve gears (i.e. is coupled to bi-metal strips direct), may be

a) rigidly attached to the transformer at a distance of at least 10 mm from the transformer tank or the cooling tubes to prevent corrosion behind the thermometer, or

b) clamped to the cooling tubes, with a corrosion-resistant, weatherproof, insulating material used to isolate the thermometer and clamping device from the tubes, or

c) mounted direct in the thermometer pocket (see C.3), provided that it is in a position where the thermometer can be reset without switching off the transformer.

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A thermometer other than one of the types referred to above, shall be flexibly mounted at a distance of at least 10 mm from the transformer tank or cooling tubes, unless the essential elements themselves are already flexibly mounted.

C.4.4 Alarm contacts

When so required (see annex A), adjustable alarm contacts, or an additional set of adjustable contacts for tripping purposes (or both), shall be fitted. The alarm and tripping contacts shall be capable of 500 make-and-break operations at a load of 20 VA that has any of the following combinations of current and voltage characteristics:

a) either an inductive direct current with a time constant of 40 ms ± 5 ms, or an inductive alternating current with a power factor of 0,4 ± 0,1; and

b) a voltage, a.c. or d.c., of 230 V across the open contacts.

C.5 Terminal boxes and auxiliary wiring

C.5.1 Terminal boxes

If the transformer is fitted with more than one fitting that requires auxiliary wiring (for example a current transformer (see clause C.1), a gas-actuated relay or an oil-actuated relay (see clause C.2), a set of alarm or tripping contacts, or both (see C.4.4)), an air-insulated, weatherproof and vermin-proof terminal box shall be so situated on the fitting-end of the tank that the bottom gland plate is ± 1,5 m above the base level of the transformer.

If, at the time of ordering the transformer, it is stated that the transformer is to be mounted at a given height above ground level, reference to a height above the base level of the transformer shall be taken to be that height above ground level.

An earthing terminal (in the form of a stud welded to the inside of the terminal box), together with washers, a nut and a lock-nut, shall be fitted.

The wiring shall enter a terminal box by a sealed side entry.

The bottom of the terminal box shall consist of a removable, undrilled gland plate, or shall have suitable knockouts that are capable of accommodating captive cone type glands. The gland plate shall have a gauze-covered drain hole of diameter 15 mm to 25 mm.

C.5.2 Auxiliary wiring

Auxiliary wiring between the terminal box and the terminals of the fittings shall be by means of multicore armoured cables that have rated voltages of 600/1 000 V and that have stranded copper conductors of cross-sectional area at least 2,5 mm^2. The thermal characteristics of the insulation of the cables shall be equal to or better than class A insulation that complies with the requirements of IEC 60085.

Alternatively, and provided that the cables are not fastened direct to the cover or the upper part of the tank or radiators, wire-armoured, PVC-sheathed cables that comply with the requirements of SANS 1507-1, SANS 1507-2, SANS 1507-3, SANS 1507-4, SANS 1507-5 and SANS 1507-6, may be used.

Cables shall by terminated in weatherproof captive cone type glands and the armouring shall be earthed at both ends.

Alarm and trip contacts shall be electrically independent and shall not be earthed.

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C.5.3 Terminal boards

The arrangement of terminal boards in the boxes shall be such as to facilitate the entry of the incoming control and other cables.

Terminals shall be suitable for the stranded conductors provided for auxiliary wiring (see C.5.2). Terminals of the type that has clamping screws in direct contact with the wire, shall not be fitted.

The internal wiring connected to one side of the terminal blocks, or the terminal blocks themselves, shall be durably and legibly marked for purposes of identification.

C.6 Wheels and axles

When so required (see annex A), two axles, each fitted with two wheels, shall be fitted to a skid underbase (see 8.20.3). If a skid underbase has not been specified, the axles may, at the discretion of the manufacturer, be welded or bolted to the tank.

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Example of a Routine Test Report

ROUTINE TEST REPORT

Customer:			Serial No.:
kVA:	Voltage:	Ph:	Order No.:
Vector group:	Current:	Hz:	Report No.:
Taps:	Cooling:		Test date:

Tests		Guaranteed values	Tolerances (SANS 780)	Transformer serial numbers (measured values)			
Ratio test	TAP 1						
	TAP 2						
	TAP 3						
	TAP 4						
	TAP 5						
	TAP 6						
	TAP 7						
No-load loss (W)							
Magnetizing current (%)							
Resistance test (Ω)	AB						
	BC						
	CA						
	ab						
	bc						
	ca						
Ambient temperature (°C)							
Reference temperature							
Load loss (W)							
Reactance (%)							
Impedance (%)							
Test amps (A)							
Test volts (V)							
Test watts (W)							

Applied voltage tests	Supply 50 kV for 60 s to HV with LV earthed.		
	Supply 2,5 kV for 60 s to LV with HV earthed.		
Induced voltage tests	100 % increased voltage for 60 s at 100 Hz.		
Insulating medium	Oil tested to SANS 555 (flash tested at a minimum of 70 kV).		
Vector test	Done in conjunction with ratio test.		
Measurement of paint thickness	Comply with:		
Test for effectiveness of sealing	Comply with:		
Test for phase displacement	Comply with:		
Notes			

Tested by:		Witnessed by:		Date:	

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Bibliography

SANS 9001/ISO 9001, *Quality management systems – Requirements.*

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