BS EN 50299-2:2014

BSI Standards Publication

Oil-immersed cable connection assemblies for transformers and reactors having highest voltage for equipment Um from 72,5 kV to 550 kV

Part 2: Dry-type cable terminations

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National foreword

This British Standard is the UK implementation of EN 50299-2:2014. Together with BS EN 50299-1:2014, it supersedes BS EN 50299:2002 which will be withdrawn on 13 October 2017.

The UK participation in its preparation was entrusted to Technical Committee PEL/14, Power transformers.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Oil-immersed cable connection assemblies for transformers and reactors having highest voltage for equipment Um from 72,5 kV to 550 kV - Part 2: Dry-type cable terminations

Boîte de raccordement de câble pour transformateurs immergés et bobine d'inductance de tensions comprises entre 72,5 kV et 550 kV - Partie 2: Extrémité de câble sèche

Ölgefüllte Kabelanschlusseinheiten mit Kompaktkabelanschlüssen für Transformatoren und Drosselspulen mit einer höchsten Spannung für Betriebsmittel Um von 72,5 kV bis 550 kV - Teil 2: Kompaktkabelanschlüsse

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Foreword

This document (EN 50299-2:2014) has been prepared by CLC/TC 14 "Power transformers".

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-10-13
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2017-10-13

This document partially supersedes EN 50299:2002, together with EN 50299-1:2014.

The new standard EN 50299-2 is issued which describes requirements for dry-type cable terminations only.

Dimensions mentioned in EN 50299-1 are valid for fluid-filled cable terminations. Dry-type cable terminations may also fit to these requirements.

_____

1 Scope

This European Standard covers the oil-immersed single-phase connection assemblies of cables for transformers and reactors designed in accordance with EN 60076 series.

NOTE The term "transformer" is used as common definition for transformer and reactor.

If no separate cable connection box is used and dry-type cable terminations are directly installed into the transformer tank the requirements of this standard should be followed.

The purpose of EN 50299-2 is to establish for the cable connection assemblies:

- electrical and mechanical requirements including interchangeability;
- limits of supply;
- tests to be carried out.

It complements and amends, if necessary, the relevant standards and applies to dry-type cable terminations for power cables with extruded insulation which may be used with similar interfaces for the cable entrance in switchgear applications according to EN 62271-209.

This standard applies to oil-filled cable connection boxes of transformers with highest voltage for equipment from U_m = 72,5 kV to 550 kV, including the conductor current terminal with removable link between the transformer and the dry-type cable termination.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 60076 Series *Power transformers (IEC 60076 Series)*

EN 60076-3:2013 *Power transformers —Part 3: Insulation levels, dielectric tests and external clearances in air (IEC 60076-3:2013)*

EN 60296 *Fluids for electrotechnical applications — Unused mineral insulating oils for transformers and switchgear (IEC 60296)*

EN 60422 *Mineral insulating oils in electrical equipment — Supervision and maintenance guidance (IEC 60422)*

EN 60529 *Degrees of protection provided by enclosures (IP code) (IEC 60529)*

EN 61099 *Insulating liquids — Specifications for unused synthetic organic esters for electrical purposes (IEC 61099)*

EN ISO 1302 *Geometrical product specifications (GPS) — Indication of surface texture in technical product documentation (ISO 1302)*

IEC 60076-7 *Power transformers — Part 7: Loading guide for oil-immersed power transformers*

IEC 60840 *Power cables with extruded insulation and their accessories for rated voltages above 30 kV (U_m = 36 kV) up to 150 kV (U_m = 170 kV) — Test methods and requirements*

IEC 62067 *Power cables with extruded insulation and their accessories for rated voltages above 150 kV (U_m = 170 kV) up to 500 kV (U_m = 550 kV) — Test methods and requirements*

HD 632 S2 *Power cables with extruded insulation and their accessories for rated voltages above 36 kV (U_m = 42 kV) up to 150 kV (U_m = 170 kV)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
cable connection assembly
combination of a dry-type cable termination and a cable connection box which mechanically and electrically connects the cable to the transformer

3.1.1
dry-type cable termination
cable termination which comprises an elastomeric electrical stress control component in intimate contact with a separating insulation barrier (insulator or socket) between the extruded cable insulation and the liquid insulation of the transformer cable connection box. The cable termination does not require any insulating fluid

3.1.1.1
socket
part to be installed in the cable connection box to plug the cable connector. Insulating barrier (socket) between cable connector and the insulating fluid of the cable connection box enabling the mechanical and electrical connection to the transformer

3.1.1.2
plug-in cable connector
equipment fitted to the end of a cable to ensure in combination with the socket an electrical connection to the transformer

3.1.1.3
dummy plug
insulating device for voltage proof sealing of the socket

3.1.1.4
sealing cap
for protection of the socket against environmental conditions

3.1.2
cable connection box
part of the transformer which houses the dry-type cable termination and the conductor current terminal with removable link

3.1.2.1
conductor current terminal with removable link
interface to the transformer with removable connection between transformer and socket which allows the transformer to be electrically separated from the cable

4 Limits of supply

The limits of supply between the transformer and the dry-type cable termination are defined in Figure 1. The manufacturer of the dry-type cable termination supplies the parts inside of the dotted line. The manufacturer of the transformer supplies the other components. Typically, the socket will be installed in the cable connection box by the transformer manufacturer. For details refer to table of Figure 1.

5 Rated values

When dimensioning the cable connection assembly the following rated values shall apply:

a) highest voltage for equipment (U_m);

b) rated currents (I_r);

c) rated short-time and peak withstand currents;

d) rated duration of short circuit;

e) test voltages and test currents for testing the transformer;

f) test voltage for cable commissioning.

6 Preferred values

6.1 Highest voltage for equipment (U_m)

The highest voltage for equipment U_m of the dry-type cable termination shall be equal to the values for the cable and the transformer and shall be selected from the following standard values:

72,5 kV – 100 kV – 123 kV – 145 kV – 170 kV – 245 kV – 300 kV – 362 kV – 420 kV – 550 kV.

6.2 Rated currents (I_r)

Sockets shall be selected with a rated current I_r higher than 1,2 times of the rated current of the transformer. They are qualified without performing additional tests or qualifications, to ensure withstand capability of overloading conditions of transformer according to IEC 60076-7.

The rated current I_r shall be selected from the following standard values which are 20 % higher than the rated current of the transformer:

1 000 A – 1 600 A – 2 000 A – 2 500 A – 3 150 A.

Short-time and peak withstand currents as well as the duration of short circuit shall refer to the levels provided by the cable system, not exceeding the values given in IEC 60076-7 loading guide.

6.3 Transformer test voltages

Transformer test voltages shall conform to EN 60076-3.

6.4 Transformer test currents

Transformer test currents shall conform to IEC 60076-7.

6.5 Cable installation test voltage

The cable installation test voltage shall conform to HD 632 S2, IEC 60840 or IEC 62067.

7 Requirements

7.1 Isolation of transformer during cable installation tests

Means shall be provided to achieve a temporary separation of the transformer during electrical tests to verify the cable installation. Therefore a removable link located in the interface to the transformer has to be foreseen.

The removable link can be omitted in case the plug-in cable connector is separated from the socket when performing the commissioning tests.

7.2 Connection interface

The current-carrying contact surfaces of the connection interface (items 2 and 3 in Figure 1) shall be either bare copper or silver-coated or tin-coated copper or silver-coated or copper-coated aluminium.

The connection interface is defined in Figure 2.

As the maximum conductor temperature for cables is limited by the maximum operating temperature for the insulation, there are certain cable insulations which cannot withstand the maximum temperature specified for the transformer if there is heat transfer across the connection interface of the cable termination. For cases when the temperature limit given by HD 632 S2, IEC 60840 and IEC 62067 cannot be achieved, the supplier of the transformer should provide data on temperature rise of the main circuit end terminal and the insulation liquid as function of current.

7.3 Mechanical requirements

The cable connection box and its internal components shall have the same degree of vacuum tightness, leak tightness and oil tightness as the transformer according to EN 60076 series.

The dry-type cable termination shall be able to withstand a static mechanical force of 2 kN applied transversely to its interface point.

Forces and movements from the transformer can be experienced due to temperature variations and vibrations in service. These forces can act on both transformer as well as on the dry-type cable termination

and largely depend on transformer design, installation of the dry-type cable termination, cable design and the type of mechanical support. The design of any support structure should take into account these forces and movements. It is particularly important that the support for the cable connection box should not be fastened to the clamping flange and/or the cable gland (Figure 1, item 8 and 11).

7.4 Shielding electrode

The fastening of the shielding electrode (item 4 in Figure 1) shall not restrict the current-carrying contact surfaces of the connection interface (items 2 and 3 in Figure 1). The shielding electrode shall be designed so that it can be vented in every installation position. There is a field-free region within the shielding electrode, i.e. the connection interface does not contribute to control the electrical field.

7.5 Insulating liquids

Filling of the cable connection box is usually performed under vacuum conditions with degassed insulating liquid. However, if the transformer tank is not designed to withstand vacuum, the filling of the cable connection box shall be carried out under the same conditions as for the main transformer tank.

The insulating liquid used for filling the cable connection box shall comply with the requirements of EN 60296 or EN 61099 and shall meet the requirements of EN 60422.

The breakdown voltage of the insulating liquid in new equipment should be > 60 kV. Depending on the nominal system voltage the breakdown voltage of insulating liquid of equipment in service can be lower.

7.6 Dimensions

Figure 1 and 2 shows a typical arrangement of a cable connection assembly with entry of the cable from below. Dimensions for cable connection assemblies are defined in Table 1.

The information about surface conditions in Figure 2 is stated in accordance with EN ISO 1302.

NOTE Dimensions, as far as applicable, are harmonised with EN 62271-209:2007, Figure 5.

7.7 Protection against corrosion

The cable connection assembly shall have the same degree of protection against corrosion as the associated transformer tank.

7.8 Measuring tap

If a socket is equipped with a measuring tap, the manufacturer shall specify the following information:

- capacitance to earth;
- capacitance to high voltage;
- dielectric strength (insulation level).

If not used, the measuring tap shall be earthed with suitable earthing equipment to secure against accidentally detachment.

7.9 Earthing

The clamping flange of the socket shall allow an earth connection to the cable connection box.

7.10 Sealing cap

Sealing caps are used for protection of the socket against environmental conditions in case that no plug-in cable connector is installed. If a socket is equipped with a sealing cap, the degree of protection shall be IP66 according to EN 60529. Sealing caps are not voltage proof.

NOTE The necessity of a sealing cap is agreed between parties. When necessary, the sealing cap is provided by the supplier of the socket.

7.11 Dummy plug

A dummy plug is a voltage proof sealing of the socket, e. g. for testing purposes, in case that no plug-in cable connector is installed. If the socket is equipped with a dummy plug, it shall be able to withstand all testing and operation conditions.

NOTE The necessity of a dummy plug is agreed between parties. When necessary, the dummy plug is provided by the supplier of the socket.

7.12 Material compatibility

The materials of the socket shall be compatible to the insulating liquids according to EN 60296 or EN 61099.

Sockets shall not be applied to the transformer drying process, as the maximum drying temperature of 115 °C may change material properties of the socket.

NOTE In case sockets shall be used when drying the transformer the maximum allowed temperature shall be agreed between socket supplier and transformer manufacturer.

8 Tests

8.1 General

Tests of the dry-type cable termination shall be performed according to HD 632 S2, IEC 60840 or IEC 62067. Tests of the transformer shall be performed according to EN 60076 series.

If a socket of the dry-type cable termination is intended to be used for transformer routine tests according to EN 60076 series a design test for this type of socket and a routine test for this sample intended to be used shall be performed according to Appendix A.

The application of Appendix A shall be agreed between parties.

The transformer manufacturer shall follow the handling and installation instructions of the supplier of the socket.

8.2 Tests on sockets

8.2.1 Tightness test

The tightness of the socket shall be proved in a routine test using a suitable test method.

8.2.2 Vacuum test

For verification of the vacuum tightness of the socket as part of a type approval test an overpressure of 5 bar is applied for 15 minutes on the side of the plug-in cable connector.

No pressure drop shall occur during the test. A dielectric routine test on the socket shall be performed before and after this vacuum test.

8.3 Factory tests on the transformer

8.3.1 Check of dimensions

The cable connection box shall comply with the arrangement according to Figure 2 and the dimensions according to Table 1.

8.3.2 Vacuum and pressure tests

Vacuum and tightness tests of the cable connection assembly shall be performed together with the vacuum and pressure tests of the transformer.

If the socket is not installed for the test, the opening of the cable connection box shall be sealed by suitable means (e.g. blind flange).

8.3.3 Dielectric tests

In order to perform the dielectric tests of the transformer a test bushing is temporarily installed on the cable connection box. A removable link adapted to the test bushing is used for the test.

If a qualified socket according to Appendix A is installed in the transformer and suitable test components are provided by the socket supplier, it is permissible to perform the transformer test with installed socket using suitable test equipment, e. g. plug-in test bushing, dummy plug or test cable.

All components used for the tests shall be designed to meet the dielectric test requirements in accordance with EN 60076 series or customer specification.

8.4 Tests after installation of the cable system

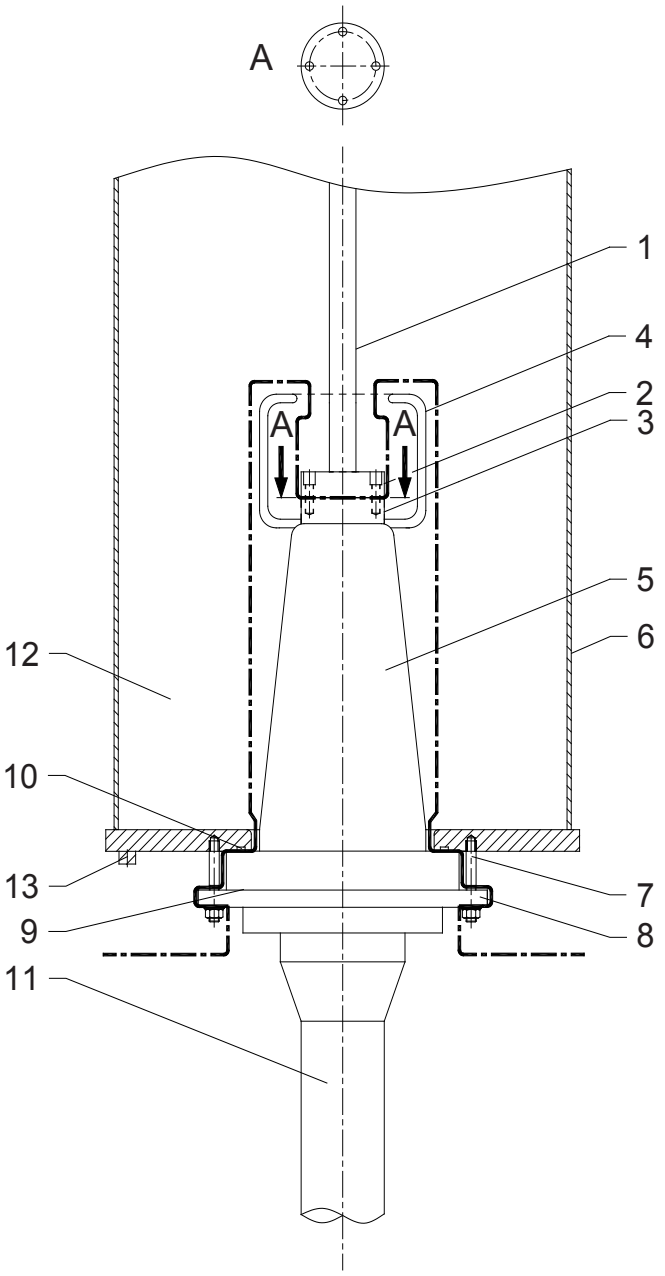
The commissioning test of the cable system is performed according to HD 632 S2, IEC 60840 or IEC 62067 or in agreement between purchaser and the contractor.

The cable system has to be separated from the transformer winding for voltage testing. Therefore, resources shall be provided which enable a separation of the transformer from the cable (e.g. removable link).

If necessary, the supplier of the socket can replace the shielding electrode (item 4 in Figure 1) by a suitable test shielding electrode taking into account the arrangement of Figure 2 and the dimensions according to Table 1.

Shielding on the transformer side is usually necessary.

NOTE If agreed between parties the plug-in cable connector can be separated from the socket and can be connected to a special test equipment for cable tests after installation and afterwards can be connected to the socket again. In this case, the installed cable connection box of the transformer needs not to be changed.

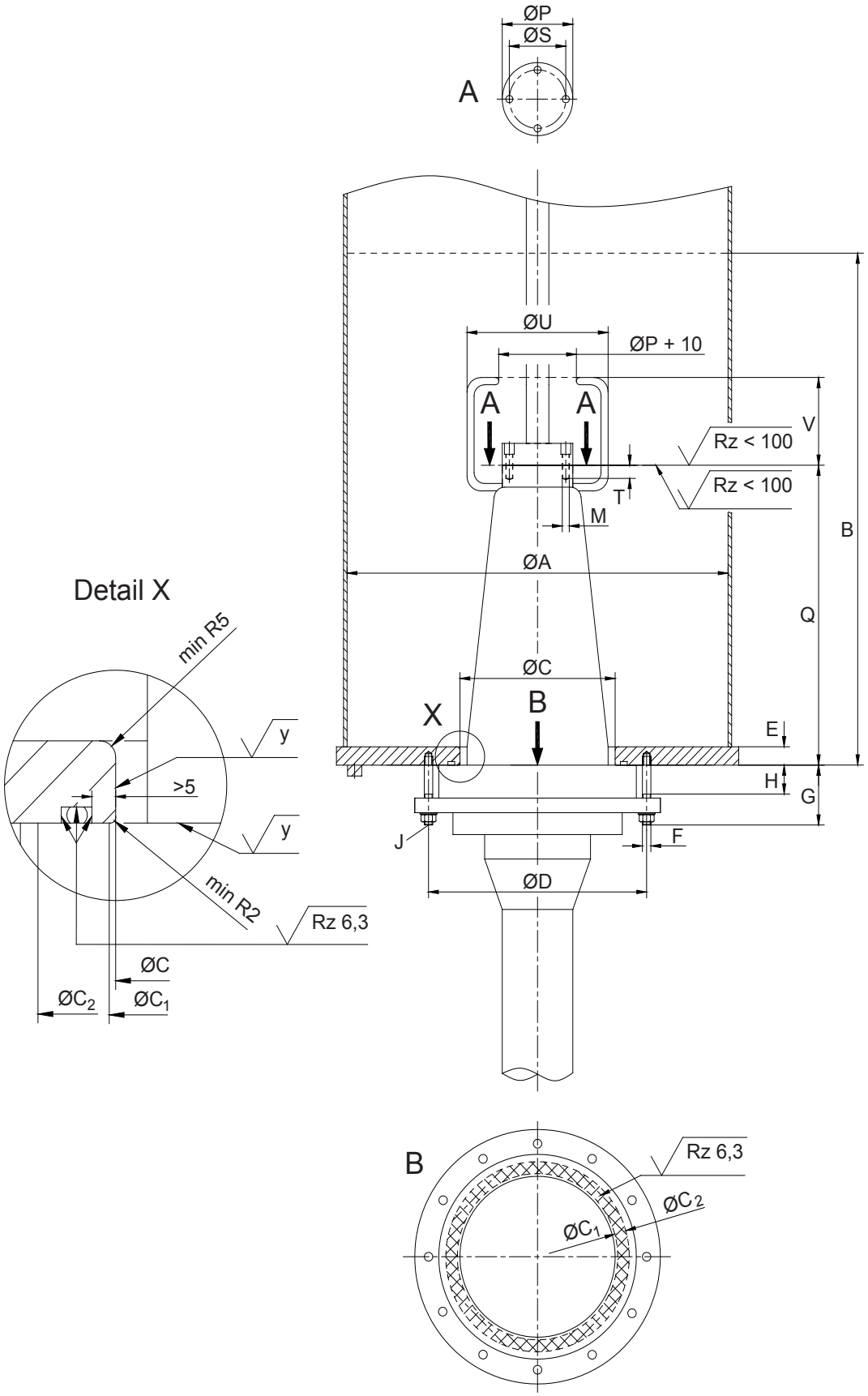


Description	Item	Supplier	
		Trans-former	Dry-type cable termination
Conductor current terminal with removable link	1	X	
Connection interface including fixing elements	2	X	
Connection interface	3		X
Shielding electrode[a]	4		X
Socket	5		X
Cable connection box	6	X	
Bolts, washers, nuts	7	X	
Clamping flange[b]	8		X
Intermediate gasket[b]	9		X
O-ring seal	10	X	
Cable gland	11		X
Insulating liquid	12	X	
Earthing terminal	13	X	

[a] divided or removable because of mounting.
[b] if needed.

Figure 1 – Limits of supply between transformer and dry-type cable termination

Dimensions in millimetres



Key

J Number of studs

Figure 2 – Typical arrangement of cable connection assemblies

Table 1 – Dimensions for cable connection assemblies

U_m	kV	72,5	123 - 145	170	245 - 300	362 - 550
LI	kV	325	550 - 650	750	850 – 1 050	1 175 – 1 550
A [a]		430 ±3	540 ±3	750 ±3	950 ±3	1 300 ±3
B [b]	min	540	760	860	1 080	1 520
C		200^{+5}_{-0}	255^{+5}_{-0}	255^{+5}_{-0}	385^{+5}_{-0}	540^{+5}_{-0}
C_1 [c]	max	206	266	266	391	551
C_2 [c]	min	242	295	295	451	613
D		$270^{+0,5}_{-0,5}$	$320^{+0,5}_{-0,5}$	$320^{+0,5}_{-0,5}$	$475^{+0,5}_{-0,5}$	$640^{+0,5}_{-0,5}$
E	max	25	30	30	35	35
F [d]		M10 35 Nm	M12 45 Nm	M12 45 Nm	M12 45 Nm	M16 50 Nm
G	min	90	90	90	110	110
H	max	30	30	30	30	30
J		8	12	12	16	20
M [d]		4 x M10 35 Nm	4 x M10 35 Nm	4 x M10 35 Nm	4 x M12 50 Nm	4 x M12 50 Nm
P	min	100	100	100	140	140
Q		310^{+1}_{-1}	470^{+1}_{-1}	470^{+1}_{-1}	620^{+2}_{-2}	960^{+2}_{-2}
S		$80^{+0,3}_{-0,3}$	$80^{+0,3}_{-0,3}$	$80^{+0,3}_{-0,3}$	$110^{+0,3}_{-0,3}$	$110^{+0,3}_{-0,3}$
T	min	18	18	18	21	21
U	max	218	218	218	350	500
V		120^{+5}_{-5}	120^{+5}_{-5}	120^{+5}_{-5}	160^{+5}_{-5}	160^{+5}_{-5}

[a] Deviating shape for the cable connection box is possible. The minimum allowed distance from center line of socket to grounded parts is $A/2$.

[b] Minimum distance to get the minimum clearance between shielding electrode and grounded parts.

[c] Inner diameter C_1 und outer diameter C_2 of sealing surface of socket.

[d] Bolt size and typical tightening torque of bolted joint.

Annex A
(informative)

Dielectric tests on sockets

A.1 General

During the dielectric tests on the socket it shall be ensured that the actual stress is equal or exceeds the stress which occurs during the transformer test.

Tests are always performed using insulation liquid. Alternatively, electrical tests in a comparable test arrangement are permitted, if the comparability is proven.

The tests shall be performed in an arrangement according to Figure 2 and according to the dimensions of Table 1.

A.2 Type approval tests

Following tests shall be performed once on each design using insulation liquid:

- Full wave lightning impulse (LI) test as well as chopped wave lightening impulse test (LIC) according to EN 60076-3:2013, with 10 % higher test levels in each case.
- Switching impulse test (SI) with negative polarity according to EN 60076-3:2013.

Prior and after the type approval test the socket shall be routine tested according A.3.

A.3 Routine tests

The withstand voltage test shall be performed according to EN 60060-1:2010, 6.3.1. Partial discharge measurements shall comply with EN 60270. The PD level shall be continuously observed for the entire duration of the test.

The test sequence shall be as follows.

- The voltage shall be raised to the 1,1 x AC withstand level to ground according to EN 60076-3:2013, Table 2 (10 % higher test level) and held there for one minute.
- Immediately after that, the voltage shall be reduced without interruption to $1{,}5 \times U_m/\sqrt{3}$.
- The voltage shall be held for duration of at least five minutes and the PD level shall be measured and recorded. 5 pC applies as limit values for partial discharges.
- The voltage shall be reduced to $0{,}4 \times U_m/\sqrt{3}$ and the background PD level shall be measured and recorded.

Bibliography

EN 60060-1:2010, *High-voltage test techniques — Part 1: General definitions and test requirements (IEC 60060-1:2010)*

EN 60270, *High-voltage test techniques — Partial discharge measurements (IEC 60270)*

EN 62271-209:2007, *High-voltage switchgear and controlgear — Part 209: Cable Connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV - Fluid-filled and extruded insulation cables — Fluid-filled and dry-type cable-terminations (IEC 62271-209:2007)*

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