



BSI Standards Publication

Power transformers

Part 22-1: Power transformer and reactor fittings - Protective devices

National foreword

This British Standard is the UK implementation of EN IEC 60076-22-1:2019. It is identical to IEC 60076-22-1:2019.

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.

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Date	Text affected
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English Version

Power transformers - Part 22-1: Power transformer and reactor
fittings - Protective devices
(IEC 60076-22-1:2019)

Transformateurs de puissance - Partie 22-1: Accessoires
pour transformateurs de puissance et bobines d'inductance
- Dispositifs de protection
(IEC 60076-22-1:2019)

Leistungstransformatoren und Drosselspulen Anbauten -
Teil 22-1: Schutzeinrichtungen
(IEC 60076-22-1:2019)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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European foreword

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- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2019-12-05
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2022-03-05

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Endorsement notice

The text of the International Standard IEC 60076-22-1:2019 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60076-6	NOTE	Harmonized as EN 60076-6
IEC 60255-27	NOTE	Harmonized as EN 60255-27
ISO 9001	NOTE	Harmonized as EN ISO 9001

Annex ZA

(normative)

Normative references to international publications with their corresponding European publications

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60068-3-3	1991	Environmental testing - Part 3-3: Guidance - Seismic test methods for equipments	EN 60068-3-3	1993
IEC 60076-1	2011	Power transformers - Part 1: General	EN 60076-1	2011
IEC 60076-7	-	Power transformers -- Part 7: Loading - guide for oil-immersed power transformers	-	-
IEC 60296	-	Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear	EN 60296	-
IEC 60529	-	Degrees of protection provided by - enclosures (IP Code)	-	-
IEC 60721-3-4	-	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities - Section 4: Stationary use at non-weatherprotected locations	EN 60721-3-4	-
IEC 60947-5-1	-	Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices	EN 60947-5-1	-
ISO 228-1	-	Pipe threads where pressure-tight joints are not made on the threads -- Part 1: Dimensions, tolerances and designation	EN ISO 228-1	-
ISO 12944-6	-	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 6: Laboratory performance test methods	EN ISO 12944-6	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

POWER TRANSFORMERS –

Part 22-1: Power transformer and reactor fittings – Protective devices

FOREWORD

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International Standard IEC 60076-22-1 has been prepared by IEC technical committee TC14: Power transformers.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
14/992/FDIS	14/997/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This Part 22-1 of the IEC 60076 series covers all accessories relevant to the safety of transformers or reactors and having a function of signalization of abnormal operating conditions, and outlines the operation requirements specific to each accessory.

POWER TRANSFORMERS –

Part 22-1: Power transformer and reactor fittings – Protective devices

1 Scope

This part of IEC 60076-22 applies to protective devices mounted on liquid-immersed power transformers in accordance with IEC 60076-1 and reactors in accordance with IEC 60076-6 with or without conservator for indoor or outdoor installation. It outlines the service conditions and the mechanical and electrical requirements that are common to all the devices, which are relevant for the safety of the machine having a function of signalization of abnormal operating conditions.

It also outlines the operation requirements specific to each device as well as, in some cases, the preferred dimensions relevant for interchangeability and the type and routine test to be performed.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-3-3:1991, *Environmental testing – Part 3-3: Guidance – Seismic test methods for equipments*

IEC 60076-1:2011, *Power transformers – Part 1: General*

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

IEC 60296, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60721-3-4, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 4: Stationary use at non-weatherprotected locations*

IEC 60947-5-1, *Low-voltage switchgear and control gear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

ISO 228-1 *Pipe threads where pressure-tight joints are not made on the threads – Part 1: Dimensions, tolerances and designation*

ISO 12944-6, *Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 6: Laboratory performance test methods*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

gas and liquid actuated relay

Buchholz relay

device intended to detect gas release from the unit to be protected, liquid surge from the tank to the conservator and complete loss of liquid in the conservator

3.2

gas and liquid sampling device at man's height

device allowing gas and liquid sampling from the Buchholz relay from ground level

3.3

protective relay for hermetically sealed liquid-immersed equipment

multifunctional protective device for hermetically sealed, liquid-immersed equipment without gas cushion

3.4

direct reading dial type liquid level indicator

oil level indicator

OLI

device indicating the liquid level in the main conservator or in a separate compartment

Note 1 to entry: This note applies to the French language only.

3.5

liquid flow indicator

oil flow indicator

OFI

device that detects the liquid flow in a forced cooling system

Note 1 to entry: This note applies to the French language only.

3.6

pressure relief device

PRD

device that releases the internal overpressure over a pre-set value, on medium and large power transformers

Note 1 to entry: This note applies to the French language only.

3.7

pressure relief valve

PRV

device that releases the internal overpressure over a pre-set value, on small transformers

Note 1 to entry: This note applies to the French language only.

3.8

direct reading mechanical dial type liquid temperature indicator

oil temperature indicator

OTI

device that indicates the temperature of the liquid of the transformer

Note 1 to entry: This note applies to the French language only.

3.9

direct reading mechanical dial type winding temperature indicator

winding temperature indicator

WTI

device which indicates the estimated temperature of the winding of the transformer

Note 1 to entry: This note applies to the French language only.

3.10

shutter valve

device which stops the liquid flow from conservator to tank in the event of a consistent liquid loss from the tank

3.11

liquid-flow control relay for on-load tap changer

device installed in the pipe between the top of the diverter or selector switch of an on-load tap changer and the liquid conservator to respond at a predetermined liquid flow and enable the transformer to be tripped

3.12

sudden pressure relay

mechanical device for detection of sudden pressure rise events

3.13

dial type gas detecting device

device for indication of gas accumulation in a sealed liquid filled transformer

3.14

gas detecting device for sealed compartment

device for detecting the presence of gas in a sealed liquid filled compartment

3.15

leakage detector for insulating liquid to water heat exchangers

device for detecting the leakage of water or insulating liquid in a double tube heat exchanger

4 Service conditions

4.1 General

The service conditions set out in 4.2 of IEC 60076-1:2011 represent the normal scope of operation of the devices and equipment specified in this document.

For any unusual service conditions that require special consideration in the design of the devices and equipment, see 5.5 of IEC 60076-1:2011. Device specification for operation under such unusual service conditions shall be subject to agreement between the purchaser and the manufacturer.

4.2 Degree of protection

The degree of protection of the connecting box or terminal box for outdoor installation shall be at least IP 54 in accordance with IEC 60529, unless otherwise specified by the purchaser.

4.3 Corrosion protection

The materials used for the construction of the devices and equipment or the surface treatment shall be resistant to the insulating liquid and suitable to withstand the environmental conditions. Unless otherwise specified, minimum withstand level shall be C4 medium durability (see ISO 12944-6).

4.4 Resistance to ambient conditions

The materials used for the construction of the devices and equipment shall be UV resistant and suitable for outdoor operation; windows and sight glasses shall not become opaque over the life of the accessory.

4.5 Insulating liquid characteristics

This subclause concerns only the accessories that are in contact with the insulating liquid.

If not otherwise specified, the insulating liquid is mineral liquid in accordance with IEC 60296 and the operating temperature shall be in accordance with IEC 60076-7.

If the insulating liquid is not mineral oil, then the viscosity variation and the operating temperature shall be indicated by the purchaser. The performance of the devices depends on the liquid properties and should be adapted if necessary.

NOTE IEC 60296 specifies a maximum viscosity of 12 mm²/s at 40 °C and 1 800 mm²/s at – 30 °C; IEC 60076-7 indicates a top liquid temperature for normal cyclic loading of 105 °C and 115 °C for emergency loading.

4.6 Vibration withstand

The accessories shall withstand:

- a non-stationary vibration causing a vertical shock of 100 m/s², with type 1 spectrum in accordance with IEC 60721-3-4;
- a stationary sinusoidal vibration class 4M4 according to IEC 60721-3-4. By agreement between purchaser and supplier, class 4M6 may also be specified.

4.7 Seismic requirements

When the accessory is specified with a seismic requirement without specified acceleration values, the performance level shall be chosen in accordance with IEC 60068-3-3 as follows:

- classification: criterion 0 (see 4.3 of IEC 60068-3-3:1991);
- performance level II (see 7.1 of IEC 60068-3-3:1991; a starting frequency of 2 Hz is acceptable).

5 Characteristics of switches

5.1 General

This clause defines the minimum performance characteristics that the electric switches used in these accessories are expected to have, in accordance with IEC 60947-5-1. Switches containing mercury are not allowed.

5.2 Dielectric strength (in accordance with IEC 60255-27)

The minimum dielectric withstand strength is given in the following Table 1 and Table 2.

Table 1 – Dielectric strength of switches – Power frequency

	Short duration power frequency withstand voltage 1 min kV (RMS)
Between circuits and earth	2
Between contacts in open position	1

Table 2 – Dielectric strength of switches – Impulse

	Lightning impulse withstand voltage kV (peak)
Between circuits and earth	4
Between contacts in open position	3

6 General requirements for routine and type test

Tests shall be carried out at an ambient temperature between 10 °C and 40 °C, unless otherwise specified.

All measuring instruments used for the tests shall have traceable accuracy and be subject to periodic calibration, according to the rules given in a system like ISO 9001 or similar.

7 Protective devices

7.1 Gas and liquid actuated relay (Buchholz relay)

7.1.1 Additional service conditions

7.1.1.1 Maximum inclination

The relay is intended to function in a horizontal position; a positive inclination of up to 5° to the horizontal axis is admissible in the direction towards the conservator. A tilt of max 5° on either side of the vertical is admissible.

Other values may be agreed between the purchaser and the supplier.

7.1.1.2 Operating pressure

The relay shall be designed for a continuous internal pressure of 50 kPa over ambient.

7.1.1.3 Sensitivity of the relay switches to magnetic fields

The relay shall be able to withstand a DC magnetic field of up to 25 mT, in any direction and any polarity, without unintentional operations.

7.1.2 Mechanical requirements

7.1.2.1 Nameplate

The nameplate shall contain the following information:

- name or logo of the supplier;
- country and manufacturing location;
- number of this standard;

- device manufacturer's identification;
- manufacturer's serial number;
- connection diagram (incorporated on the nameplate or included in the terminal box);
- seismic withstand class, if applicable.

The device manufacturer's identification shall allow identification of the device characteristics from the mounting, operating and maintenance manual supplied by the supplier.

7.1.2.2 Terminal box

A terminal box shall be provided to connect the switches of the device; it shall include also one protective conductor or earth terminal. The number and marking of the terminals shall comply with the connection diagram.

The terminals shall be designed to accept cables having a cross-sectional area of between 1,5 mm² to 4 mm².

A minimum of two threaded holes for cable glands M25 × 1,5 shall be provided; one shall be closed by a weather-resistant plug, the other being protected for transport and storage. Other thread dimensions are subject to agreement between the supplier and the purchaser.

Cable glands are supplied on demand.

7.1.2.3 Testing facility

The relay shall be provided with a device to functionally check the operation and sequence of the switches. The mechanical test device shall differentiate between the alarm and trip contact.

7.1.2.4 Gas and liquid sampling facility

The relay shall be fitted with a gas release and sampling petcock.

A facility shall be provided for the connection of the gas and liquid sampling device at man's height.

7.1.2.5 Draining device

A draining device shall be provided.

If required, a provision shall be provided for draining at man height.

7.1.2.6 Inspection windows

The relay shall be fitted with at least two scaled inspection windows for the visual check of the presence of gas from both sides. On request, the windows are provided with protection covers.

7.1.2.7 Mounting arrangement

An arrow on the relay shall indicate the liquid flow direction towards the conservator.

7.1.2.8 General overall dimensions

Table 3 and Table 4 are to be read with Figure 1 and Figure 2.

Table 3 – Preferred dimensions of relay body in mm

Nominal diameter <i>DN</i>	A max.	B max.	C max.	D ^a min.	L		E ^b
					Short type	Long type	
25 ^c	205	75	275	300	200	240	190
50	205	90	275	300	195	240	220
80	220	100	275	400	195	240	220
100	220	110	275	400	220	-	-

^a Minimum clearance to remove the mechanism from the body of the relay.
^b Minimum clearance for mounting and access to the relay.
^c For nominal diameter (DN), 25 mm thread connections of G1 ½ A (ISO 228-1) are allowed with L = 185 mm (see Figure 2).

Table 4 – Flange dimensions in mm

Nominal diameter <i>DN</i>	d1	d2	d3	d4	Number of bolt holes		d5 max.
					Short type	Long type	
25	25	115	85	14	4	4	16
50	50	165	125	18	4	4	18
80	80	200	160	18	8	4	18
100	100	220	180	18	8	-	18

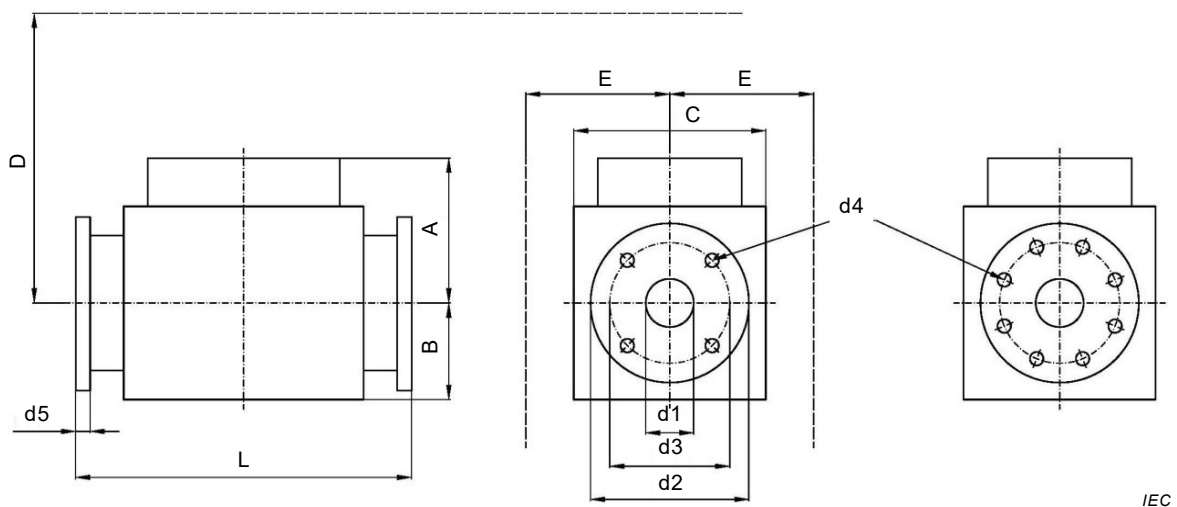


Figure 1 – DN 25 to 100 with circular flanges

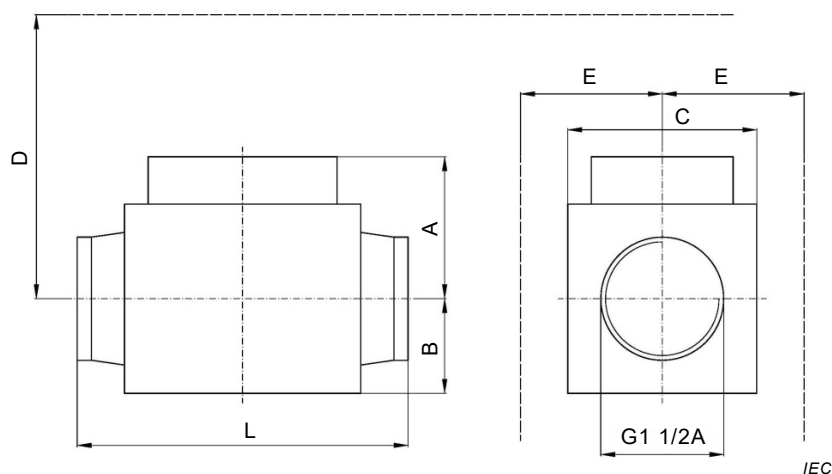


Figure 2 – DN 25 with threaded connections

7.1.2.9 Alternative overall dimensions

In some countries, alternative dimensions as indicated in Table 5 and Table 6 may be agreed between the purchaser and the supplier.

The dimensions refer to Figure 1 above or Figure 3 below for the relay with rectangular flanges.

Table 5 – Alternative dimensions of relay in mm

Nominal diameter DN	A max.	B max.	C max.	D1 ^a min.	L	E ^b
25	180	140	320	200	127	315
50	170	150	320	200	184	315
80	170	150	320	200	184	315
^a Minimum clearance for access of petcocks.						
^b Minimum clearance for mounting and access to the relay.						

Table 6 – Alternative flange dimensions of the relay in mm

Nominal diameter DN	d1	d2	d3	d4	Number of bolt holes	d5 max.
25	25,4	76	72	M10	4	N/A
50	50,8	139	110	11,1	6	14
80	76,2	160	130	11,1	6	14

Dimensions for Buchholz relay DN 80 with rectangular flanges are given in Figure 3.

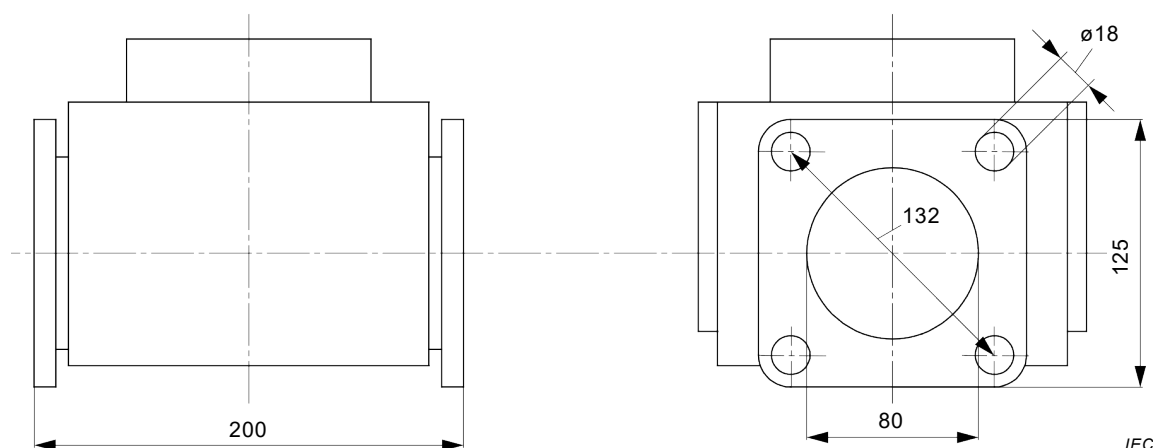


Figure 3 – Gas and liquid operated relay with rectangular flanges for DN 80 mm

7.1.3 Performance requirements

7.1.3.1 Switch type

Switches shall be potential free. Unless otherwise specified, the switches shall be open ("normally open") under normal operating conditions (normal operating conditions are when the relay is filled with oil and there is no fault on the protected equipment). On request, the switches can be also of the normally closed or changeover type.

7.1.3.2 Switch performance

Switches shall have a minimum rated operational current of 2 A RMS for normally open contacts and 1 A RMS for changeover contacts and short time current of 10 A RMS for 30 ms.

Making and breaking capacity shall comply with the requirements of Table 7. Typically, magnetically operated Reed type switches are provided.

Table 7 – Making and breaking capacity – Buchholz relay

Voltage	NO Switches				Changeover switches			
	Making capacity		Breaking capacity		Making capacity		Breaking capacity	
24 V DC. to 220 V DC	250 W	L/R < 40 ms	30 W	L/R < 40 ms	130 W	L/R < 40 ms	30 W	L/R < 40 ms
230 V AC	400 VA	cos φ > 0,5	40 VA	cos φ > 0,5	250 VA	cos φ > 0,5	40 VA	cos φ > 0,5

Other values may be agreed between the purchaser and the supplier.

The minimum switch life shall be 1 000 operations.

The switch shall also be able to make a low current down to 50 mA for any value of voltage defined in Table 7.

7.1.3.3 Switches setup

This device shall be provided with at least one switch for gas accumulation and one switch for liquid surge and liquid loss.

The gas accumulation switch shall operate due to a gas accumulation volume between 100 cm³ and 400 cm³. The gas accumulation switch shall operate before any gas escapes into the pipework toward the conservator.

The manufacturer shall state for every type of Buchholz relay the range of gas accumulation for which the gas accumulation switch operates.

The gas accumulation switch will also react to a liquid leakage introducing air in the relay chamber.

The liquid surge switch shall operate at a steady liquid flow as indicated in Table 8.

This operation shall not be adversely affected when the alarm switch has already closed and gas is escaping freely.

The liquid loss switch shall operate before the pipe is empty.

The liquid surge and liquid loss switches are usually the same, unless a different setting is agreed between the purchaser and the manufacturer.

Upon special request, the liquid surge switch can be provided with a mechanism, which holds it in position after a liquid flow operation until it is manually reset.

Table 8 – Steady liquid flow for relay operation

Liquid pipe connection internal diameter [mm]	Steady liquid flow for relay operation [m/s]	Tolerance %
25	1	±15
50	1	±15
80	1 or 1,5 or 2	±15
100	1,5 or 2	±15

Other values may be agreed between the purchaser and the supplier.

The switches shall not operate in case of liquid flow from the conservator to the tank.

7.1.4 Tests

7.1.4.1 List of tests

7.1.4.1.1 Routine tests

The following list of tests is not in any specific order:

- Liquid leakage test (7.1.4.2.1);
- Insulation test (7.1.4.2.2);
- Functional test (7.1.4.2.3).

7.1.4.1.2 Type tests

The following list of tests is not in any specific order:

- Calibration of gas collection scale test (7.1.4.3.1);
- Vacuum withstand test (7.1.4.3.2);

- Pressure withstand test (7.1.4.3.3);
- Reverse liquid flow test (7.1.4.3.4);
- Magnetic field test (7.1.4.3.5);
- Vibration withstand test (7.1.4.3.6).

7.1.4.1.3 Special tests

- Seismic withstand test (7.1.4.4).

7.1.4.2 Routine tests

7.1.4.2.1 Liquid leakage test

The manufacturer shall perform a test to prove the device will not leak in operation. The description of the test procedure shall be made available to the customer, on request.

The test performed by the manufacturer shall be at least as reliable as a test performed by injecting air with an over pressure of $2,5 \times 10^5$ Pa in the device immersed in a water container for at least 5 min at ambient temperature to observe if there are escaping air bubbles or a helium leakage test with a leakage rate lower than 4×10^{-6} Pa m³/s.

7.1.4.2.2 Insulation test

The manufacturer shall perform a short-duration (60 s) power frequency withstand voltage test between all circuits together and earth.

Test voltage is given in Table 1.

7.1.4.2.3 Functional test

Requested values are given in 7.1.3.3.

Switch functionality and setting shall be checked by draining liquid from the relay; the operation values of the switches shall be within the tolerance.

The minimum steady liquid flow for operation of the trip switch of the relay shall also be checked.

The switches shall also be tested by means of the mechanical test device.

The test shall be performed under the following conditions:

- liquid temperature range: +10 °C to +40 °C;
- test layout designed to assure steady liquid flow; this can be achieved for instance with:
 - length of connection pipe on tank side: ten times the internal diameter;
 - length of connection pipe on conservator side: three times the internal diameter.
- inclination of the flow-axis of the relay: not exceeding 5°.

The liquid flow speed shall rise with a constant acceleration of $0,2 \pm 0,1$ m/s² until the operation of the switches. The liquid flow speed shall at that time meet the requirement. Starting acceleration from an offset value is permissible.

7.1.4.3 Type tests

7.1.4.3.1 Calibration of gas collection scale test

The test shall verify that the volume of gas collected in the Buchholz relay corresponds to the volume indicated on the scale. A tolerance of $\pm 10\%$ is admitted.

7.1.4.3.2 Vacuum withstand test

The test shall be carried out on the complete relay empty of liquid for 24 h at 2,5 kPa absolute pressure.

At the end of the test, the relay shall be visually inspected to ensure that no damage has occurred, and the functional test shall be repeated.

7.1.4.3.3 Pressure withstand test

The test shall be carried out on the complete liquid filled relay at 250 kPa for 2 min at a temperature of 70 °C.

At the end of the test, the relay shall be visually inspected to ensure that no damage has occurred, and the routine test shall be repeated.

7.1.4.3.4 Reverse liquid flow test

The test shall be carried out on the complete relay with a liquid flow of 1 m/s from conservator to the tank. The test is successful if there is no relay operation.

The test shall be performed under the following conditions:

- liquid temperature range: +10 °C to +40 °C;
- test layout designed to assure steady liquid flow; this can be achieved for instance with:
 - Length of connection pipe on tank side: ten times the internal diameter;
 - Length of connection pipe on conservator side: three times the internal diameter;
- inclination of the flow axis of the relay: not exceeding 5°.

The liquid flow speed shall rise with a constant acceleration of $(0,2 \pm 0,1) \text{ m/s}^2$ until the value of 1 m/s is reached. Starting acceleration from an offset value is permissible.

7.1.4.3.5 Magnetic field test

The relay shall be able to withstand a DC magnetic field up to 25 mT, in any direction and any polarity, without unintentional operations.

7.1.4.3.6 Vibration withstand test

The device shall be subjected to vibrations in accordance with 4.6; no operation of the switches shall be recorded.

7.1.4.4 Special tests – Seismic withstand test

Upon customer request, the device shall withstand seismic test in accordance with 4.7.