

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Power transformers –

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

Transformateurs de puissance –

**Partie 22-1: Accessoires pour transformateurs de puissance et bobines
d'inductance – Dispositifs de protection**



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POWER TRANSFORMERS –

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

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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.

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- withdrawn,
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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

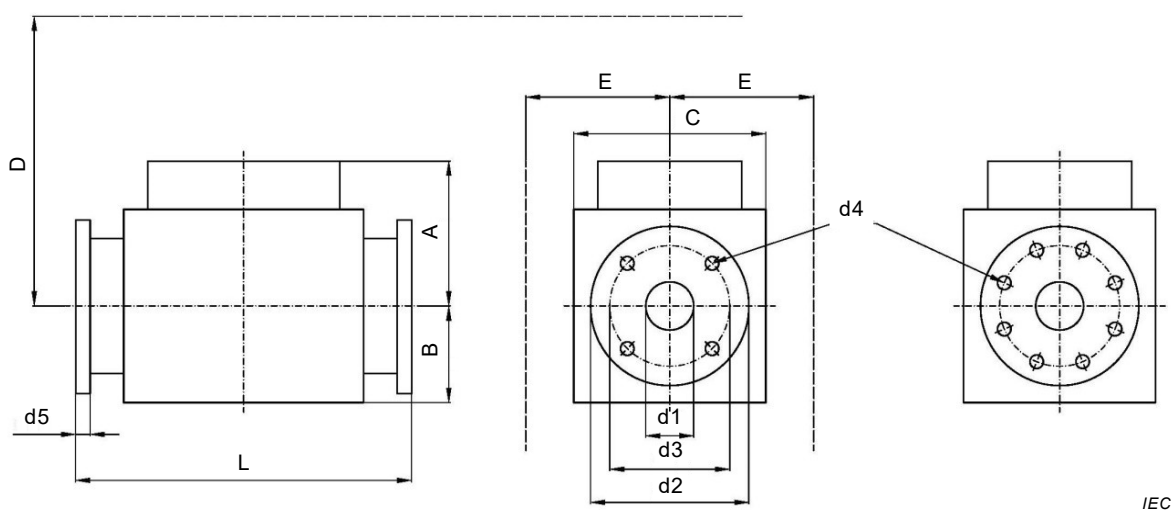


Figure 1 – DN 25 to 100 with circular flanges

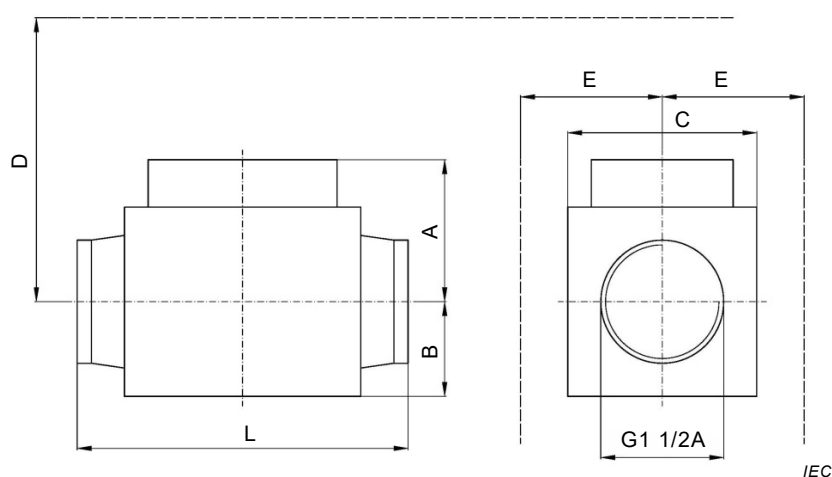


Figure 2 – DN 25 with threaded connections

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.

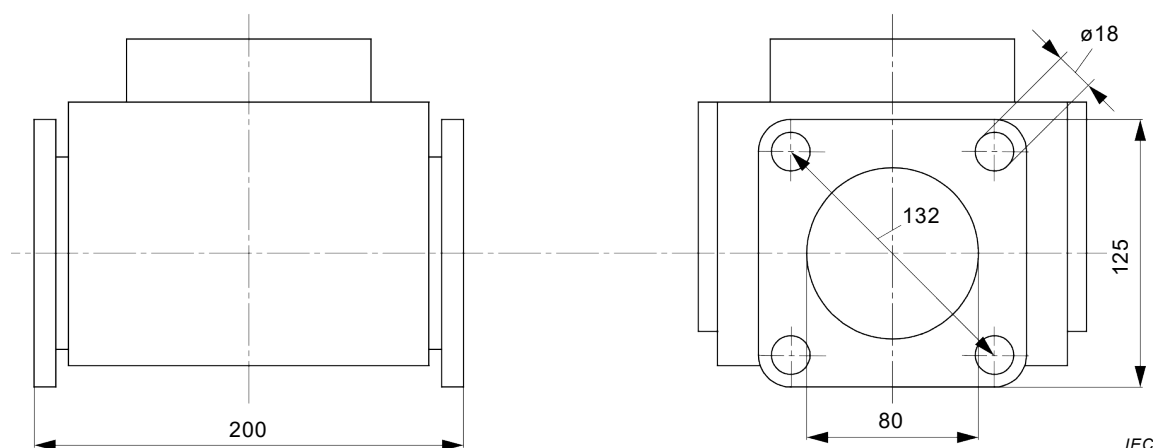


Figure 3 – Gas and liquid operated relay with rectangular flanges for DN 80 mm

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	$\cos \varphi > 0,5$	40 VA	$\cos \varphi > 0,5$	250 VA	$\cos \varphi > 0,5$	40 VA	$\cos \varphi > 0,5$

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.

7.2 Gas and liquid sampling device at man's height

7.2.1 Additional service conditions – Operating pressure

The gas and liquid sampling device shall be designed for a continuous internal pressure of 100 kPa over ambient.

7.2.2 Mechanical requirements

7.2.2.1 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;

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

7.2.2.2 Construction details

The gas and liquid sampling device at man's height shall be equipped with:

- a petcock allowing draining of the liquid of the device, this petcock being connected to the bottom of the sampling device;
- a petcock allowing sampling of gas when it appears in the sampling device, this petcock being connected to the upper part of the sampling device;
- a petcock for connection to the Buchholz relay sampling petcock by means of a tube of suitable diameter; this petcock shall stay open in operation;
- a window allowing screening for the incoming of gas in the sampling device. On request, the window is provided with protection covers.

7.2.3 Performance requirements – Visibility

The sampling device shall allow a clear visibility of the liquid level inside.

7.2.4 Tests

7.2.4.1 List of tests

7.2.4.1.1 Routine tests

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

- Liquid leakage test (7.2.4.2.1);
- Petcock functionality (7.2.4.2.2).

7.2.4.1.2 Type tests

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

- Calibration of gas collection scale test (7.2.4.3.1);
- Vacuum withstand test (7.2.4.3.2);
- Pressure withstand test (7.2.4.3.3);
- Petcock endurance test (7.2.4.3.4).

7.2.4.2 Routine tests

7.2.4.2.1 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.

7.2.4.2.2 Petcock functionality

All petcocks shall be operated for one closed – open – closed cycle without difficulties.

7.2.4.3 Type tests

7.2.4.3.1 Calibration of gas collection scale test

Where a scale is present, the test shall verify that the volume of gas collected in the device corresponds to the volume indicated on the scale. A tolerance of ± 10 % is admitted.

7.2.4.3.2 Vacuum withstand test

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

At the end of the test, the device shall be visually inspected to ensure that no damage has occurred.

7.2.4.3.3 Pressure withstand test

The test shall be carried out on the complete device filled with liquid at 250 kPa for 2 min at a temperature of 100 °C.

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

7.2.4.3.4 Petcock endurance test

All petcocks shall be operated for 100 closed – open – closed cycles without failure. Following the endurance test, the liquid leakage test shall be repeated.

7.3 Protective relay for hermetically sealed liquid-immersed equipment

7.3.1 Additional service conditions

7.3.1.1 Maximum inclination

The relay is intended to function in a vertical position. An inclination of up to 5° to the vertical axis shall be admissible (mobile equipment, trailer, etc.).

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

7.3.1.2 Operating pressure

The maximum continuous operating pressure shall be 50 kPa over ambient.

7.3.1.3 Sensitivity of the relay switches to magnetic fields

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

7.3.2 Mechanical requirements

7.3.2.1 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 (it may be 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.

7.3.2.2 Terminal box

A terminal box shall be provided with three terminals for each function. The terminals shall be designed to accept cables having a cross-sectional area of between 1,5 mm² and 2,5 mm².

One clearly marked earth terminal shall also be provided.

A minimum of two holes suitable to accept 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.

Cable glands are supplied on demand.

7.3.2.3 Gas sampling

The relay shall be equipped with an easily accessible sampling petcock.

7.3.2.4 Presence of gas in the relay

It shall be possible to check visually the presence of any gas from at least three sides at all times.

7.3.2.5 Identification of relays

Table 9 – Identification of relays

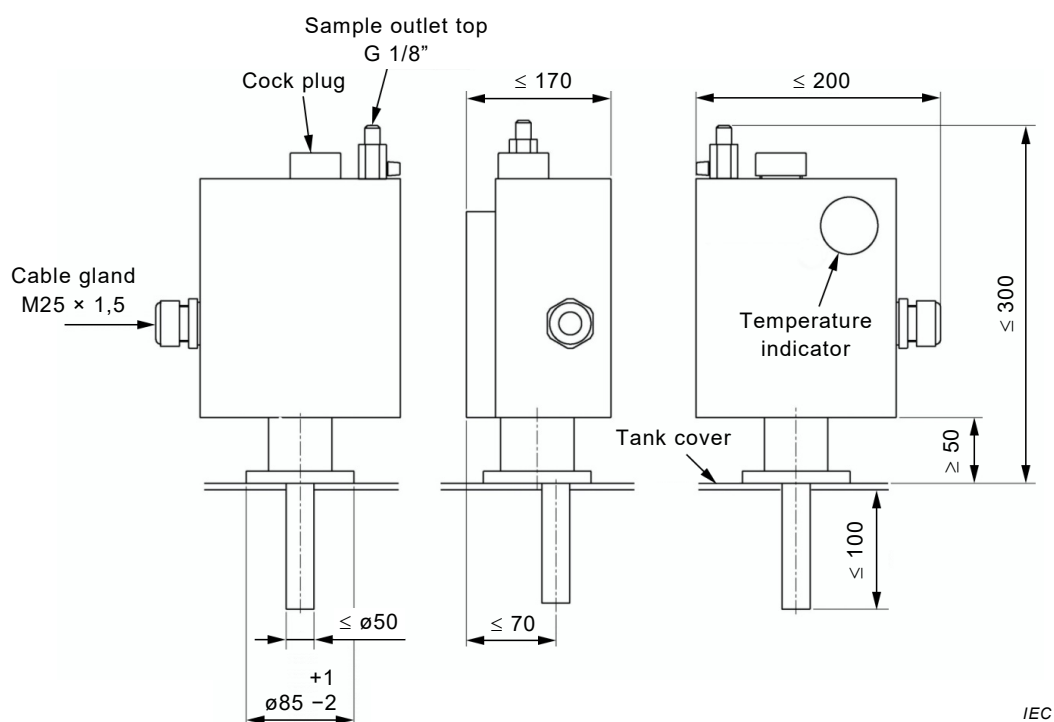
Function	Relay type 1	Relay type 2
Gas and leakage detection	1 switch	1 switch
Overpressure detection	1 switch	1 switch
Over temperature detection		2 switches – (alarm/tripping)
Temperature indicator	Yes	Yes
Visual leakage control	Yes	Yes

NOTE The two functions gas and leakage detection are usually actuated by one switch in common.

Other types of relay having functions additional to those defined in Table 9 are acceptable by agreement.

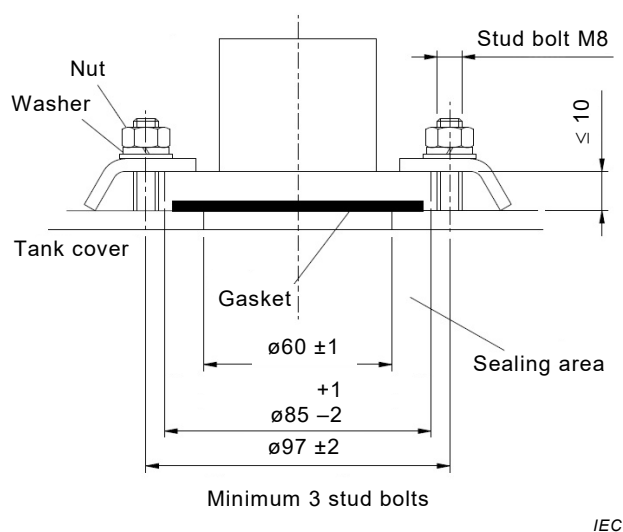
7.3.2.6 Overall dimensions and mounting details

Figure 4 and Figure 5 show overall dimensions and mounting details.

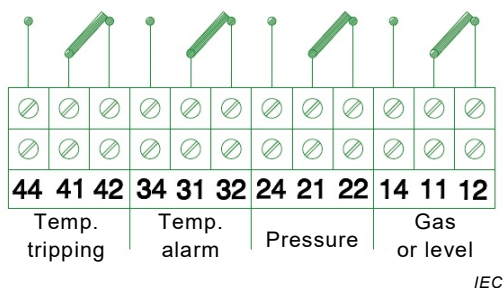


The figure shows preferred arrangements and typical dimensions.

Figure 4 – Outline and mounting details: general view



5a – Fixing detail



5b – Terminal marking relay liquid filled

Figure 5 – Fixing detail and terminal box arrangement

7.3.3 Performance requirements

7.3.3.1 General

This relay shall also permit partial refilling of liquid of the transformer.

Each function of the relay shall be performed by an independent operating mechanism and switch.

7.3.3.2 Switches

7.3.3.2.1 Switch type

Switches shall be potential free. Unless otherwise specified, the switches shall be of the changeover type.

7.3.3.2.2 Switch performance

Switches shall have a rated current of 2 A RMS and short time current of 10 A RMS for 30 ms. Making and breaking capacity shall conform to Table 10.

Table 10 – Making and breaking capacity – Protective relay

Voltage	Making and breaking capacity	
24 V DC. to 220 V DC	25 W	L/R < 40 ms
230 V AC	60 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.

When the switch is required to make a low current down to 50 mA even after one year of non-operation, special switches are required with contacts that may be damaged by high currents and therefore the values in Table 1 do not apply.

7.3.3.2.3 Switches setup

This device shall be provided with at least one switch for gas accumulation and liquid loss and one switch for overpressure. For relay type 2, an additional two switches for temperature detection shall be provided.

The gas accumulation switch shall operate when a gas accumulation or a liquid loss volume is between 100 cm³ and 200 cm³.

The overpressure switch shall be adjustable in the range of 10 kPa to 50 kPa and set by default to operate at a pressure of 50 kPa, unless otherwise specified. The tolerance is ± 5 kPa.

The two temperature detection switches (of relay type 2) shall be adjustable at least within the range of 40 °C to 120 °C. Accuracy of the switching on temperature rise shall be ± 3 °C.

7.3.3.3 Temperature indicator

The temperature indicator minimum range shall be from 40 °C to 120 °C. Accuracy in this range shall be ± 4 °C. A resettable maximum pointer shall be provided.

7.3.4 Tests

7.3.4.1 List of tests

7.3.4.1.1 Routine tests

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

- Liquid leakage test (7.3.4.2.1);
- Insulation test (7.3.4.2.2);
- Functional test (7.3.4.2.3).

7.3.4.1.2 Type tests

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

- Vacuum withstand test (7.3.4.3.1);
- Pressure withstand test (7.3.4.3.2);
- Operation under inclination test (7.3.4.3.3);
- Magnetic field test (7.3.4.3.4);
- Vibration withstand test (7.3.4.3.5).

7.3.4.1.3 Special tests

- Seismic withstand test (7.3.4.4).

7.3.4.2 Routine tests

7.3.4.2.1 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.

7.3.4.2.2 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.

7.3.4.2.3 Functional test

The following tests shall be performed; the results shall be within the tolerances stated above:

- check the functionality of the temperature switches at pre-set values;
- check the functionality of the overpressure switches at pre-set values;
- check the functionality of the liquid loss volume switch;
- check the functionality of the thermometer.

7.3.4.3 Type tests

7.3.4.3.1 Vacuum withstand test

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

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

7.3.4.3.2 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 100 °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.

7.3.4.3.3 Operation under inclination test

The operation of the relay with an inclination of 5° (unless otherwise agreed between purchaser and supplier) in comparison to all directions from the vertical direction shall be checked in accordance with the functional test indicated in 7.3.4.2.3.

7.3.4.3.4 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.

7.3.4.3.5 Vibration withstand test

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

7.3.4.4 Special tests – Seismic withstand test

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

7.4 Direct reading dial type liquid level indicators

7.4.1 Mechanical requirements

7.4.1.1 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 (it may be 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.

7.4.1.2 Construction details

There shall be no direct mechanical contact between the float mechanism and the dial indicator.

The indicator shall be fitted with a solid float operating on the displacement principle (hollow floats are not permitted).

Unless otherwise agreed, the minimum and maximum levels and the level at the average ambient temperature shall be indelibly and clearly marked.

These devices are not intended to give indication of the liquid temperature.

The movement of the pointer from the minimum to the maximum level shall be clockwise when facing the dial.

The mounting arrangement of the indicator shall be such that it can be mounted and removed from the outside of the main conservator or the separate compartment.

It shall be possible to remove the dial, maintain or replace switches, without draining the conservator or the compartment to which it is fitted.

On request, it can be equipped with one or more switches and their setting is subject to agreement between the manufacturer and the purchaser.

7.4.1.3 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 terminal block shall comply with the connection diagram.

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

One threaded hole for cable glands M25 × 1,5 shall be provided. Other thread dimensions or number of cable entries are subject to agreement between supplier and purchaser. Cable glands are supplied on demand.

7.4.2 Performance requirements

7.4.2.1 Liquid level

The position of the pointer on the dial shall correspond to the level of the liquid in the conservator or the compartment.

7.4.2.2 Switch type

Switches shall be potential free. Unless otherwise specified, changeover switches shall be provided.

7.4.2.3 Switch performance

Switches shall have a minimum rated current 2 A RMS and short time current 10 A RMS for 30 ms. Making and breaking capacity shall conform to Table 11.

Table 11 – Making and breaking capacity – OLI

Voltage	Changeover switches			
	Making capacity		Breaking capacity	
24 V DC. to 220 V DC	130 W	L/R < 40 ms	25 W	L/R < 40 ms
230 V AC	250 VA	cos φ > 0,5	60 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.

When the switch is required to make a low current down to 50 mA even after one year of non-operation, special switches are required with contacts that may be damaged by higher currents and therefore the values in Table 1 do not apply.

7.4.3 Tests

7.4.3.1 List of tests

7.4.3.1.1 Routine tests

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

- Liquid leakage test (7.4.3.2.1);
- Insulation test (7.4.3.2.2);
- Functional test (7.4.3.2.3).

7.4.3.1.2 Type tests

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

- Vacuum withstand test (7.4.3.3.1);
- Vibration withstand test (7.4.3.3.2).

7.4.3.1.3 Special tests

- Seismic withstand test (7.4.3.4).

7.4.3.2 Routine tests

7.4.3.2.1 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 helium leakage test with a leakage rate lower than 4×10^{-6} Pa m³/s.

7.4.3.2.2 Insulation test

The manufacturer shall perform a short duration (60 s) power frequency withstand voltage test between independent circuits and between the circuit and the earth.

Test voltage is given in Table 1.

7.4.3.2.3 Functional test

A functional test shall be carried out to prove the mechanical and electrical operation of the indicator and associated switches.

The maximum tolerance on the switch setting and the dial indication is 5° (angle).

7.4.3.3 Type test

7.4.3.3.1 Vacuum withstand test

The devices shall be subjected to a vacuum test of an absolute pressure of 2,5 kPa for 24 h. This test shall be followed by the test as detailed in 7.4.3.2.3.

7.4.3.3.2 Vibration withstand test

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

7.4.3.4 Special tests – Seismic withstand test

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

7.5 Liquid flow indicators

7.5.1 Mechanical requirements

7.5.1.1 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 (it may be 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.

7.5.1.2 Construction details

These devices are not intended to measure the flow rate, but only to detect the flow above or under the setting point.

The supplier shall give the direction of liquid flow depending on the mounting position either by an arrow marked on the body or the dial, or by any other suitable means.

The device shall be provided with a visual indication. If the indication is by dial and pointer, the movement of the pointer from no flow to flow position shall be clockwise when facing the dial.

The mounting arrangement of the indicator shall be such that it can be dismantled and removed from the outside of the pipe.

It shall be possible to maintain or replace switches, without draining the pipe.

The indicator shall be equipped with a minimum of one switch of the normally open, normally closed or changeover type upon agreement, which changes its status when the sensor actuates. Additional sets of switches shall be provided if required.

7.5.1.3 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 and 4 mm².

A minimum of one threaded hole for cable glands M25 × 1,5 shall be provided. Other thread dimensions are subject to agreement between supplier and purchaser. Cable glands are supplied on demand.

7.5.1.4 Construction types

7.5.1.4.1 Magnetic coupling type constructions

In this construction, the interface between the paddle movement and the visual indication is by magnetic coupling.

7.5.1.4.2 Mechanical coupling type construction

In this construction, the interface between the paddle movement and the visual indication is by mechanical coupling.

7.5.2 Performance requirements

7.5.2.1 General

Performance requirements include the following.

- The position of the visual indication shall correspond to the presence or absence of flow.
- A reverse flow of liquid shall give no flow indication.
- The speed of the liquid flow, which actuates the visual and electrical indication, is subject to agreement between the manufacturer and the purchaser.

7.5.2.2 Switches

7.5.2.2.1 Switch type

Switches shall be potential free. Unless otherwise specified, changeover switches shall be provided.

7.5.2.2.2 Switch performance

Switches shall have a rated current 2 A RMS and short time current 10 A RMS for 30 ms. Making and breaking capacity shall conform to Table 12.

Table 12 – Making and breaking capacity – OFI

Voltage	Changeover switches			
	Making capacity		Breaking capacity	
24 V DC. to 220 V DC	130 W	L/R < 40 ms	25 W	L/R < 40 ms
230 V AC	250 VA	$\cos \varphi > 0,5$	60 VA	$\cos \varphi > 0,5$

Other values may be agreed between purchaser and supplier.

The minimum switch life shall be 100 000 operations.

When the switch is required to make a low current down to 50 mA even after one year of non-operation, special switches are required with contacts that may be damaged by higher currents, and therefore, the values in Table 1 do not apply.

7.5.3 Tests

7.5.3.1 List of tests

7.5.3.1.1 Routine tests

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

- Liquid leakage test (7.5.3.2.1);
- Insulation test (7.5.3.2.2);
- Functional test (7.5.3.2.3).

7.5.3.1.2 Type tests

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

- Vacuum withstand test (7.5.3.3.1);
- Vibration withstand test (7.5.3.3.2);
- Mechanical endurance test (7.5.3.3.3);

- Pressure withstand test (7.5.3.3.4).

7.5.3.1.3 Special tests

- Seismic withstand test (7.5.3.4).

7.5.3.2 Routine tests

7.5.3.2.1 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 helium leakage test with a leakage rate lower than 4×10^{-6} Pa m³/s.

7.5.3.2.2 Insulation test

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

Test voltage is given in Table 1.

7.5.3.2.3 Functional test

A functional test shall be carried out to prove the mechanical and electrical operation of the indicator and associated switches. If not adjustable, the electrical operation shall be within ± 10 % of the agreed setting value.

7.5.3.3 Type test

7.5.3.3.1 Vacuum withstand test

The devices shall be subjected to a vacuum test of an absolute pressure of 2,5 kPa for 24 h. This test shall be followed by the test as detailed in 7.5.3.2.3.

7.5.3.3.2 Vibration withstand test

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

7.5.3.3.3 Mechanical endurance test

A mechanical endurance test shall be performed by placing the device in a liquid filled pipeline loop at ambient temperature and switching the pump on and off. The pipeline diameter, the design of the loop and the pumped liquid speed shall reflect the design values and confirm the operational range of the device. The frequency of the on and off cycles shall ensure that the stability of the liquid flow is reached.

There shall be no malfunction or prejudicial wear before 100 000 cycles.

For liquid flow devices of the same design but different dimensions, it is accepted that the mechanical endurance test be only performed on one version of the design. The validity of this test is applicable to the full range of liquid flow devices of the same design.

7.5.3.3.4 Pressure withstand test

The test shall be carried out on the device liquid filled at 250 kPa for 2 min at a temperature of 100 °C.

At the end of the test, the device shall be visually inspected to ensure that no damage has occurred and the functional test of 7.5.3.2.3 shall be repeated.

7.5.3.4 Special test – Seismic withstand test

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

7.6 Pressure relief devices

7.6.1 Additional service conditions

It shall be possible to install the device on the tank cover or walls, in each position or any inclination, without alteration of its operating performance.

7.6.2 Mechanical requirements

7.6.2.1 Nameplate

The nameplate shall contain the following information:

- name or logo of the supplier;
- country and manufacturing location;
- number of this standard;
- device manufacturers identification;
- operating pressure;
- manufacturer's serial number;
- connection diagram (it may be 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.

7.6.2.2 Construction requirements

PRDs are composed of a flanged body and a spring-loaded shutter and can have the spring out of tank or inside tank. They are typically used on power transformers and reactors.

7.6.2.3 Mandatory fittings

7.6.2.3.1 Visual indicator

The PRD shall be fitted with a visual indicator of operation, to be reset manually. The visual indicator shall be in a highly visible colour.

7.6.2.3.2 Vent screw

The PRD shall be fitted with a vent screw for bleeding air or gas, which may alter the correct functioning; the vent screw should be positioned on the opposite side of the exhaust of the liquid spray protection, if present.

7.6.2.4 Optional fittings

7.6.2.4.1 Liquid spray protection

If the valve is opened, the basic type liquid spray protection shall prevent the outpouring liquid from spraying upwards. Liquid spray protection of the directional type can be connected to a duct to canalize the outpouring liquid.

7.6.2.4.2 Electric switches

The PRD can be fitted with one or more electric switches to signal the operation of the PRD. The switches shall be preferably manually resettable.

If switches are fitted, a terminal box, eventually embedded in the switch itself, shall be provided; 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 and 2,5 mm².

A minimum of one threaded hole for cable glands M20 × 1,5 or M25 × 1,5 shall be provided. Other thread dimensions are subject to agreement between the supplier and the purchaser. Cable glands are supplied on demand.

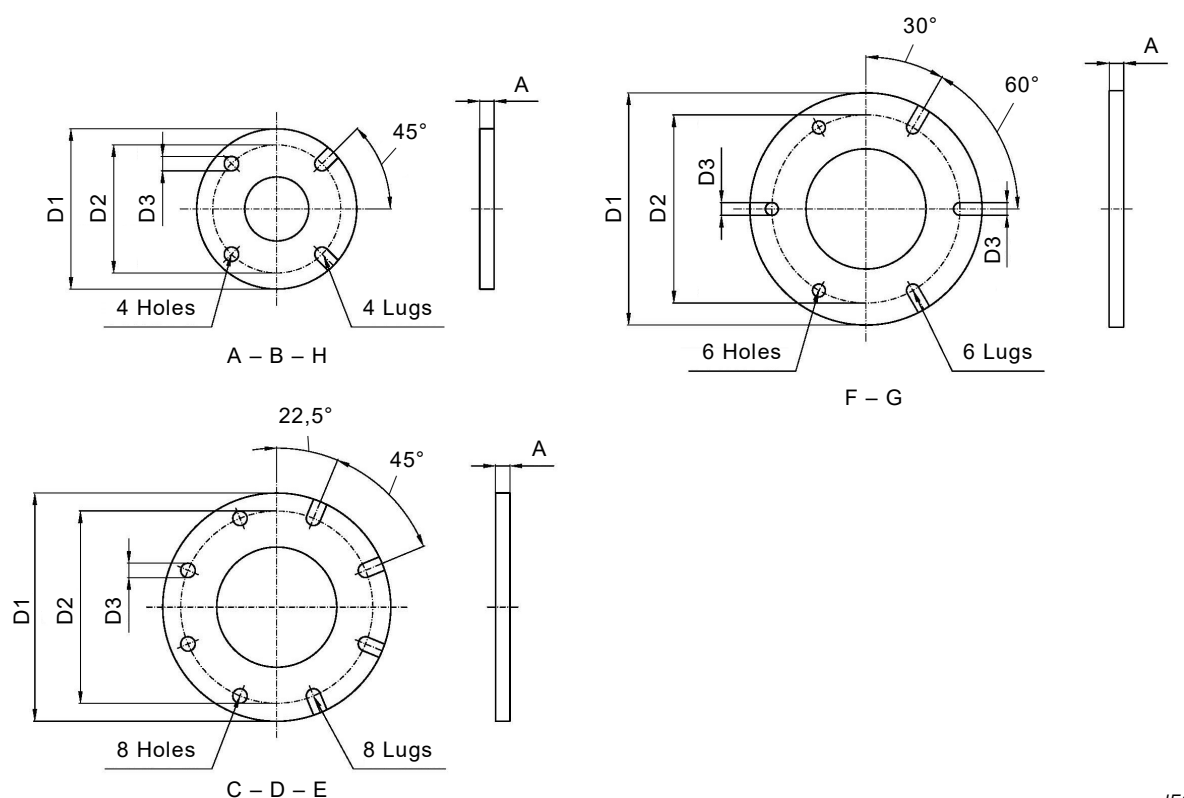
7.6.2.5 Dimensions

The fixing flange sizes are based on nominal diameter (DN), which is the diameter of the opening hole in the tank.

Table 13 and Table 14 give flange dimensions and overall dimensions.

Table 13 – Fixing interface dimensions according to Figure 6

Size	Device flange dimensions [mm]				Holes or lugs
	D1 (max)	D2	D3	A Max	Number
A – DN 50	170	125	18	18	4
B – DN 80	200	160	18	18	4
C – DN 125	280	210	18	18	8
D – DN 150	285	240	18	18	8
E – DN 200	350	295	22	18	8
F – DN 175	290	235	16	18	6
G – DN 125	290	235	16	18	6
H – DN 100	220	180	18	18	4
NOTE The flange can also be square. The use of holes or lugs is left to the manufacturer's choice.					



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Figure 6 – Flange interface

Table 14 – Overall dimensions according to Figure 7

Size	Max dimensions for interchangeability [mm]					HE (max.)	HI (max.)
	D7 (max) Circumscribed circle	D8 (max.) (Diameter of the part protruding inside)	D9 (max.) (Diameter of the hole in the cover)				
			Spring inside type	Spring outside type			
A – DN 50	200	70	80	60	175	100	
B – DN 80	250	110	120	80	200	150	
C – DN 125	300	160	170		300	200	
D – DN 150	370			150	300	180	
E – DN 200	400	240	250		400	280	
F – DN 175	350			175	300	180	
G – DN 125	300	160	170		300	200	
H – DN 100	280			100	200		

D7 does not include the provision for the protuberance of the liquid spray protection of the directional type; see 7.6.2.4.1.

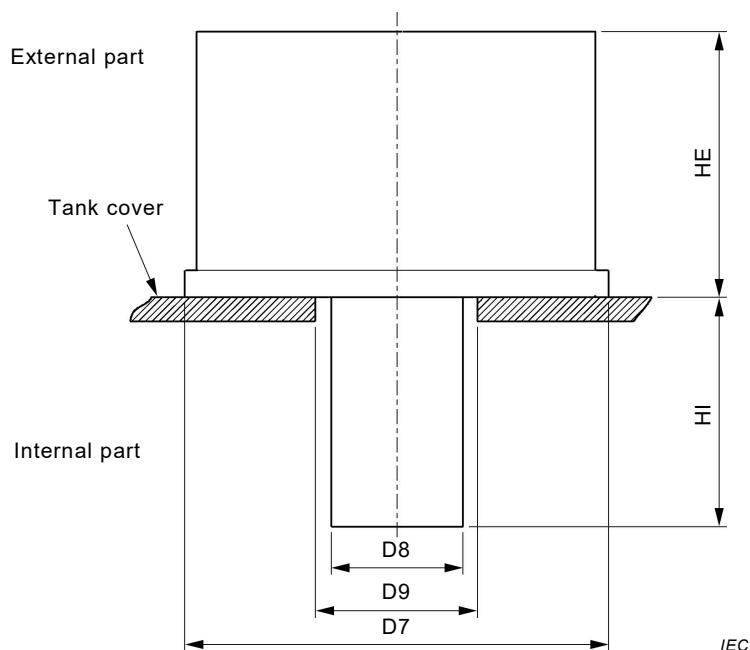


Figure 7 – Maximum overall dimensions

7.6.3 Performance requirements

7.6.3.1 Nominal operating pressure

The pre-fixed overpressure value shall be agreed between supplier and purchaser within the standard range from 20 kPa up to 90 kPa, with 10 kPa steps, with a tolerance of –7 kPa to +7 kPa. Preferred values are 30 kPa, 50 kPa and 70 kPa.

Nominal operating pressure above the standard range (> 90 kPa) shall be agreed between supplier and purchaser.

The device shall be capable of reclosing at a pressure of not less than 50 % of the operating pressure.

The maximum pressure without any liquid leakage in the range from 20 kPa up to 90 kPa shall be equal to the nominal operating pressure less 10 kPa.

7.6.3.2 Switches

7.6.3.2.1 Switch type

Switches shall be potential free. Unless otherwise specified, changeover switches shall be provided.

7.6.3.2.2 Switch performance

Switches shall have a rated current 2 A RMS and short time current 10 A RMS for 30 ms. Making and breaking capacity shall conform to Table 15.

Table 15 – Making and breaking capacity – PRD

Voltage	Changeover switches			
	Making capacity		Breaking capacity	
24 V DC to 220 V DC	130 W	L/R < 40 ms	25 W	L/R < 40 ms
230 V AC	250 VA	$\cos \varphi > 0,5$	60 VA	$\cos \varphi > 0,5$

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

The minimum switch life shall be 1 000 operations.

When the switch is required to make a low current down to 50 mA even after one year of non-operation, special switches are required with contacts that may be damaged by higher currents and therefore the values in Table 1 do not apply.

7.6.4 Tests

7.6.4.1 List of tests

7.6.4.1.1 Routine tests

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

- Liquid leakage test (7.6.4.2.1);
- Insulation test (7.6.4.2.2);
- Functional test (7.6.4.2.3).

7.6.4.1.2 Type tests

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

- Vacuum withstand test (7.6.4.3.1);
- Vibration withstand test (7.6.4.3.2);
- Mechanical endurance test (7.6.4.3.3);

7.6.4.1.3 Special tests

- Seismic withstand test (7.6.4.4).

7.6.4.2 Routine tests

7.6.4.2.1 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 helium leakage test with a leakage rate lower than 4×10^{-6} Pa m³/s.

7.6.4.2.2 Insulation test

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

Test voltage is given in Table 1.

7.6.4.2.3 Functional test

A functional test shall be carried out to prove the mechanical and switch operation of the device. The operating pressure value shall be recorded and shall be within the tolerance (see 7.6.3.1). The pressure rise rate during the operating pressure test shall be not less than 10 kPa/s.

7.6.4.3 Type tests

7.6.4.3.1 Vacuum withstand test

The devices shall be subjected to a vacuum test of an absolute pressure of 2,5 kPa for 24 h. This test shall be followed by the test as detailed in 7.6.4.2.3.

7.6.4.3.2 Vibration withstand test

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

7.6.4.3.3 Mechanical endurance test

The mechanical endurance test shall be performed by operating the device for 1 000 cycles. At the end of the test, all the routine tests shall be performed successfully.

7.6.4.4 Special test – Seismic withstand test

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

7.7 Pressure relief valves

7.7.1 Additional service conditions

It shall be possible to install the device on the tank cover or walls, in each position or any inclination, without alteration of its operating performance.

7.7.2 Mechanical requirements

7.7.2.1 Nameplate

Owing to the limited dimensions of the device, the nameplate can show only a limited number of data. The minimum requirement for the nameplate is to show following information:

- name or logo of the supplier;
- operating pressure.

7.7.2.2 Construction requirements

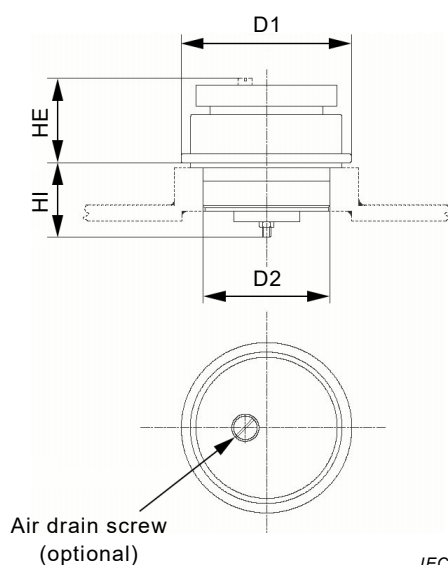
PRVs are composed of a threaded body and a spring-loaded shutter with the spring inside of the tank. They are typically used on small transformers. They are always without switches and without liquid spray protection.

7.7.2.3 Dimensions

Table 16 gives the overall dimensions according to Figure 8.

Table 16 – Fixing interface and overall dimensions according to Figure 8

Size	Max overall dimensions			Connection
	D1 [mm]	HE [mm]	HI [mm]	D2 Pipe thread ISO 228-1
1	60	40	40	G1
2	60	40	110	G1
3	80	40	40	G2
4	22	31	15	¼" NPT

**Figure 8 – Mounting interface and general overall dimensions**

7.7.3 Performance requirements – Nominal operating pressure

The pre-fixed overpressure value shall be agreed between supplier and purchaser within the standard range from 25 kPa up to 80 kPa, with 5 kPa steps, with a tolerance of –7 kPa to +7 kPa.

Nominal operating pressure above the standard range (> 80 kPa) shall be agreed between the supplier and the purchaser.

The device shall be capable of reclosing when the pressure reaches at least 50 % of the operating pressure.

The maximum pressure without any liquid leakage in the range from 25 kPa up to 80 kPa setting shall be equal to the nominal operating pressure less 10 kPa.

7.7.4 Tests

7.7.4.1 List of tests

7.7.4.1.1 Routine tests

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

- Functional and liquid leakage test (7.7.4.2).

7.7.4.1.2 Type tests

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

- Type test – Mechanical endurance test (7.7.4.3)

7.7.4.2 Routine tests – Functional and liquid leakage test

A functional test shall be carried out to prove the mechanical and switch operation of the device. The operating pressure value shall be recorded and shall be within the tolerance (see 7.7.3). The pressure rise rate during the operating pressure test shall be not less than 10 kPa/s.

During the functional test, the leakage of the device also has to be checked.

7.7.4.3 Type test – Mechanical endurance test

The mechanical endurance test shall be performed by operating the device for 1 000 cycles. At the end of the test, all the routine tests shall be performed successfully.

7.8 Direct reading mechanical dial type liquid temperature indicators

7.8.1 Mechanical requirements

7.8.1.1 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 including the wording "OTI" or "liquid temperature indicator";
- manufacturer's serial number;
- connection diagram (it may be 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.

7.8.1.2 Construction details

The OTI shall be of the mechanical dial type.

To allow the indicator to be read easily, the scale's diameter (dial) shall be at least 110 mm.

Maximum overall dimensions are width 200 mm, height 350 mm, depth 200 mm.

The movement of the pointer from the minimum to the maximum temperature shall be clockwise when facing the dial.

The choice of the colours of the background, letters and pointer should guarantee good readability; preferred colour combination is bright (white) background and black letters and arrow.

The scale shall be divided in steps of 2 °C or 5 °C.

Marking of the dial plate shall be indelible.

Standard measuring ranges are $-20\text{ °C}/+130\text{ °C}$ or $-20\text{ °C}/+140\text{ °C}$

Special temperature ranges may be supplied by agreement between the manufacturer and the purchaser.

The temperature indicator shall be equipped with a maximum indicating pointer of red colour with a suitable manual resetting device.

The case shall be provided with an air hole or a breathing system for ventilation.

7.8.1.3 Sensing bulb and capillary

The sensing bulb shall be suitable to be accepted inside thermometer pockets.

Capillary tube: if provided, the standard lengths of capillary are 6 m and 10 m.

Other lengths by agreement between customer and purchaser.

The capillary tube, if provided, shall be adequately armoured in order to avoid accidental damages, which can be prejudicial to a correct indication of the instrument.

7.8.1.4 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 terminal block shall be designed to accept cables having a cross-sectional area of between $1,5\text{ mm}^2$ and 4 mm^2 .

A minimum of two threaded holes for cable glands $M25 \times 1,5$ shall be provided; one shall be closed by a weather resistant plug, the other being protected for transport and storage. For equipment with more than three threaded holes, $M20 \times 1,5$ is accepted. Other thread dimensions are subject to agreement between the supplier and the purchaser. Cable glands are supplied on demand.

7.8.1.5 Special requirements

Upon request, the temperature indicators may be fitted with one or more outputs (type Pt100 or transmitters 4 mA – 20 mA) for remote indication or connection via digital output.

7.8.2 Performance requirements

7.8.2.1 Measuring accuracy

Measuring accuracy shall be $\pm 2\%$ of full-scale value. By agreement between the purchaser and the supplier, the device can be supplied with accuracy less than the standard value.

The accuracy shall be compensated over the ambient temperature range of -25 °C to $+40\text{ °C}$.

7.8.2.2 Switches

7.8.2.2.1 Switch type

Switches shall be potential free. Unless otherwise specified, changeover switches shall be provided.

7.8.2.2.2 Switch performance

Switches shall have a minimum rated current 2 A RMS and short time current 10 A RMS for 30 ms. Making and breaking capacity shall conform to Table 17.

Table 17 – Making and breaking capacity – OTI

Voltage	Changeover switches			
	Making capacity		Breaking capacity	
24 V DC. to 220 V DC	130 W	L/R < 40 ms	25 W	L/R < 40 ms
230 V AC	250 VA	$\cos \varphi > 0,5$	60 VA	$\cos \varphi > 0,5$

An optional value of 1 200 VA at 230 V AC may be agreed between the purchaser and the supplier.

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

The minimum switch life shall be 100 000 operations.

When the switch is required to make a low current down to 50 mA even after one year of non-operation, special switches are required with contacts that may be damaged by higher currents, and therefore, the values in Table 1 do not apply.

7.8.2.2.3 Number and setup of switches

Number of switches: standard configuration is with 2 or 4 switches; other switch configurations to be considered as special executions may be agreed between the manufacturer and the purchaser.

Switch setting shall be adjustable over the whole measuring range. With the standard design, a minimum of 10 °C difference shall exist between two switches. If two or more contacts are requested to switch at the same temperature, this shall be agreed between the customer and the purchaser.

The setting shall be related to rising temperature.

The accuracy shall be 2 % of the measuring range.

The hysteresis shall be between 5 °C and 15 °C at the choice of the manufacturer.

NOTE The hysteresis depends on the technology and the type of contact used in the device; therefore, the hysteresis is usually not adjustable.

7.8.3 Tests

7.8.3.1 General requirements for routine, type and special tests

7.8.3.1.1 General

The reference temperature shall be measured as close as possible to the thermometer sensing bulb.

7.8.3.1.2 List of tests

7.8.3.1.2.1 Routine tests

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

- Insulation test (7.8.3.2.2);
- Functional tests (7.8.3.2.3).

7.8.3.1.2.2 Type tests

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

- Mechanical overheating withstand test (7.8.3.3.1);
- Vibration test (7.8.3.3.2).

7.8.3.1.2.3 Special tests

- Seismic withstand test (7.8.3.4).

7.8.3.2 Routine tests

7.8.3.2.1 General

The following tests shall be performed on 100 % of the instruments. Evidence of the measuring and commutation tests shall be filed.

7.8.3.2.2 Insulation test

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

The test voltage is given in Table 1.

7.8.3.2.3 Functional tests

The following functional tests shall be carried out to prove the mechanical and electrical operation of the indicator and associated switches:

- accuracy of the indication across the dial range of temperatures (at least four points equally spaced between 40 °C and 100 °C in a liquid thermostatic bath); care should be taken to ensure that the operation of the switches does not affect the reading;
- tolerance of the switch operation;
- commutation differential of the switches; the switching temperatures shall to be read by a calibrated sensor and not by the thermometer under test;
- analogue/digital output functionality test, if applicable.

The maximum tolerance on the switch setting and the dial indication is 5° (angle).

7.8.3.3 Type tests

7.8.3.3.1 Mechanical overheating withstand test

The sensing bulb being immersed in a fluid bath heated at 120 % of the maximum dial temperature, the total system shall withstand the internal overpressure.

No leakage from the sensor nor the capillary shall be observed and the functional test shall be successfully repeated.

7.8.3.3.2 Vibration test

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

7.8.3.4 Special test – Seismic withstand test

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

7.9 Direct reading mechanical dial type winding temperature indicators

7.9.1 Mechanical requirements

7.9.1.1 Nameplate

The nameplate shall contain the following information:

- name or logo of the supplier;
- country and manufacturing location;
- number of this standard;
- device manufacturers identification including the wording "WTI" or "winding temperature indicator";
- heating system maximum current;
- manufacturer's serial number;
- connection diagram (it may be 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.

7.9.1.2 Construction details

The WTI shall be of the mechanical dial type.

Included in the measuring system is a heating element supplied by a current derived from the line terminal of the winding by the use of a current transformer. This element adds an incremental value proportional to the square of the measured terminal current to the top liquid temperature. Normally, the setting of the increment is such that it reflects the gradient between the winding hot spot and the top liquid temperature.

To allow the indicator to be read easily, the scale's diameter (dial) shall be at least 110 mm.

Maximum overall dimensions are width 200 mm, height 350 mm, depth 200 mm.

The movement of the pointer from the minimum to the maximum temperature shall be clockwise when facing the dial.

The choice of the colours of the background, letters and pointer should guarantee good readability; preferred colour combination is bright (white) background and black letters and arrow.

The scale shall be divided in steps of 2 °C or 5 °C.

Marking of the dial plate shall be indelible.

Standard measuring ranges are 0 °C/+150 °C or 0 °C/+160 °C

Special temperature ranges may be supplied by agreement between the manufacturer and the purchaser.