M A K I T E L D O O E L

T R A F I T A L I A G R O U P

TRANSFORMERS WITH LOW AND MEDIUM CAPACITY

GUIDE FOR THE USE OF DISTRIBUTION TRANSFORMERS IN SAFETY CONDITIONS

1. GENERAL

The purpose of this publication is to provide informations on the properties and use limits of indoor or outdoor distribution transformers with mineral oil ation or with natural cooling (ONAN), and dry-type resin transformers, with the aim of preventing the incorrect usage of the equipment. These transformers have the following characteristics :

- Maximum operating voltage 24 KV
- Power rating from 50 to 2500 KVA

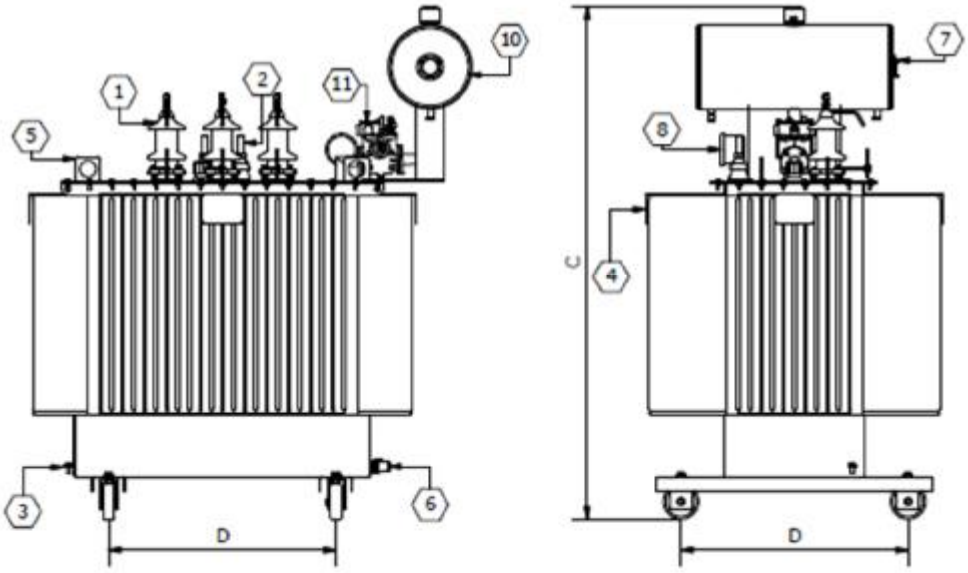


Figura 1. ACCESSOIRES LAYOUT IN OIL-INSULATED TRANSFORMERS

2. SUBJECT

This publication provides recommendations for the use of three-phase distribution transformers, with mineral oil or dry or resin insulation, in safety conditions which are in accordance with CEI specifications 14-4 and 14-8. The publication refers especially to transformers that are to be used for the transformation of electric energy in industrial, commercial and service situations. these transformers must be used exclusively for the purposes and in the ways described below, and as listed in the CEI specifications.

3. DEFINITIONS

The meaning of the terms used in this publication are as defined in CEI Specifications 14-4 and 14-8.

4. SAFETY REQUIREMENTS

4.1 Basic requirements

4.1.1. Safety is defined as the absence of dangers for persons or objects when a transformer is in use or in storage. This implies the identification of stresses. risks and possible faults, and of their elimination or control so as to reduce the risk to an acceptable level.

4.1.2. The transformers must not be used for purposes other than the transformation of electrical energy.

4.1.3. The methods, parameters and requirements for the tests specified in CEI Specifications 14-4 and 14-8 are aimed at controlling design and construction in relation to safety and quality aspects.

4.1.4. This publication must be applied in the light of CEI Specifications. such as, for example, specifications referring to electrical systems and installations.

4.2 General requirements

4.2.1 The user must check that the following data are included on the information plate:

- Name of manufacturer, type, number and year of construction;

- Frequency;
- Power rating;
- Primary voltage;
- Secondary voltage (no-load);
- Current ratings for each winding in relation to each voltage;
- Indoor or outdoor use specification;
- Cooling system;
- Type of cooling fluid, if applicable;
- Standard insulation ratings for each winding, expressed with two numbers: the first usually refers to the impulse test and the second to the industrial frequency test;
- Insulation classes.

The values and data listed above must be compatible with the mains network to which the transformer is connected, the loads it has to supply and the physical surroundings in which it is installed.

4.2.2. The user must verify that the installation of the transformer is conform to the specification on the information plate (indoor or outdoor).

4.2.3. The user must not run a transformer that has oil leaks. For cleaning the transformer surroundings, refer to the manufacturer's instructions.

4.2.4. The user must verify that the metal parts of the transformer are grounded via the correct terminals, using a suitable type of ground connection.

4.2.5. The transformers must be selected so that they can sustain not only the normal running conditions which may arise, such as, for example: overloads, overvoltages, overcurrents and temperature excesses.
Refer to the loads guide, CEI issue s/564

4.2.6. The transformers must not be exposed to damaging action from chemical substances, or to attack from flora and/or fauna.

4.2.7. The transformers must be suitably protected against the risk of the physical damages to which may be exposed under normal use conditions or during installation.

5. HANDLING AND STORAGE RECOMMENDATIONS

5.1. Transport and reception

The transformers are sent from the factory ready for installation. To reduce the risk of damage during transportation, the transformers must be tied down with ropes, using the special attachments. The ropes must be arranged so that they do not go against radiators or, for the dry-type transformers, against the windings.

5.2 Lifting

The transformers can be lifted using the special lifting rings, being sure to use ropes of sufficient length to ensure that H (see Fig. 2) is never less than L. Always use all existing rings, never just some of them.
Hydraulic jacks can be used for small lifting operations, provided there are suitable support plates.

5.3 Changing the direction of the rollers

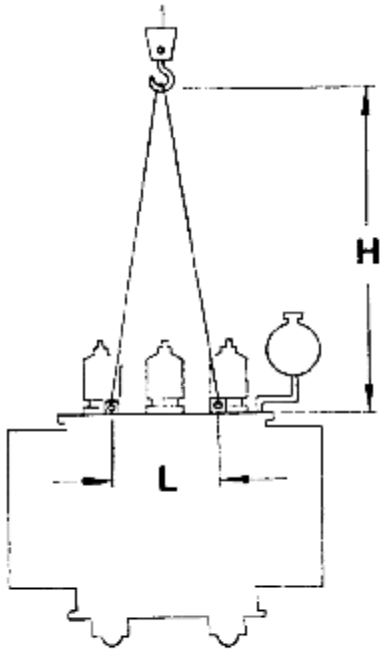
To change the direction of the rollers, lift up the transformers and unscrew the roller fork relainer nuts. Take off the forks, turn through 90° and refill, lightening up the nuts thoroughly. Repeat this operation on all four wheels.

5.4 Transfer

To move the transformers, use the rollers, or push on the tank or at the bottom of the tank (avoid exerting pressure on the radiators or on the insulators).

5.5 Holding in stock

f the transformer is not installed straight away, it can be stored in a closed room (indoor model), or outside (outdoor model).



2. *Lifting a transformer.*

6. INSTALLATION RECOMMENDATIONS

For the installation, refer also to the current ("Regulations for the prevention of accidents at work")

When there is, or may be, a particular danger due to the presence of an explosive or inflammable atmosphere, refer to CEI specification 64-2 "Electrical systems with danger of explosion and fire"

6.1. Control device

6.1.1. The control devices must be suitably proportioned for the expected current levels.

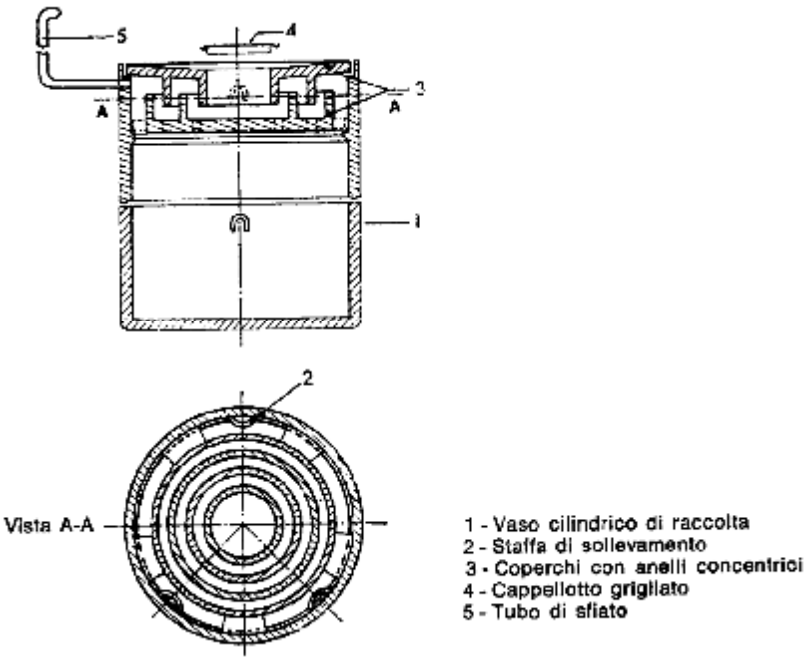


Figure 3. Prefabricated siphon-type oil recovery system, for indoor installation

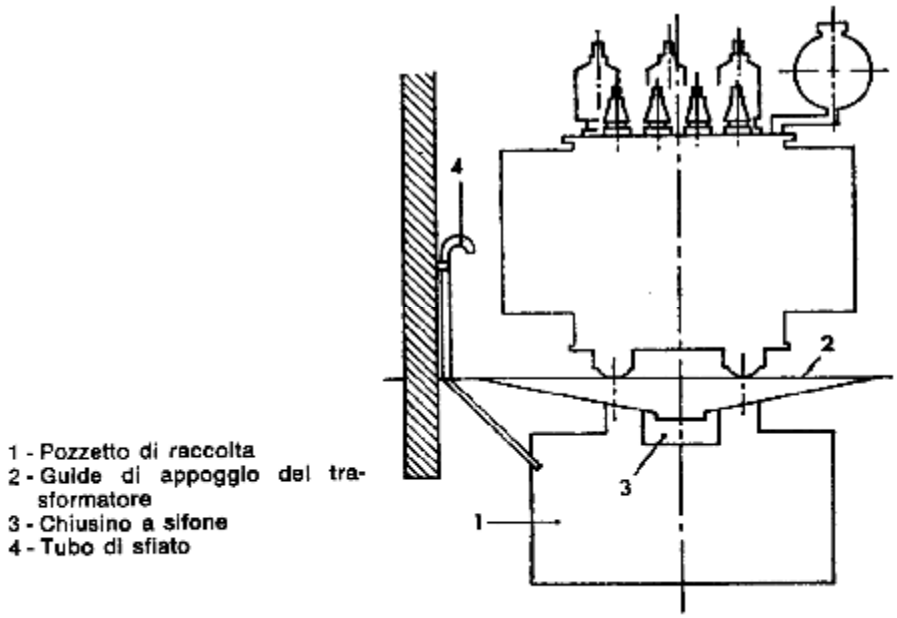


Figure 4. *Oil collection sump built on-site together with other building works, for indoor installation.*

1 - Vasca di raccolta
2 - Guide di appoggio del trasformatore
3 - Sifone
4 - Pozzetto di passaggio per il recupero dell'olio
5 - Lamiera di protezione

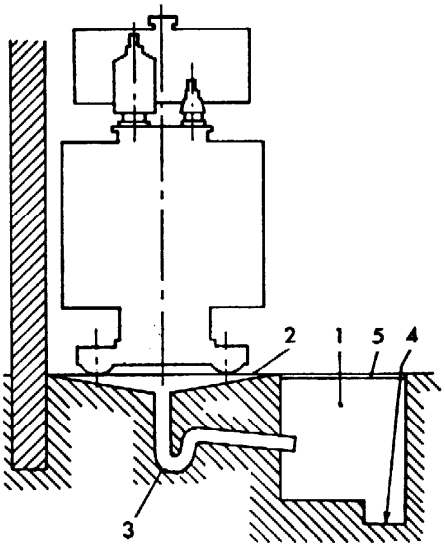
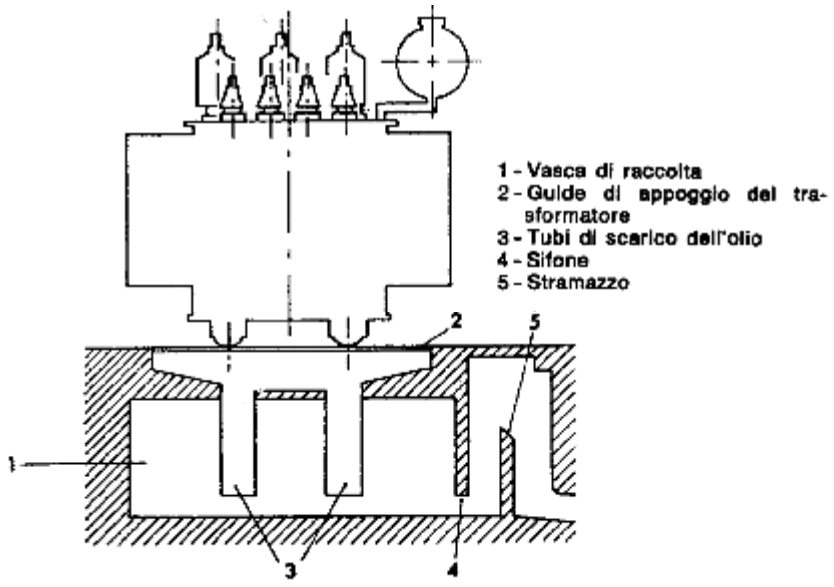


Figure 5.Collection task set at a distance from the transformer, for indoor installation.



6.1.2. The insulation level for all the control devices must be in line with CEI Specifications.

6.2. Fitting the air dryer

If the air dryer, if supplied, is delivered not mounted on the transformer, then it needs to be screwed in position in place of the threaded plug underneath the conservator on the HV side.

6.3. Protection of the personnel and of the surrounding area.

The impregnating oil that is normally used is inflammable, and consequently the necessary precautions must be taken.

Also for oils with a low flash point, the use of a pit is recommended, as described in point 6.3.1, to prevent the oil from spreading into the surrounding area.

6.3.1. The current “Regulations for the prevention of accidents at work” make it compulsory to construct sumps, tanks or other systems to prevent burning oil from spreading out of the cabin and fenced area, for oil-type electric transformers housed in non-insulated cabins and containing a quantity of oil greater than 500 Kg.
Note that the quantity stated above refers to the total quantity of oil contained in one or more transformers housed in the cabin. Also, the oil collection sump must be constructed not only when a transformer containing this quantity of oil is installed in the cabin, put also when spaces in the cabin are set aside to house more transformers in the future, even if, at first, only one transformer is to be run, and the power level of this transformer is such that it contains less than 500 Kg. of oil.
The quantity of oil contained in the transformer is given in the illustrative booklet, or is shown on the information plate on the transformer itself.
We will now give a description of some of the types of sumps or tanks normally used.
A first type generally used for lower power levels, is a prefabricated device, the construction details of which are shown in Fig. 3, and is generally defined as a “siphon type oil recovery system”. It consists of a cylindrical container, which can either be in a single piece or divided in two halves to facilitate transport and positioning operations. There are three lifting brackets inside the container for lowering the cylinder into the pit. Two covers, with consecutive, staggered,

concentric rings, create a labyrinth through which the burning oil is forced to pass to be extinguished due to lack of oxygen. A meshed cap prevents any material from obstructing the passage of the oil. There is a hole in the upper left-hand part through which the air can escape, and an iron pipe is fitted to the hole, which comes up from the floor next to one of the walls of the room. The mouth of the pipe faces downward, and has a small grid to stop any blockages from occurring which may affect the operation of the whole system. Another type of sump is illustrated in Fig. 4. This type needs to be constructed when the initial building works are being carried out. The burning oil is made to flow off down a slight slope on the floor, towards a trap that forms a siphon. A variation of this system is shown in Fig. 5, where the tank can be shared by more than one transformer, and the oil flows into this tank from the individual sumps via a siphon-type pipe system.
The devices described above are suitable for indoor installation inside a cabin, as the pit would fill up with rainwater if this system was used outdoors.

For external installations, the system illustrated in fig. 6 is more suitable. The oil runs down the pipes 3 and rises up again due to a lower specific weight, extinguishing due to lack of oxygen. The excess part flows over the overflow, whereas the internal level stays more or less the same. In this case, the system should be constructed, in such a way as to ensure that the oil does not flow into the surrounding area.

6.3.2. In order to allow the cooling to take place, the transformer must be installed at a distance of less than 30 cm from the walls and not less than 60 sm from other transformers. The room must be sufficiently ventilated to allow an air change rate at least 5-6 m3/min for every Kw loss.

6.3.3. Transformers with rollers should be wedged, to prevent any type of movement.

6.3.4. The HV and LV line connections should be made in accordance with the phasing market on each insulator on the attachments points, and the weight of the connection must not pull down on themselves.

6.3.5. If the transformer is equipped with a Buchholz relay and/or thermometer, make the connections to the terminal of the lead centralization box or, if this is not installed, connect directly to the relay/thermometer terminals. The table below shows the normal contacts arrangement and the numbering for identifying the corresponding terminals.

Unit	Contact for	Contact arrangement	Terminals numbering
Buchholz relay	Alarm	n.o.	1-2
	Triggering	n.o.	3-4
Thermometer	Alarm	n.o.	1-2
	Triggering (if applicable)	n.o.	3-4

The contacts arrangement can be changed, including the contacts on the transformer itself, from normally open to normally closed and vice-versa, as desired.
Resin and dry-type thermometers have thermal resistance for heat control and the contacts to these resistance, when taken back to the terminal board, are connected to the central and display unit, in accordance to the instructions provided by the unit manufacturer.

6.4. Danger to personnel

6.4.1. During the installation of the transformers, the live parts should be adequately protected against accidental contacts in accordance to CEI Specifications 11-1.
Anyway, the area where the transformer is installed must be inaccessible when the transformer is live.

6.4.2. When putting the transformer into operation, it is essential to ensure that the terminals are properly tightened.

6.5. Mechanical stresses

The user must avoid subjecting the transformer to excessive mechanical stresses. The electrical connections must be made in such a way to ensure that the torque exerted on the terminals is not greater than the torque level specified by the manufacturer. Ensure, when setting the electrical and geometrical dimensions of the connections, that mechanical stress will not be caused by weight and/or temperature change factors.

7. TRANSFORMERS PROTECTION SYSTEMS

7.1. Introduction

Some of the protection system are designed to verify the occurrence of faults and others are designed to limit the consequences of faults when they occur. All the protection systems, however, must respect the same principle of the selectivity of the protection.
The continuity of the service being supplied (and the safety of the staff running the plant) can only be obtained if a series of adequate protection systems are installed, and, in the transformer room, these protection devices must be set up in accordance to currently binding regulations and law.

NOTE: The installation must be performed by a qualified service engineer, and therefore the following points are intended to be of a general character.

7.2. Overvoltage

The overvoltages that occur in the transformer room can be of the following types:

- Overvoltages of atmospheric origin
- Overvoltages resulting from operations with control devices.

7.2.1. Overvoltages at atmospheric origin, originating from the lightning conductor system or from static charges, are more frequent during storms, and the higher the conductor line in the air the greater the effect of the overvoltages. Special construction measures can be taken to guarantee the efficient operation of the transformer even in the case of frequent occurrence of overvoltages, on the conductor line, provided that these overvoltages do not exceed the insulation limits of the conductor system itself, based on the expected voltages levels.

7.2.2. Operating overvoltages are caused by the switching on and off of the switches on the primary voltage network, with sudden high-load breaks and/or power factor correction condenser batteries, as a result of service demands or the triggering of protection systems.

These overvoltages can be of the same amplitude as the overvoltages of atmospheric origin, but they last only a few secs.

NOTE:

All MV leads have large capacity/length characteristics and, when a lead of a certain length feeds a no-load transformer, the moderate primary current being carried produces a voltage increase at the end of the lead.
Then, if the lead supply is disturbed by an overvoltage, this will be amplified drastically along the length of the lead, which may lead to the transformer being subject to an overvoltage much larger than its expected maximum.

Therefore, always protect the lead ands against overvoltages.

7.3 Overcurrents

Overcurrents can be caused by:
- an external fault;
- a fault in the transformer;
- a connection of the transformer;
- overloads.

7.3.1 Any kind of fault that occurs downstream on the line fed by the transformer causes an increase in current in the line which can reach extremely high levels.

This causes the generation of heat and abnormal electrodynamic stress in the machinery and various connected units, and it is necessary to prevent the damaging effect from reaching the transformer, which means eliminating the cause of the fault as quickly as possible.

As regards the selectivity of the protection systems, if the fault occurs on only one of the lines supplied by the transformer, the switch on that line only should switched on, whereas the switch for the transformer itself should be switched on (with a slightly greater delay) only if the fault occurs between the transformer and the switches on the various lines it supplies, or if the line switch is ineffective.

7.3.2 If the faults occurs inside the transformer, the situation is similar to that described in 7.3.1, the only difference being that in this case the part of the line to be protected is the part upstream from the transformer.

Therefore, the protection devices installed have the purpose of preventing the fault from spreading to the network upstream from the transformer, and they must act on the primary switch to stop the transformer from being damaged.

Obviously, the relay on this primary switch must be set so that it doesn't open before the relative secondary switch (line or transformer) switches on when an external fault occurs.

7.3.3 If the transformer is switched on at the exact moment when the supply sinusoidal voltage reaches its maximum value, the instant which, in steady-state running, corresponds to a null flux value, there are no notable transient phenomena, and the magnetizing current, starting from the value zero corresponding to null flux, the normal steady-state running curve.

If, on the other hand, the transformer is switched on at a moment when the voltage is not at maximum value, the flux at this instant would have a non-null value, which would be, in specific terms, the maximum value.

As the flux cannot reciprocate by changing value instantly, and as it has to start from the zero value in any case, there is a transient period in which the steady-state sinusoidal flux is joined by an additional exponential-trend transient flux with a maximum value equal and opposite to the value that the steady-state flux would have at the moment of switching on.

The transient phenomenon lasts only a few seconds. A half-cycle after the switching on, the flux can reach a value which is theorerically almost twice (in practice only 1.8 times) the maximum steady-state value given the inevitably strong saturation level of the iron in these conditions, the magnetizing current can then take on extremely high values, almost at the level of the D.C. current (for normal-type transformers, up to medium power range).

The protection that has be set up on the primary, therefore, on the basis of the considerations in 7.3.2, must therefore be delayed to allow the first peaks of the transformer switch-on current to run off without triggering the protection, and this protection must then be active and available for triggering by lower current levels which continue for longer times.

7.3.4 If an overload occurs on the transformer above the set limit, the ambient temperature near to the maximum permitted level, or if, for a number of possible reasons, the transformer cannot eradicate is energy losses at temperature within the set limits, the temperature of the windings may go to such a high level than the insulation could be damaged and internal fault could be caused.

What is important here, therefore, more than the maximum load current and the efficiency of the cooling system, is the overheating that can be produced in the windings (small overloads of long duration are often more dangerous than strong, short-tasting overloads).

The overloads protection system must, in the first place, limit the secondary loads to the maximum permitted value, in real running conditions.

7.4 Overvoltage preventives protection systems

When planning a plant power supply transformation zone, the protection systems should always be taken into account. Protection devices should be installed on each input line, with a ground discharge outlet for any waves of overvoltage that arrive from the mains network.

This protection is obtained by installing overvoltage dischargers.

In order to choose the correct type of discharger, the characteristics of the network upstream from the point where the protection is to be installed must be considered, and the type of discharger must be selected from the tables published by the various manufacturers.

7.5 Transformer fault limiter protection systems

The protection systems described in 7.4 are preventive, but even if they are correctly installed they are not always able to stop the overvoltages, described above from reaching and damaging a transformer, which could also lead to the breakdown of the insulators inside the transformer by thermal and/or electrodynamic action.

It is necessary, therefore, to set up protection systems to limit the spread of damage from the fault that has occurred.

The protection systems can be set up with the following devices:
- Buchholz relay
- Internal pressure control valve

7.5.1 The various types of fault that occur inside the transformers almost always lead to the production of gas resulting from decomposition of the oil and/or insulators affected by the fault current, in quantities which vary according to the size of the fault. Sometimes the formation of gas is so voluminous that a violent wave of overpressure is created, which attempts to escape to the exterior at the point where the fault has occurred.

The Buchholz relay consists of a chamber containing two floats, positioned, one above the other, each one being triggered by a drop in a certain contact.

This type of protection is used universally, because of its simplicity, economy and excellent working action, although it can be triggered accidentally by air bubbles that remain trapped in the transformer after installation, or pumped in by the oil circulation pump; for this reason, the relay has a tap for drawing off a sample of the gas that has triggered the alarm so that it cab be identified, before proceeding with the disassembly of the transformer.

7.5.2 The internal pressure control valve is normally used is hermetically sealed transformers to control the internal pressure of the transformer.

The special feature of these valves is that they are able to discharge any pressure increases to the exterior in a very short time (3-5 thousandths of a second).

In fact, if a violent short circuit occurs inside the transformer, an enormous volume of gas is produced immediately which changes the internal pressure in a marked way.

If there is no possibility of discharging to the exterior, the transformer will explode, with all the damaging consequences that may result. To prevent this from happening, a valve is used with a discharge cross-section proportional to the volume of the oil contained in the transformer.

7.6 Fault overcurrent limiter protection systems

Protecting equipment against the effects of a short circuit is a complex problem. In fact, as well as the other protection systems that have been described in detail, it is also necessary to install protection devices at the specific points which need protecting that are capable of cutting off current levels that have nothing to do with the equipment itself, but which depend on the power of the short circuit at that particular point in the network, which, in turn, depends on the network layout upstream from the point to be protected.

The low voltage switch break power level, on the other hand, is set by the power of the transformers in the transformer room.

Also, it is always important to take the protection selectivity criteria into account, to prevent useless and inconvenient breaks in the continuity of the service.

7.6.1 The simplest type of maximum current protection system is set up on the primary, and consists of ampere relays or fuse valves, and is mainly used for low or medium power distribution transformers, where there is no need to set up more complex or costly protection systems. To prevent the system from

triggering accidentally, the relays must be set to current levels that are much higher than normal, which means that the protection is not effective against overloads.

Two types of maximum current protection can be used:
- direct magnetic relay;
- High break-power valve

7.6.1.1 The direct magnetic relay is the simplest of the ampere relays mentioned above.

It is installed in series with the circuit phases, linked to the switch, and consists of a spiral winding around magnetic core which exerts an attractive force that is proportional to the line current level on an armature. Whenever the current level exceeds the set limit, the armature is attracted and transmits its movement to the release device on the switch, causing it to open.

The relay does not act instantly, but works with a short delay. this is necessary if it is used as a primary voltage protection, to allow the first peaks of the transformer switch on current to run off without triggering the switch.

7.6.1.2 The high break-power valves are the most effective economical system for protecting against potentially very high overcurrents and are used universally in low and high-power transformer rooms, linked to the switches, or else to simple isolating switches.

The secret of the high break capacity lies in the very fast switch-off speed that is achieved in the valve prevents the fault current from reaching its maximum level.

7.7 Overloads limiter protection systems

The direct relays and the valves described in 7.6.1 have a limiting function only if a short circuit occurs or if there is a current much higher than the current rating, and do not work with currents that are only slightly above the rated value.

To fulfill this type of function, other types of protection systems are used:
- LV magnetothermic switches;
- thermometers;
- heat control devices for resin or dry-type transformers.

7.7.1 Protection systems for overcurrents caused by overloads are set up in the general line with automatic switches which, as well having a magnetic relay (similar to those described above), also have a thermal relay which works with the bending of a bimetallic plate when subject to heating, in relation to the current running in the circuit.

The thermal relay is particularly suited as an overload protection system, as it works with a considerable delay, when compared to the magnetic relay, so that the system is not triggered by transient load points.

7.7.2 The power of the transformer is based on the temperature of the windings when working on full load.

In general, the excessive heating of the oil in the sump, which is also a consequence of an increase in losses from the active part of the transformer, means that the unit is overload, and that the protection systems need to be put into effect.

Consequently, a contact thermometer is often installed on transformers, these thermometers are set to trigger an audible alarm when a first temperature level is reached, to be followed by the shutdown of the transformer if the temperature rises to dangerous levels.

It is also common practice to fit the thermometers with a pointer which moves only to show the highest temperature reached by the thermometer.

7.7.3 A thermal resistance is fitted in at the hottest points on each of the columns of resin or dry-type transformers. The resistance is normally of type PT 100 Ohm, with the contacts indicated on the terminal board.

These heat-sensitive probes are then connected to a central temperature control and display unit line, with settable contacts for the alarm or for the triggering action, supplied on request.

8. START-UP

Before starting up the transformer, the following checks need to be run.

8.1 Tank round connection

In order to be sure that the potential of the transformer tank stays at the same level, and that it is capable of conducting the fault current if there is a current discharge towards the tank, then it must be fitted with a grounding conductor that is able to take the fault current, as specified in CEI Specifications 17-13.

8.2 Cleaning

If the transformer has been held in stock for a long period then proceed with a general cleaning, paying particular attention to the insulators or dielectric fluid transformers (see point 8.3).

For resin and dry-type transformers, clean off any dust, dirt and condensation deposits (especially on dry-type transformers) from the HV/LV windings, using a jet of low-pressure, dry compressed air and dry rags.

8.3 Dielectric strength of insulating fluid

If the transformer has been held in stock for more than six months in normal climates, or for more than a month in damp climates, check the dielectric strength of the insulating oil, using the following procedure.

Using the discharge device near the bottom of the tank, draw off about a one-liter sample of all and test it, using the correct equipment, according to the method laid down in CEI standards. When the discharge voltage is equal to or greater than 40 KV, the fluid can be assumed to be in a good state and suitable for use; if this is not the case, the insulating fluid needs to be tried (see point 8.4).

If no equipment for testing the dielectric strength is availabl4e, a qualitative assessment of the moisture content can be made by mixing a small quantity of the oil with anhydrous copper sulphate powder in a test tube; the mixture turns blue if there is the slightest trace of moisture in the oil.
Another qualitative assessment of the presence of water can be made by heating a sample of the oil in a test tube; a cracking noise will be heard if water is present.

8.4 Drying the transformer

The transformer is dried by circulating the insulating fluid through special external heating apparatus and then running it through a filter press or a centrifuge; the insulating fluid is drawn off from the transformer discharge device and poured back into the transformer via the filler device on the conservator.

From the range of available types of heating apparatus, the preferred types are those in which the fluid being dried does not come into direct contact with heating elements.

For example, the fluid to be dried can be circulated in a coil immersed in a spare oil bath, heated directly with heating elements. The temperature of the fluid, taken at about 20 cm beneath the transformer cover, should be kept at about 50° C.

If a filter press is used, the filter cartridges must be replaced before they become saturated with water.

After the drying process, a check should be made on the dielectric strength of the insulating fluid. The dielectric strength test should be repeated on a sample taken number of hours after the heating has finished.

8.5 Insulating fluid level

Check that the reading on the level indicator approximately corresponds to ambient temperature. If the insulating fluid needs to be topped up, then only fluid with the same characteristics must be used and with the required dielectric strength.

Mineral oil-type transformers must be topped up according to the manufacturers' instructions.

NOTE:

Having stated that the supplied oil must contain no PCB note that DPR n. 216 of date 24.5.1988 (G.U. no. 143) specified a maximum PCB contamination level of 100 ppm.

The proposal of European Community directive No. 88/C 43/09 of date 4.2.88, is to reduce the above stated level to 50 ppm.

We recommend therefore, that the top-up fluid should have a PCB contamination level of less than 50 ppm, in order to avoid the contamination of the oil already container in the transformer.

8.5.1 Spark gap rods

If the transformer has insulators with a spark gap rod-type discharger (currently in disuse with most types of equipment, with preference being given to the variable resistance-type discharger), check that the position of the spark gap rods mounted on the HV insulators corresponds to the insulation class given in the table.

Voltage class KW	A mm	B mm
10	70	≥15
15	85	≥15
20	100	≥15
30	220	≥15

8.5.2 Connections

Check that the connections to the HV and LV lines, the round connections and the auxiliary connections have been made correctly.

8.5.3 Outlet switch

Check that the switch is in the voltage position closet to the actual network voltage.

8.5.4 Air dryer

If a dryer is fitted, check that the air holes are not blocked and check that the silicagel salts are blue in colour. If they are pink, this means that they have already absorbed moisture and are no longer suitable for drying the air. Remove the dryer and regenerate the salts by heating them in an oven at 150°C until they go back to the blue colour.

8.5.5 Buchholz relay

To prevent the relay (if fitted) from triggering accidentally, proceed carefully with the bleeding operation by means of the bleed taps. If, during start-up or during the first few hours of running, the Buchholz relay signals the formation of gas, repeat the bleeding operation before interpreting this as being a transformer fault.

8.5.6 Dial thermometer

Check that the triggering temperatures of the thermometer (if fitted) are suited to the expected running conditions.

The calibration temperatures are provided by the manufacturers, in relation to the type of transformer and the classes of insulators used.

8.5.7 Supplying with voltage

After the general check has been made on the equipment, shut down the supply switch on the HV side.

For dielectric fluid and dry-type transformers, it is advised to keep the transformer fed at full voltage level, but without load (LV side switch open), for about two hours, for the elimination of air bubbles; after this time, check that there is no accumulation of air in the Buchholz (if fitted), and then engage the load by shutting the LV switch.

9. RUNNING

According to CEI Specifications, the standard power rating for a transformer refers to the following conditions: an altitude of less than 1000 meters above sea level, a maximum over-temperature based on the classes of insulating material and manufacturer specifications.

9.1 Limiting conditions for transformers with dielectric fluid insulation

The influence of each of the factors described in this article must not be considered individually, but in combination with the other factors.

The acceptable loads, in relation to the transformer power rating, are listed in CEI Specifications issue S.564 “Load guide for oil-immersed transformers”

9.1.1 The overload values listed below are intended as being non-consecutive and non-repeatable, i.e. the transformer must go back to steady-state running each time after attaining one of the listed values.

1) The transformers are able to take the following overloads without exceeding the CEI specified temperature level, considering a maximum ambient temperature of 40°C.

Previous load at steady-state running expressed as % of power rating	Acceptable duration of an over-load expressed as % of power rating				
	10%	20%	30%	40%	50%
50	3 hrs	1,5 hrs	1 hrs	30 min	15 min
75	2 hrs	1 hrs	30 min	15 min	8 min
90	1 hrs	30 min	15 min	8 min	4 min

2) The transformers are able to take the following overloads with a 10°C increase in over-temperature without exceeding the CEI specified temperature level, still considering a maximum ambient temperature of 40°C.

Previous load at steady-state running expressed as % of power rating	Acceptable duration of an over-load expressed as % of power rating				
	10%	20%	30%	40%	50%
100	4 ore	2 ore	1 ora	30 min	15 min

3) If the maximum ambient temperature is less than 40°C, the transformers are able to take the following overloads without exceeding the CEI specified temperature level.

Previous load at steady-state running expressed as % of power rating	Maximum ambient temp. °C	Permanent acceptable overload expressed as % of power rating
100	0	40
100	10	30
100	20	20
100	30	10
100	35	5

9.2 Voltage

The power rating for a transformer is the specified no-load value to be applied or induced between the line terminals of a transformer winding, and is the value to which the test voltage refer.

9.3 Current

The load current must be practically sinusoidal.

9.4 Uneven load

As a general rule, the load should be divided equally between the three phases. However, in cases of necessity, the current levels in three phases can be different, provided that they do not exceed the limit stated on the information plate. The LV neutral must carry a load equal to 10% of the current rating for transformers with group 0 connection, and equal to 100% of the current rating for transformers with group 6 connection.

9.5 Running in parallel

For correct running in parallel, the following conditions are necessary:

- equal turns ratio at all switch positions
- equal phases connection group
- equal short circuit % voltage

As the ratio between % voltage drops due to short circuit losses and inductive % voltage drops varies with the power of the transformer, even when at equal short circuit % voltage, the closer the power level of the transformers, the better will be the running in parallel.

Consequently, running in parallel is not recommended for transformers with a power ratio greater than 1/2.

This should always be kept in mind when ordering the transformers.

Once the parallel connections have been made for the two or more transformers, before connecting to the power supply, check that the HV and LV terminals are connected in the same phase and that the outlet switches are in the same transformation ratio position.

10. CHANGING CONNECTIONS

When the transformer is required to run at two voltage levels, the following instructions should be referred to when changing voltage.

10.1 Changing the HV connections

For dielectric fluid transformers, if a special switch has not been fitted for the voltage changeover, then it will be necessary to change the connections under the cover.

Lower the level of insulating fluid down to 4-5 cm below the tank cover, transferring the fluid to perfectly clean receptacles. Lift up the core with windings above the level of the fluid, and make the changeover, carefully following the directions on the diagram supplied with the transformer. Re-close the transformer, making sure that the seal between the cover and the tank is correctly positioned, then fill the insulating fluid back up to the pervious level.

With resin or dry-type transformers, the changeover is done by moving the metal bridges on the coil over the appropriate base fitting, carefully following the directions in the diagram provided by the manufacturer.

10.2 Changing the LV connections

1) If the terminals are under the cover, proceed as above. Be sure to tighten up the terminals thoroughly; bad contacts could seriously damage the transformer.
In resin and dry-type transformers, the terminals are situated in the upper or lower part of the transformer. Follow the diagram indications carefully, and use the connection plates provided by the manufacturer.

2) If the terminals are above the cover, change the connections according to the diagram supplied with the transformer when first delivered. The connections should be made with an ample contact surface (current density not greater than 25 A per cm2) and with a sufficiently large cross-section (for bar copper conductors, current density not greater than 1.5 A per mm2). Tighten up the terminals properly, as mentioned above.

NOTE:
If the transformer is still under guarantee, the connection changeover under the cover must be performed by personnel authorized by the Manufacturer or by a local service agency recognized by the Manufacturer, otherwise the terms the guarantee will be invalidated.

11. MAINTENANCE

11.1 Transformers with dielectric fluid insulation

A series of periodic checks need to carried out with the frequency of depending on the ambient and running conditions. In clean, dry environments with regular and even running conditions, the supervision can be reduced and the checks can be made less frequently; in dusty or damp environments, however, or when there are frequent and violent load and temperature changes, the supervision must be continuous and the checks more frequent.

During the first month of running, it is recommended to make frequent checks and to set up a schedule of systematic inspections, with the frequency depending on the particular running conditions.

As an example, the following table contains a schedule for average running conditions.

Type of check Frequency of check	Insulating fluid level	Air dryer salts	Insulator cleanness state	Buchholz relay	Spark gap rods positioning	Dielectric strength	Insulating fluid filtration
every week	X	X					
every month			X				
every three months				X			
every year					X	X	
every two years							X
if the dielectric strength is low							X

11.2 Resin and dry-type transformers

Make a list of the checks to be carried out in continuous and/or discontinuous service conditions at the Customer's discretion, it is recommended to record the results of these inspections and to draw up a Transformer Record Card, to help in making a more efficient assessment of the transformer's behaviour over time.

11.2.1 Every six months, clean off all the dust and dirt from the medium and low voltage windings of the transformer.

These operations can be performed using a jet of low-pressure, dry compressed air and dry rags.

Also, this occasion should be used to check if there are any blockages in the windings cooling ducts, and to check the tightness of:
- the anchorage nuts and bolts that attach the transformer to the floor;
- the nuts and bolts on the MV/LV lead connection terminals and the star-shaped and triangular connections;
- the adjustment plates.

The tightening of these components should be performed according to the recommendations provided by the manufacturer.

If particular problems are encountered in any of these operations, call for the Assistance Service

11.2.2 If the transformer is being operated discontinuously, the following operation before start-up, especially after a long stand-down.

a) clean off all the dust, condensation and dirt deposits from the MV/LV windings, using a jet of low pressure, dry compressed air and dry rags.

b) check that all the nuts and bolts are properly tightened.

11.3 Insulating fluid level

If the indicator shows a notable lowering in the oil level, add the insulating oil following the instructions in point 8.5. Remember that the fluid volume can contract slightly in the first running period.

If the indicator does not change when the fluid is topped up, check that the working of the indicator is not affected by leak in the float.

11.4 Air dryer salts

Proceed as described in point 8.9.

11.5 Cleaning the insulators

Dust deposits on the insulators may create a surface charge on the porcelain and on the windings. Clean the porcelain with rags and alcohol.

11.6 Buchholz relay action

To check the efficiency of the relay follow the instructions supplied with the relay itself.

11.7 Spark gap rods positioning

Check the distance between the point, as described in point 8.6.

11.8 Insulating fluid dielectric strength

The treatment of the fluid should be carried our every two years to eliminate any deposits, even if the dielectric strength is still at a sufficiently good level. Proceed as described in point 8.4.

A more precise maintenance schedule can be drawn up in the light of the specific running conditions. For example, in a heavily polluted, dusty or saline environment, it may be necessary to clean more frequently.

NOTE:
The manufacturer cannot be held responsible for the efficiency and safety of the installation if the assembly, connection and maintenance operations are not carried out either by the manufacturer himself, under the manufacturer's supervision or by personnel expressly and previously authorized by the manufacturer.

12 COMPATIBILITY

The correct precautions must be taken in order to avoid dangerous interferenceses with adjacent equipment units.