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1.0 - INTRODUCTION

This manual intends to supply all the needed explanations in order to guarantee the correct use of our electric transformers as well as the maintenance and control operations.

Modern environmental necessities and the consequent legal requirements which prohibit the use of poly-chlorodiphenyl dielectric fluids such as Askarel or Pyrochlor have given rise to the development of products that are not only non-inflammable but also have dielectric strength properties enough to support working voltages of 20 to 30 kV.

Epoxy resin in combination with other components guarantees “non-flammability” feature and also special physical and technical characteristics that enable to design units that result smaller than the standard oil-insulated type ones.

Dry type transformers have demonstrated their considerably improved resistance to transient overloads, network short circuits and impulsive voltages.

They behave extremely well in damp environments and have a very low average noise level.

This features of non-inflammability, limited size, etc., mean a reduction in the plant’s general costs and therefore makes this kind of transformer competitive and advantageous compared to the traditional solutions.
2.0 - REFERENCE STANDARDS

The cast resin transformer has been designed and manufactured by Power. Sp.zo.o. in order to meet international IEC Standards requirements in force at the moment of its manufacturing (unless different agreement) as well as to meet the client specifications.

- **CEI EN 60076-1** - Power Transformers – Section 1: Generality
- **CEI EN 60076-2** - Power Transformers – Section 2: Heating
- **CEI EN 60076-3** - Power Transformers – Section 3: Insulation levels, dielectric tests and insulation air distances
- **CEI EN 60076-5** - Power Transformers – Section 5: Short circuit withstand test
- **CEI EN 60076-10** - Power Transformers – Section 10: Determination of transformer
- **CEI EN 60076-11** - Power Transformers – Section 11: Dry - Type power transformers
- **CEI EN 61378-1** - Converter transformers – Section 1 : Transformers for industrial application
- **CEI EN 61378-2** - Converter transformers – Section 2 : Transformers for HVDC application
- **CEI EN 60289** - Reactor
3.0 - OUTLINE OF THE TRANSFORMERS AND THE ACCESSORIES

The complete equipment consists of the windings, the magnetic core, the clamping/support structure, the thermal protection systems and, if provided protective enclosures or ancillary devices such as fans.

IMPORTANT: NOTES AND DRAWINGS CONTAINED HEREIN MAY DIFFER IN ASPECT FROM THE DESIGN DELIVERED. THEY ARE FOR REFERENCE ONLY AND ARE SUBJECT TO CHANGE WITHOUT NOTICE.

Figure 1 – Transformer complete with standard accessories
STANDARD COMPONENTS AND ACCESSORIES

1) Low Voltage Output Bars
2) Lifting Eyebolts
3) Lamination Holder
4) Windings Pressure Plugs
5) Primary Voltage Regulating Tapping
6) High Voltage Windings
7) Eyebolts for Horizontal Movement
8) Earthing Terminal
9) Magnetic Core
10) Centralization Auxiliary Box
11) Data Plate
12) Low Voltage Windings
13) Thermal Sensors
14) Medium Voltage Output Insulator
15) Orthogonal Revolving Wheels

OPTIONAL COMPONENTS AND ACCESSORIES

- Tangential fans
- Metallic screen between primary and secondary connected to the ground
- Thermo-controller
- Enclosure
- Anti vibration pads for wheels
4.0 – RECEPTION, HANDLING AND STORAGE

4.1 – RECEPTION

The transformer is generally supplied totally assembled and ready to be connected to the medium and low voltage line. According to the specification, the transformer is shipped with a polythene protection, or packed into wooden cage, for protection against dust, rain or excessive dampness, or finally packed into a wooden case for over-sea shipments.

On receipt of the transformer, both at the client's plants or site, it is necessary to carry out the following checks:

- To check there are not signs of damage on the packing or the transformer occurred probably during the transport.
- The characteristics of the transformer detailed on the rating plate must correspond to those of the shipping documents and with those of the test report, which is attached to the transformer.
- To check that each transformer is complete with the accessories foreseen in the contract (wheels, thermo-controller etc.).

Before unpacking the transformer, especially during winter period when the temperature difference between the room and the outdoor is considerable, it is necessary to wait for a period of at least 8-24 hours in such a way that the temperature of the transformer has the necessary time for reaching that of the room, in order to avoid water condensation on the coils surface.

**IMPORTANT:** In case any anomalies are found, please contact immediately the manufacturer. If within 5 days there will be no notification of anomalies or defects, it can be considered that the transformer has been delivered in perfect conditions. The manufacturer, therefore, cannot be considered responsible neither for what could happen to the transformer during service nor for the eventual consequences.
4.2 – HANDLING

Before setting up, check that the medium voltage coils have not been damaged during transport or storage.

For lifting, the upper frame of the transformer is complete with n. 4 lifting eyes for slings. Lift with a maximum sling angle of 60°.

For movement by forklift the position of the forks under the bottom clamping profile has to be as far apart as practicable. Has to be lift only a small amount above the floor surface at all times during transit.
**IMPORTANT:** The transformer cannot be moved pushing the coils and the connections.

![Figure 3 – Wrong manual handling](image)

4.3 – STORAGE

The transformer must be stored in a sheltered, clean and dry ambient maintaining the packing up to the installation.

**IMPORTANT:** Wide temperature changes must be avoided. If the level of humidity is excessive then the use of local heaters and/or silica gel (dehydration) crystals is recommended. The storage temperature must not be lower than -25°C.
5.0 – INSTALLATION

Installation of this equipment must be done in full compliance with relevant to local regulations of installation and all work must be carried out by suitably qualified personnel.

5.1 – SITE PREPARATION

The equipment is designed for indoor installation. It must only be operated in a clean, dust free environment, protected from direct sunlight, rain, snow and contamination.

Ensure that the floor of the room is capable of supporting the weight of the equipment. Sufficient space should be left around the perimeter of the transformer to ensure:
- Ease of installation, cable connection and maintenance
- To maintain adequate circulation of free cooling air
- To maintain minimum electrical clearance in line with local safety standards.

Special consideration should be given to the installation of any transformer if noise is a factor in its location and operation. Many locations can result in an amplification of the sound level.

5.2 – STANDARD INSTALLATION CONDITIONS

The maximum height of installation must not exceed 1000 m above sea level.

When the transformer is in service, the ambient temperature of the room must be within -25°C ÷ +40°C limits.

IMPORTANT: In case the height of the place of installation and/or the ambient temperature values are higher than the ones specified above, it is necessary to specify it at the ordering stage since a particular dimensioning of the transformer depends upon these values.
5.3 – WORKING TEMPERATURE

The electric current passing through the windings, and the effect of the core magnetizing current produce electrical loss resulting in localized heating of the core and windings.

The transformer is designed in such a way that natural cooling maintains the transformer temperature under the maximum values foreseen by the standards. In order to avoid temperature accumulation in the room where the transformer is installed, it is necessary to provide suitable ventilation.

The working temperature of the units change according to the insulation and the climatic class as per IEC 60076-11 and are indicated in the Table I:

<table>
<thead>
<tr>
<th>INSULATION CLASS</th>
<th>RANGE TEMPERATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>From -25 to 120°C</td>
</tr>
<tr>
<td>F</td>
<td>From -25 to 155°C</td>
</tr>
<tr>
<td>H</td>
<td>From -25 to 180°C</td>
</tr>
</tbody>
</table>

Table I

For connecting and setting the thermo-controller against over temperature, please read the relative manual attached to the same.

For the regulation we suggest the values showed on the Table II:

<table>
<thead>
<tr>
<th>INSULATION CLASS</th>
<th>ALARM</th>
<th>TRIPPING</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>120°C</td>
<td>130°C</td>
</tr>
<tr>
<td>F</td>
<td>140°C</td>
<td>150°C</td>
</tr>
<tr>
<td>H</td>
<td>160°C</td>
<td>170°C</td>
</tr>
</tbody>
</table>

Table II

5.4 – VENTILATION

In order to make optimum use of the full transformer rating it is essential that the losses produced by the core and the windings are effectively removed. Obstructions around the transformer or adjacent to the enclosure ventilation openings which could restrict airflow must be avoided.

In the room where the transformer is installed, it is necessary to install air...
louvers sufficient to dissipate the heat during service, in order to guarantee the standard service conditions and to prevent the transformer from exceeding the over temperature limits.

Forced cooling is necessary in the following cases:
- Frequent overloading
- Low-dimensioned room
- Room scarcely ventilated
- Medium daily temperature higher than 30°C

The forced cooling can be realized by means of:
- Tangential fans (Figure 4), installed directly during the manufacturing stage or added successively at site, dimensioned as function of transformer power and of the over-temperature to be dissipated

![Figure 4 – Tangential bar](image)

### 5.5 – INSULATION DISTANCES

The transformer supplied for service without enclosure (IP00) must be installed in the relative room respecting the insulating distances according the Table III:

<table>
<thead>
<tr>
<th>RATED VOLTAGE (kV)</th>
<th>DISTANCE FROM THE WALL (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7,2</td>
<td>300</td>
</tr>
<tr>
<td>12</td>
<td>300</td>
</tr>
<tr>
<td>17,5</td>
<td>300</td>
</tr>
<tr>
<td>24</td>
<td>300</td>
</tr>
<tr>
<td>36</td>
<td>320</td>
</tr>
</tbody>
</table>

Table III
While the transformer is working it is necessary to observe a minimum distance among the active parts of the transformer, the surrounding metal masses and other elements of the device, according to the IEC 60076-3 standards. Table VI shows the minimum insulation distances to be respected:

<table>
<thead>
<tr>
<th>RATED VOLTAGE (kV)</th>
<th>NOMINAL VOLTAGE AT SERVICE INDUSTRIAL FREQUENCY (kV)</th>
<th>NOMINAL VOLTAGE AT CREST VALUE ATMOSPHERICAL PULSES (kV)</th>
<th>AIR MINIMUM DISTANCE (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7,2</td>
<td>20</td>
<td>40</td>
<td>7</td>
</tr>
<tr>
<td>12</td>
<td>28</td>
<td>60</td>
<td>9</td>
</tr>
<tr>
<td>17,5</td>
<td>38</td>
<td>75</td>
<td>12</td>
</tr>
<tr>
<td>24</td>
<td>50</td>
<td>95</td>
<td>16</td>
</tr>
<tr>
<td>36</td>
<td>70</td>
<td>145</td>
<td>30</td>
</tr>
</tbody>
</table>

Table VI

IMPORTANT: it must be remembered that the resin be considered as a part under voltage.

5.6 – VISUAL INSPECTIONS

Before energizing the unit, it is necessary to verify that no material is blocked in the channels or in proximity of active parts as it could seriously damage the unit. In fact, it is possible that during the operations of installation and connection, or during storage, bolts, nuts, washers or other material coming from the surrounding equipments, remain stopped in the winding channels.

IMPORTANT: It is well advised that after a storing or a stoppage, to clean the MV and LV windings eliminate all dust, condensation and dirt blowing dried compressed air or wiping them with a dry cloth.

5.7 – MECHANICAL AND ELECTRICAL CONTROLS

Before energising the unit, an inspection should be carried out in order to guarantee a proper installation and connection of the transformer.
The following points must be carefully examined:

- Clean the MV and LV windings and the channels from dust and dirt by blowing dried compressed air or wiping them with a dry cloth
- Pre-heat the transformer in case of condensation with an oven or energizing it at no-load
- Check the good tightening of the MV and LV windings, of the terminal connection and the adjustment plates
- Check the MV and LV windings to be concentric to the magnetic core
- Check the tie rods to the core or to the mass
- Check all the protection devices of the transformer against possible overvoltage
- Check the position of the connection bar on the tapping board. This must be the same on the three MV windings and must coincide with the specified feeding and loading voltages. If the voltage is higher than allowed by the tapping intake, the no-load losses and the noise will be higher
- Check all metallic parts to be at the safety insulation distances from all active parts
- It is absolutely prohibited to put in contact MV and/or LV cables, metallic parts with the windings
- Check the good tightening of the bolts, nuts and tie rods in case the transport would be characterized by continuous loadings and unloading for an exact mechanical tightening see the information included in this manual.

**IMPORTANT:** In case a transformer is put into service after a long storage period, or after a long de-energised period, it will be necessary to clean the HV/LV windings from eventual dust, condensate and dirt, by means of dry compressed air jets and dry cloth.

It is recommended, finally, to carry out always a visual check of the transformer in order to verify any unlikely presence on the surface and inside the cooling ducts.
5.8 – EARTHING CONNECTIONS, TAPS AND PROTECTION POSITION

Power. Sp.zo.o. is not responsible for the transformer installation. The installation must be carried out according to the standards in force, to the applicable laws and to the present instructions. The following points must be taken into consideration when the installation is carried out:

- To connect the earthing conductors to the relative earth points on the metallic parts of the transformer and enclosure.
- To connect the LV neutral to earth when required or when required by the protection system to earth.
- To connect the thermal protection to the control system according to the sketch as shown in the thermal protection relay manual (thermo-controller).
- To ensure that the connection means of the primary winding are safely bolted.
- To ensure that the voltage regulation taps are safely bolted, and if necessary modify the position as a function of the supply voltage.
- In case of transformers with double ratio, please be sure that the link corresponding to the voltage of the system feeding the transformer is properly connected.

5.9 – MV AND LV CONNECTIONS

The cables and the bus bars which are connected to the transformer must be duly fixed to avoid any mechanical stress on the LV and HV transformer terminals.

Both upper and bottom cable connections can be performed, being sure, however, to respect the configuration showed in the Figure 5 and 6. In case the connections arrive from the bottom please ensure that there is sufficient depth for the minimum radius of curvature of the cables.
5.10 – REGULATION OF TRANSFORMER RATIO

When it is necessary to adapt the transformation ratio to the feeding voltage proceed according to the following indications:

- Disconnect the unit from the mains on both medium and low voltage and connect it to ground
- Connect the tapping plates in the most suitable position according to the feeding voltage
- Re-connect the transformer to the mains.

5.10.1 – MV WINDING ADJUSTMENT ON SINGLE VOLTAGE

In order to obtain the secondary voltage variation, act on the primary winding adding or taking off turns. See figure 7 for standard tapping on our
transformers.
The plate shown on the right is applied on the transformer to point out the proper position (+5% of the primary voltage correspond a variation of -5% in the secondary voltage) and that the chosen positions must be identical in all the three phases.

5.10.2 – MV WINDING ADJUSTMENT ON DOUBLE VOLTAGE

In case of two primary voltages - for example 10-20 kV -, two adjustment units are required.
The voltages variation is obtained by putting the windings in line or parallel as shown in Figure 8.
Special attention must be paid whether the two primary voltages are 8.4-20 kV; in this case it is necessary an attentive examination of an exact connection of the change voltage terminals.

5.11 – CONNECTION IN PARALLEL MORE TRANSFORMERS

If the transformer must be connected in parallel with other transformers, please verify the total compatibility of the voltage ratio and of the conditions stated by the IEC 60076-1 standards, and particularly:
- Identical voltage ratio
- Identical frequency of functioning
- Identical vector group
- Identical short circuit voltage (tolerance ± 10%)
6 – TRANSFORMER PROTECTION

6.1 – OVER TEMPERATURE PROTECTION BY THERMO-CONTROLLER

Our company can supply two different types of control devices, allowing the visual and acoustic inspection and the possibility to trip. For normal applications the tripping temperature for alarm is according to the STANDARDS and specifically indicated in this handbook.

The devices illustrated are:
- Electronic device with control PTC sensors
- Electronic device with control PT100 sensors

6.1.1 – ELECTRONIC DEVICE WITH CONTROL PTC SENSORS

The electronic device for thermo contacts visualise the central phase temperature allowing at the same time to control the winding temperatures, by means of 3+3 thermal contacts, normally opened or closed and set for alarm and trip.

Electronic device for temperature control with thermal contacts figure 05 and electronic device for PTC sensors Figure 7:

Figure 7 – PTC scheme
6.1.2 – ELECTRONIC DEVICE WITH CONTROL PT100 SENSORS

The function of this device is to control the temperatures of all the three phases and, if required, of the core. The electronic temperature control is obtained by means of PT100 sensors -100 Ohm at 0°C-. The electronic device shows the highest temperature of the transformer; however, the operator can check the temperature of all three phases. The function of warning and tripping is obtained by means of electrical output contacts -Opening/Closing- according to the diagram Figure 8. The operation temperatures can be set by the operator, but normally it is set at 140°C for warning and 150°C for tripping. On the electronic device it is also installed an output contact for signalling sensor's faults and for starting possible cooling fans (5A-250V).

![PT100 scheme](image)

Figure 8 – PT100 scheme

6.2 – OVERLOADING AND SHORT CIRCUIT PROTECTION

According to the parameters of the standards CEI EN shown at point 2, the transformer is designed and manufactured in such a way to withstand limited abnormal situation of over-voltages, overloading and short circuit on the secondary windings. Therefore, the transformer must be protected against thermal and dynamic effects caused by continuous overloading and secondary short circuits by means of an automatic switch or suitable fuses, able to disconnect the transformer in case of current flow higher than the one fixed to the protection.
The protections setting and/or the choice of fuses HV and LV side, must be carried out taking into consideration the primary and secondary rated currents stated in the transformer rating plate, taking also into consideration that when we feed the transformer, a very high magnetizing current is established on the primary, by means of variable starting from a minimum of 10 times the rated current (in the worst conditions of insertion depending from the instant when the feeding circuit is closed, from the electric characteristics of the feeding network, from the reactance and resistance values of the circuit network-transformer, the insertion current can reach also 20 times the rated current), even if the automatic switch located on the secondary is open and therefore without loading.

Therefore, it is necessary to duly set the relay of maximum current HV side, in current and time value, by introducing a little delay (approx. some tens of ms), in such a way that the protection relay will not operate. Furthermore, we suggest limiting the number of connections and disconnection of the transformer on the network.

**6.3 – OVERVOLTAGE**

In order to protect the transformers against over-voltages at industrial frequencies or the ones due to atmospheric origin, it is recommended that voltage surge arrester with variable resistance are used. The characteristics of the surge arresters depend on the transformer insulation level and from the characteristics of the distribution system.
7.0 – MAINTENANCE

7.1 – ORDINARY MAINTENANCE

A careful check of the transformer during its functioning will prevent damage and prolong its life.
In standard service conditions it is sufficient to perform, at least once per year, the following operations:

- Cleaning of the HV/LV windings from eventual dust, condensate and dirt, by means of dry compressed air jets and dry cloths
- Cleaning of the cooling and ventilation ducts between the coils in order to avoid overheating during service
- Verify of tightening of the HV and LV connections, of the voltage tap-changer links and of the bolts (yoke and spacer blocks)
- Check the correct functioning of the thermal protection (thermo-resistances and thermo-controller) as well as of the correct intervention of the overloading and short-circuit protection and tripping of the corresponding automatic switch. This check must be carried out preferably by means of suitable equipment that will allow the simulation of the real damage.

**IMPORTANT:** In case it is found absences, which cannot be eliminated, please contact immediately our Assistance Service.

7.2 – ORDINARY MAINTENANCE

In case the transformer function in a discontinuous way, before the commissioning, especially after a long stop, it is necessary to perform the entire checks prior the commissioning listed on point 5.6 and 5.7.
In case the transformer during its operation has withstood exceptional events such as: short circuits, atmospheric or operational over-voltages, overflowing, or other exceptional events, before energizing it once again, you are requested to call for our service.
7.3 – WARRANTY

All the machines are guaranteed for a time period in accordance with the agreement from the delivery date.