TRANSFORMERS & BUSWAYS SOLUTIONS

HIGH EFFICIENCY
CAST RESIN
TRANSFORMERS
UP TO 5000 KVA, 36 KV

BAHRA TBS

BAHRA TBS CAST RESIN TRANSFORMERS & BUSWAYS SOLUTIONS

The power solutions for commercial and industrial sector applications

HIGH EFFICIENCY CAST RESIN TRANSFORMERS UP TO 5000 KVA

Bahra TBS high-quality cast resin transformer are the ideal choice for all needs thanks to their different advantages:

- Total safety for the customer, guaranteed by the total absence of combustible products,
- Maximum environmental protection, thanks to the absence of polluting and flammable insulating liquids.
- Energy saving, with the exclusive “reduced loss” range.
- Maximum flexibility straight from the beginning of the installation.

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BAHRA TBS FACTORY OVERVIEW

INTEGRATED SOLUTIONS FOR GLOBAL PROJECTS

Bahra Electric began in 2008 and it is a leading manufacturer of an extensive range of electricity distribution products. In 2015, **Bahra Electric** expanded its manufacturing facilities & product range by creating a new factory **"Transformers and Busways Solutions Company"** specialized in producing high efficiency transformers and busways in partnership with **Legrand France** as an initiative to localize the important industries in the kingdom of Saudi Arabia and to become market leader in its industry.
In-line with Kingdom of Saudi vision 2030, **Bahra Electric** has acquired **Transformers and Busways Solutions Company (TBS)** in 2021 and has signed a license agreement with **Legrand France SA** permitting to use the existing designs and knowhow. **Bahra Electric** has crafted the new brand of TBS to be a **Bahra TBS.**

Bahra TBS is spread across 50,000 sq m area equipped with state-of-the-art latest European & Italian technology with complete backward process integration including epoxy casting and tinning. The manufacturing facility have implemented the Integrated Management Systems: ISO 9001, ISO 14001 & ISO 45001 as well as SASO mark.

IEC & ISO 9001
QUALITY PRODUCTS

Our design and R&D have broken new ground in transformers systems. The Design and Quality of every single product is overseen by Bahra TBS.

State of the art manufacturing processes guarantee long lasting quality. Standard options for protection and temperature management are used according to specific installation needs.

Certifications:

- IEC 60076 / IEC 60068-3-3
- IEC 60529
- IEC 60616 / IEC 61378 / IEC 62032
- Seismic
- SASO

CUSTOMER SUPPORT
FULL FLEDGED SERVICE

We persist on providing our customers ultimate services starting from the begining of the project all the way to the final installation and onwards

Complete customer service:

- Customizable solutions
- Technical and training support
- Project design
- On-site surveys
- Validated accurate measurements
- Plans and drawings verifications
- Fast deliveries and lead time
- Product warranty
- After Sales support

QUALITY CONTROL
IN-HOUSE TESTING

- Windings Resistance Measurement
- Transformer Ratio Measurement and Check of the Polarity
- Impedance Voltage and Load Losses Measurement
- No load Current and Losses Measurement
- Insulation Test with Applied Voltage
- Insulation Test with Induced Voltage
- Partial Discharge Measurement
- Lightning Impulse Withstand Measurement
- Temperature Rise Test
- Noise Level and Noise Pressure Measurement
- Dielectric test

Details matter. At TBS you can rest assured that your project is managed and executed in a professional manner. Every single detail is important. A full-fledged team of experts overlook your projects from the very beginning of the design stage all the way to the testing and commissioning and even after the handing over of your project.

Design Support

We provide consultants a design support from the very beginning. Our design department is able to make solid electrical systems covering every detail of your requirements.

Technical Support

Our skilled technical expertise is at your disposal for consultation, training, orientation and support during the course of your project. We conduct regular training courses.

Product Availability

Our factory along with our wide network of partners and distributors in the Middle East region ensure a sustainable product availability to secure fast deliveries, efficient logistics alteration.

Testing & Commissioning

We cover all preliminary tests and inspections, functional performance tests and the supervision of commissioning of busways & transformers.

After Sales Service

A vast team of technical experts within Bahra TBS and our partners' teams are at your disposal for extending full After Sales Support meeting your expectations.

Technical Support at your service

Bahra TBS with its innovation and cutting-edge technology continue setting up latest trends in the market which enables us to meet the needs of our customers. You can be assured that your project is handled in the most efficient and professional manner meeting the industry standards and specifications.

We have all the necessary resources used to keep pace with market trends through our:

- Technical expertise - capable of providing the most practical and cost effective solutions for projects of any size.
- Bahra TBS Design office - supports customers throughout every step of their project providing a single contact, which is competent and easy to reach.
- Strong presence and experience of all our partners and distributors in the market.

CAST RESIN TRANSFORMERS

BAHRA TBS PRODUCT OFFER

HIGH EFFICIENCY CAST RESIN TRANSFORMERS UP TO 5000 KVA

Bahra TBS range of cast resin transformers is wide and can respond to market's needs, by proposing standard products and special and customized products following specific request.

INSTALLATION SIMPLIFICATION

- reduction of the overall dimensions
- reduction of expensive construction achievements, absence of fire-resistant separation barriers possibility of installation inside buildings, including places attended by people
- immediate integration with Bahra TBS busbars trunking systems (connection kit).

FLEXIBILITY DURING USAGE

- it is possible to increase the delivered power through the application of special ventilation systems, to be used when dealing with particular operating situations (temporary overloads or high environmental temperatures)
- no maintenance is required in addition to the standard periodic checks.

REDUCTION OF THE ENVIRONMENTAL IMPACT

- low fire hazard
- no risk of insulating fluid leakages into the environment
- possibility of retrieving end-of-life materials
- availability of a "reduced loss" range (energy saving)

APPLICATIONS

- Service Sector
- Data Center
- Infrastructures
- Industry
- Conversion and Rectification
- Railways & Tramways
- Marine Applications

Bahra TBS Cast Resin Transformers (Main Features)

RANGES:
- **NL** — Normal losses
- **RL** — Reduced losses (High Efficiency)[1]

Materials of Windings: Copper/Aluminum[2]

- Rating (kVA): **100-5000**
- Frequency (Hz): **50/60**
- Tapping links, HV side: **± 2 x 2.5%**
- Thermal class of the insulating system: **155 °C (F) / 155 °C (F)**[3]
- Partial Discharge **<10 pC**
- Cooling: AN/AF
- Temperature rise: **100/100 K***

***Available on request temperature rise 80k, 90k, etc.**

COMPLIANCE
- IEC 60076-11 / IEC 60068-3-3
- IEC 60529
- IEC 60616

CERTIFICATIONS
- Fully Type tested
- E2-C2-F1 Certified
- SASO
- Seismic

PROTECTION ENCLOSURE
- IP-23/31[4]

12 kV INSULATION CLASS
- Primary voltages (kV): **6-10-11.** Insulation class: **12 kV BIL 60 kV/75 kV**

17.5 kV INSULATION CLASS
- Primary voltages (kV): **12-13.8-15.** Insulation class: **17.5 kV BIL 75 kV/95 kV**

24 kV INSULATION CLASS
- Primary voltages (kV): **20-23.** Insulation class: **24 kV BIL 95 kV/125kV**

36 kV INSULATION CLASS
- Primary voltages (kV): **25-33.** Insulation class: **36 kV BIL 170 kV**

[1]Reduced Losses Bahra TBS Transformers-HE I High Efficiency I available upon request [2]At request special version (Cu/Al and Al/Cu I [3]Class H available on request [4]Other IP available on request

CESI/KEMA | Type Tested | E2 C2 F1 | Cu/Al | Global Presence

CAST RESIN TRANSFORMERS

BAHRA TBS PRODUCT OFFER

Bahra TBS high-quality cast resin transformer is the ideal choice for all needs.

Using technical, state of the art solutions and materials of the highest quality, Bahra TBS cast resin transformers can grant many advantages: total safety for the customer, guaranteed by the total absence of combustible products; maximum environmental protection, thanks to the absence of polluting and inflammable insulating liquids.

Unlike the oil solution, a cast resin transformer does not require additional building structures (eg. pool for oil leaks), thus guaranteeing the maximum practicality and flexibility straight from the beginning of the installation.

Furthermore, no cooling fluids are used, hence minimizing maintenance costs and risk in
case of fire.

STANDARD PRODUCTION:

Distribution transformers

- Rated power: ***100 – 3150 kVA***
- Primary rated voltage: ***up to 36kV***
- Secondary rated voltage: ***up to 1000V***

SPECIAL PRODUCTION:

Special transformers

- Rated power: ***up to 5 MVA***
- Primary insulation level: ***up to 36kV***
- Secondary insulation level: ***on request***

STANDARD EQUIPMENT

- HV terminals (n°3 pieces)
- LV bar terminals (n°4 pieces)
- Off load tapping links (n°3 pieces)
- Rating plate (n°1 pieces)
- Lifting lugs (n°4 pieces)
- Earth terminals (n°2 pieces)
- Orientable rollers (n°4 pieces)

MATERIALS OF WINDINGS

- **Copper (Cu) & Aluminum (Al)**
  at request special version (Cu/Al and Al/Cu)

ACCESSORIES (on request)

- Pt100 thermosensors with connection box
- PTC thermistors (as an alternative to the Pt100 thermosensors)
- Electronic unit for thermal control, with inputs for Pt100 and temperature display
- Electronic unit for thermal control, with inputs for PTC, without temperature display
- Forced ventilation systems (for temporary power increase)
- Electronic unit for ventilation system
- Transformer protective enclosure (degree protection IP23 & IP31)
- Surge arresters kit
- Antivibration pads

Special:

- HV terminals for plug-in connections (Elastimold)
- Antiseismic frame (in base of level of earthquake)
- OLTC (On-Load Tap-Changers)
- CT and VT instrument transformer

Cast resin transformers manufactured by Bahra TBS comply with respect the European directive 76/769/EC about the restriction on the sale and use of certain dangerous substance and preparations.

CHOICE OF TRANSFORMERS

WHY BAHRA TBS CAST RESIN TRANSFORMERS?

High-Voltage transformers are generally classified in three types depending on their construction. Features comparisons between cast resin and oil transformers are below described.

Three types of transformer are present on the market:

- Cast Resin Transformers
- Air insulated transformers
- Oil transformers

Transformers are available on the market in different constructional technologies which have a considerable influence on the electrical properties and the fields of application.
To correctly select the type of transformer it is necessary to know its different electrical and thermal properties and the resistance to stresses due to faults or normal service of the transformer itself. The transformer manufacturing technology thus also determines the selection of the adequate protection.
Another key parameter, when selecting the transformer, is the type of operation for which it is intended.

Technical comparison

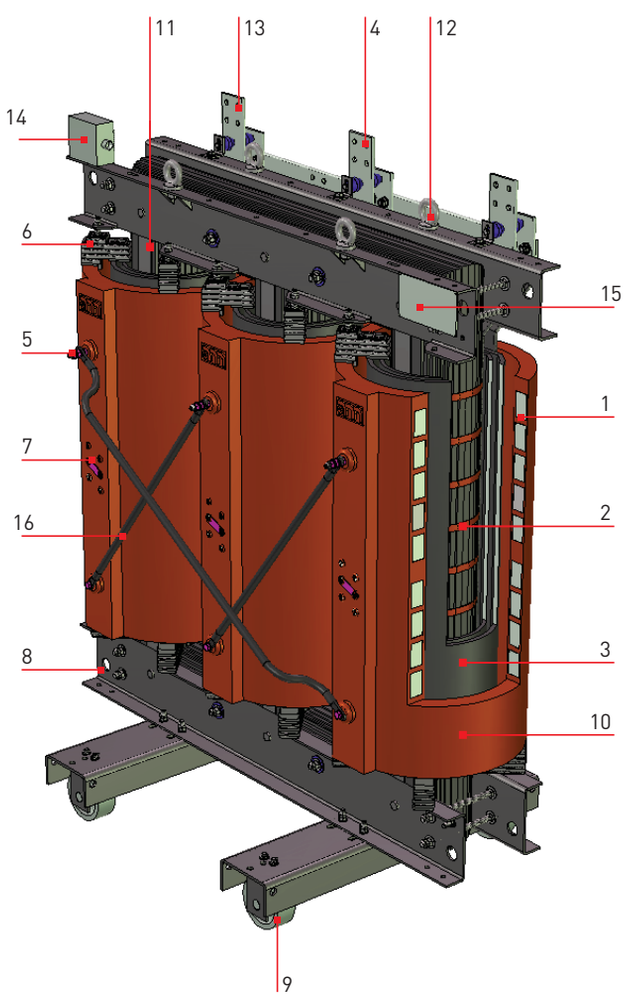
Properties	Resin	Oil	Air
			
Inflammability	NO	YES	YES
Self-extinguishing in the case of an electric fault	YES	NO	NO
Need for anti-fire structures such as oil collection pit and anti-flame walls	NO	YES	YES
Hygroscopicity of the insulation materials	NO	YES	YES
Environmental pollution	NO	YES	NO
Strip windings and good resistance to short-circuit	YES	NO	NO
Stability of the heating element to short-circuit over the machine lifetime	YES	NO	NO
Special commissioning procedures	NO	NO	YES
Regular maintenance	NO	YES	YES
Risks of environmental pollution because of leak of liquid	NO	YES	NO
Deterioration of the dielectric properties because of the effect of time and environmental effects	NO	YES	YES
Lack of sensitivity to humid, saline and tropical environments	YES	YES	NO
Location at the centre of gravity of the load and reduction of system and management costs	YES	NO	NO
Reliability when not maintained and when labour specialised in installation is not readily available	YES	NO	NO
Capacity of withstanding high instantaneous overloads of short duration thanks to the lower current density and high thermal constant	YES	NO	NO

BAHRA TBS TECHNOLOGY

HIGH QUALITY PRODUCTION

Bahra TBS is recognized for its high-quality production. Using state of the art constructional techniques and equipment, constant attention throughout the production process (ISO 9001:2008) and rigorous checks in the final phase, Bahra TBS guarantees quality for 100% of the production.

1. HV windings:
   made of copper or Aluminum strip coils and cast in resin under vacuum.
2. Core in three columns made of magnetic steel laminations with high-permeability oriented crystals, available with different level of losses.
3. LV windings:
   made of copper or Aluminum strip foil impregnated in resin under vacuum.
4. LV connections upwards (standard) or downwards version (on request).
5. HV connections upwards (standard) or downwards version (on request).
6. Rubber inserts attenuate the transmission of vibrations between core and windings and reduce to a minimum the operating noise generated by the transformer as well as absorbing the thermal expansion of the components.
7. Off-load tapping links on the HV side to adapt the primary voltage to the mains, which can be set with transformer switched OFF.
8. Structure, core and carriage, made in strong painted sheet steel (available on request hot – dip galvanized)
9. Carriage with bi-directional rollers. The carriage allows safe movement and is pre-equipped for the mounting of an IP reinforced boxes.
10. HV epoxy resin insulation makes the transformer suitable for low maintenance. Class 155°C (F) insulating material, withstanding a temperature rise of 100K.
11. The operating temperature is checked by Pt100 sensor or PTC which are mounted in the LV windings.
12. Lifting eyebolts conform to the DIN-580 standards with safety hooking at 4 points.
13. LV terminals with optional pre-equipment for connection of the LV - Bahra TBS busbar trunking system.
14. Terminal box for temperature probes
15. Rating plate
16. Delta connection



BAHRA TBS TECHNOLOGY

HIGH QUALITY PRODUCTION

(HV) - HIGH VOLTAGE WINDINGS

The High Voltage windings are manufactured using highly automatic winding machines, constructed using the continuous disk technique, and made of Aluminum/copper strips with a double layer of insulating material. On these disks here will be a glass fibre mesh providing static support to the winding.

The winding will then be enclosed in a vacuum mould with epoxy resin with the addition of inner charges and alumina, in order to guarantee the F1 fire behaviour set in the IEC 60076-11 standard.

The thermal class for the insulating materials used will be class 155°C (F): the consequent permitted over temperature shall be 100 K, in accordance with IEC 60076-11 standard.

Modern electronically controlled winding machines

HV strip winding machine.

(LV) - LOW VOLTAGE WINDINGS

The Low Voltage windings, made of one single/double Aluminum/Copper foil, has a height equal to the height of the HV winding, with an insulating sheet made of polyester material. All weldings between the Aluminum foil and the Aluminum* LV terminals are butt welded, executed in inert atmosphere under electronic control, avoiding the formation of any material deposits that may potentially affect or damage the insulation between the output end and the next layer.

LV winding shall then be impregnated by resin under vacuum. Afterwards, it is polymerized, forming a unique compact cylinder resistant to the axial and radial electro-dynamic stresses that may occur during short circuits in the downstream circuits powered by the transformer. Insulations using pre-impregnated (Pre-preg and similar) materials are not permitted.
The thermal class for the insulating materials used in low voltage coils shall be class 155°C (F): the consequent permitted over temperature shall be 100 K, in accordance with EN60076-11 standard.

LV Winding machine

Vacuum pressure impregnation plant

ASSEMBLING OF THE WINDINGS

HV and LV windings are assembled one inside the other, around the column of the magnetic core. The Primary winding shall be mounted outwards.

Appropriate spacers keep constant distances between the core and the secondary winding, and between the secondary winding and the primary winding, in order to avoid magnetic stress due to dangerous geometrical dissymmetry.

Core coils assembly

BAHRA TBS TECHNOLOGY

HIGH QUALITY PRODUCTION

TERMINALS HV AND LV

HV terminals, connected to the winding, are made of brass pins protruding from the resin, in order to:

• facilitate connection to the HV cables, irrespective of their direction of entry
• avoid galvanic couplings among the various materials that may coexist in the connection

The delta connection between the HV windings are completed using copper rod to ensure that the relative positions and the performances remain unchanged over a long period of time.

The **LV terminals**, welded to the layer across the overall height of the coil are on the top section of the transformer (at the bottom only when clearly requested), and are made of flat Aluminum profile suitable for the connection of tin plated copper lugs.

example of HV terminals

example of LV terminals

MAGNETIC CORE

The three-column magnetic core is made of magnetic Grain-Oriented steel sheet.

At the junctions between the columns and the yoke, the sheets are cut at 45° following the step-lap procedure, to reduce the corresponding air gaps as much as possible.

A disconnectable equipotential connection is guaranteed between the metal structure and the magnetic sheet packet.

All the magnetic cores are protected against corrosion by black non-hygroscopic paints (RAL 9005), with minimum thickness >100 µm (microns).

BAHRA TBS TECHNOLOGY

SERVICE CONDITIONS

Bahra TBS includes a range that can also be used under severe environmental conditions. The standard installation is carried out indoors, protected from direct sunlight and with normal industrial atmosphere. The transformers, in standard configuration, are capable of withstand seismic disturbance with ground acceleration level ***up to 0,2g****.
The transformers are capable of withstanding the following environmental conditions during storage, transport, and use.

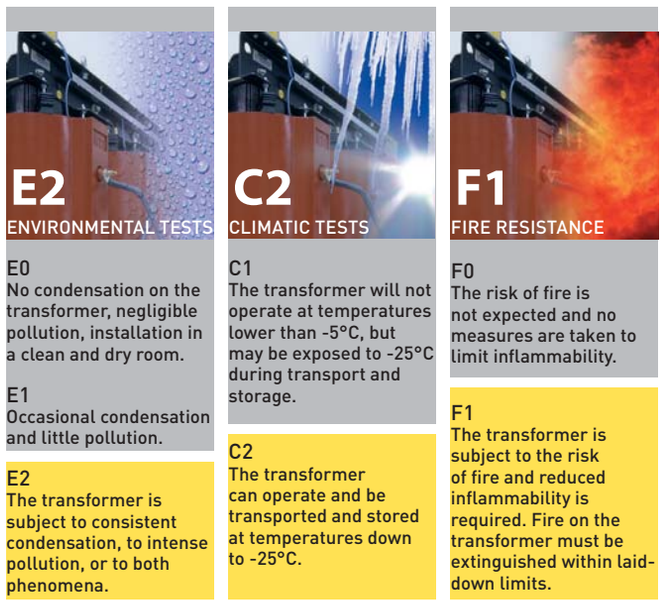
*** g=9,81m/s² (gravity acceleration)**

- minimum ambient temperature: -25°C
- maximum ambient temperature: 40°C*
- maximum relative humidity: 93%

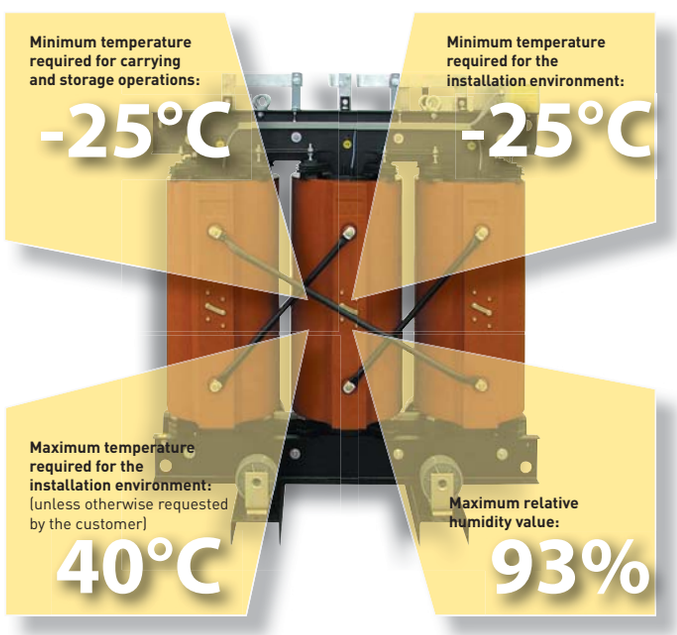
Note: * Up to 60°C, upon customer request

Standard IEC 60076-11 uses an alphanumeric code to identify the environmental, climatic and fire behaviour classes of dry-type cast resin transformers.
The whole Bahra TBS range can also be used to withstand the most severe conditions:

- Environmental class E2
- Climatic class C2
- Fire-behaviour class F1



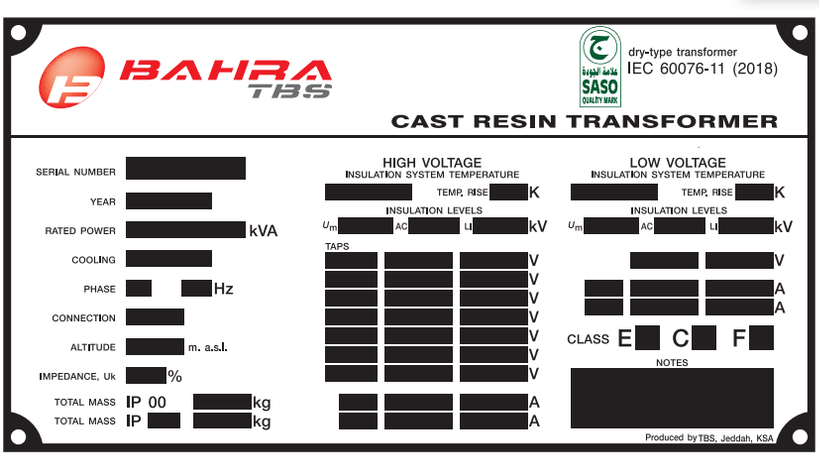
Seismic disturbance, Environmental (E), climatic features (C) and fire resistance (F), the perfect solutions for any condition



CHARACTERISTIC OF RATING PLATE

The rating plate shall be in accordance with IEC/EN 60076-11.

The characters are embossed on the Aluminum rating plate on a contrasting background, to ensure that they remain unaltered and easy to read over a long period of time.



BAHRA TBS TECHNOLOGY

PROTECTION AGAINST TEMPERATURE RISE

During its normal operation a transformer has no-load losses and load losses which generate thermal energy. This energy depends on the construction of the transformer, its power and the installation conditions.
It should be remembered that the transfer of thermal energy is proportional to the temperature difference between the transformer and the room (ambient). At a given room temperature, the transformer temperature depends mainly on the load losses. As the load increases, losses and room temperature increase favouring a more rapid degradation of the insulation materials and thus a higher probability of failure of the dielectric.
This situation could also occur when, with equal losses due to load, the room temperature and consequently the transformer temperature increase. The standards define insulation classes which indicate the maximum temperatures can be reached by the transformers in their normal operation and which must not be exceeded.
Temperature rises depend not only on the load and the overcurrents which may be detected by the protection devices, but also on environmental factors (inefficiency of the cooling system, fault on the forced ventilation and increase of the room temperature) which influence the dissipation of heat produced by the transformer's losses.
For this reason, electronic temperature measuring devices are normally provided. These are necessary to give the alarm or to trigger the transformer protection.
For Bahra TBS transformers the following temperature sensors are available:
Pt100 thermosensors and PTC thermistors.

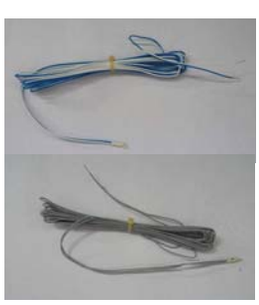
• **Pt100**: supplies a signal proportional to the measured temperature;
• **PTC**: supplies an ON/OFF signal depending on whether the measured temperature is less or more than the sensor's threshold.
The sensors are positioned in the hot point of the winding.
Both the Pt100 and PTC signals must be processed by the temperature control unit, which is not part of the standard equipment.
On request, other accessories to check the temperature are available:

• a separate temperature display, to be installed on the control panel;
• an output relay for alarm and trip and control of the fans.

Terminal box (cast Aluminum) for temperature probes, Pt100 sensor to check the temperature

CHECKING THE TEMPERATURE

The temperature may be checked using Pt100 temperature sensors or thermometers. An alternative solution is to use PTC sensors, which however has the disadvantage that the temperature cannot be displayed.
These systems are used to check the temperature of the low-voltage windings (LV).
For transformers for the supply of static current converters, the temperature of the magnetic core should also be checked.



PTC sensors

Pt100 sensors

USING PTC SENSORS

In three-phase transformers, the checking system is made of three sensors, one per phase, connected in series.
The sensors are just resistances which send the release signal to a relay when the reaction temperature threshold is exceeded.
The sensor working conditions are quickly reset when the temperature drops 3K below the threshold. When there are two monitoring systems, one gives the alarm signal and the other the release.
The temperature values of the two systems deviate by 20K. When the protection relay is fed by the mains served by the transformer, a delayed contact inhibits the alarm and releases signals starting when the transformer is put into service until the relay coil is powered.

BAHRA TBS TECHNOLOGY

VENTILATION OF THE TRANSFORMERS

During service, a transformer generates heat due to losses (fig.1). This heat must be dissipated from the room where the transformer is installed. For this purpose, if the adequate natural ventilation in the room is not sufficient, forced ventilation has to be installed.
IEC 60076-11 standards specify that the ambient temperature of the installation must not exceed the following values:

20°C yearly average
30°C monthly average of the hottest month
40°C at any time

The system protecting against temperature rises must be calibrated based on the max cooling air increase by the max temperature rise.
A good cooling system is obtained when the air current enters from the bottom, crosses the room where the transformer is installed and exits from the top on the opposite part (fig.2).

To evaluate the effectiveness of the **natural ventilation** and to consequently check the section of the ventilation openings and the possible positioning heights, consider the following variables:

TL = total losses in kW
sum of the no load (Po) and load losses (Pk) in kW generated by the CRT referred to 120°C and of the other losses in kW generated by any other equipment in the same room

dT = temperature difference in °C between air inflow (entrance) and outflow (outlet)

Q = airflow through the lower opening in m^3/s

H = distance in metres between the median of the cabin and the median of the upper opening (outlet).

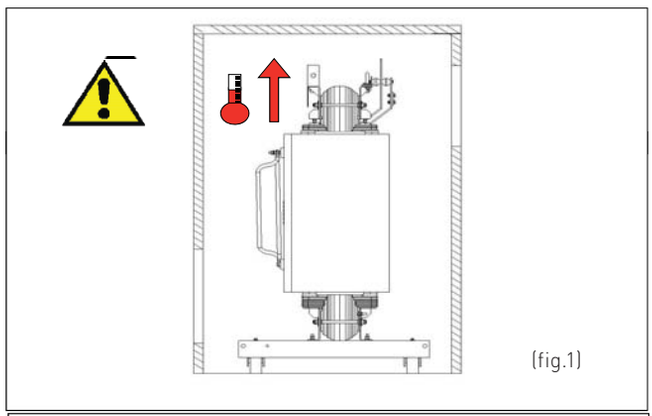
S = net surface on entry in m^2, is the surface of the bottom opening (inflow) in m^2, into which possible, and advisable, grids have to be reduced $[m^3/s]$.

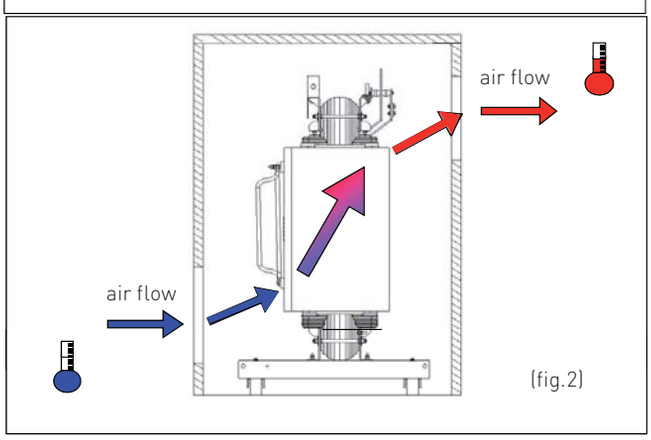
S' = net surface of exit in m^2

TL = Po+Pk [kW]
Q = TL / (1,15 x dT)
S = (10,752 x TL) / √(H x dT³) $[m^2]$

Assuming dT = 15°C, the formula to dimension the inlet opening is:

S = 0,185 x (TL / √ H) $[m^2]$


(fig.1)

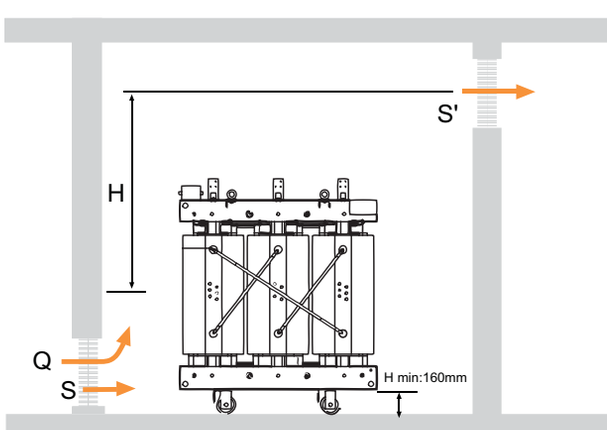


(fig.2)

Formula valid for an average year temperature of 20°C and a height of max 100 mt on sea level.

The outlet opening (S') must be about 15% larger than the inflow (entrance) opening, due to the different density of the air at different temperatures.

S' = S x 1,15 $[m^2]$



Following Table 1 refers to the most frequent cases and gives the advised surface of the bottom openings, related to the kW generated in the room. To ensure a sufficient ventilation, the CRTs have to be positioned at at least 0,5 mt from the walls and from other CRTs.
For CRTs without rollers, it is advisable that they are positioned higher from the floor, to allow a sufficient air flow from the bottom.

- The values in the table refer to the necessary net surface of the windows; the presence of a grid (advisable) reduces the net surface achieved
- For dT different from 15°C multiply the value in the table by √(dT³/58)

If the air flow so calculated cannot be obtained, use ventilation bars, i.e. forced ventilation.

Example of transformer with ventilation bars

Table 1- relating surface S in function of the height of the windows and the total losses in the room.

Total Losses (kW)	Height (m)					
	0.5	1.0	1.5	2.0	2.5	3.0
	S (m^2)					
3,0	0.8	0.6	0.5	0.4	0.4	0.3
4,0	1.0	0.7	0.6	0.5	0.5	0.4
5,0	1.3	0.9	0.8	0.7	0.6	0.5
6,0	1.6	1.1	0.9	0.8	0.7	0.6
7,0	1.8	1.3	1.1	0.9	0.8	0.7
8,0	2.1	1.5	1.2	1.0	0.9	0.9
9,0	2.4	1.7	1.4	1.2	1.1	1.0
10,0	2.6	1.9	1.5	1.3	1.2	1.1
11,0	2.9	2.0	1.7	1.4	1.3	1.2
12,0	3.1	2.2	1.8	1.6	1.4	1.3
13,0	3.4	2.4	2.0	1.7	1.5	1.4
14,0	3.7	2.6	2.1	1.8	1.6	1.5
15,0	3.9	2.8	2.3	2.0	1.8	1.6
16,0	4.2	3.0	2.4	2.1	1.9	1.7
17,0	4.4	3.1	2.6	2.2	2.0	1.8
18,0	4.7	3.3	2.7	2.4	2.1	1.9
19,0	5.0	3.5	2.9	2.5	2.2	2.0
20,0	5.2	3.7	3.0	2.6	2.3	2.1
21,0	5.5	3.9	3.2	2.7	2.5	2.2
22,0	5.8	4.1	3.3	2.9	2.6	2.4
23,0	6.0	4.3	3.5	3.0	2.7	2.5
24,0	6.3	4.4	3.6	3.1	2.8	2.6
25,0	6.5	4.6	3.8	3.3	2.9	2.7
26,0	6.8	4.8	3.9	3.4	3.0	2.8
27,0	7.1	5.0	4.1	3.5	3.2	2.9
28,0	7.3	5.2	4.2	3.7	3.3	3.0
29,0	7.6	5.4	4.4	3.8	3.4	3.1
30,0	7.9	5.6	4.5	3.9	3.5	3.2
31,0	8.1	5.7	4.7	4.1	3.6	3.3
32,0	8.4	5.9	4.8	4.2	3.7	3.4

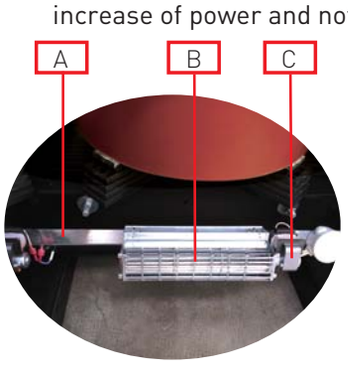
FORCED VENTILATION

Forced ventilation is necessary in the following cases:

- frequent overloads
- small room
- room with poor ventilation / air exchange
- annual average temperature higher than 20 °C

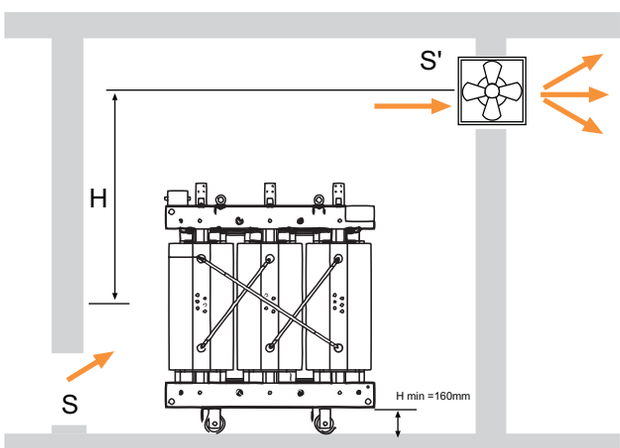
Forced ventilation can be achieved with:

- Ventilation fans (installed directly by the manufacturer, or successively). The fans have to be dimensioned according to the rating of the CRT and the overtemperature to be dissipated.
- If the CRT is fitted with ventilation bars, the expected life of the fans is approx 20.000 hours. After this period fans must be changed. For this reason ventilation bars should be used only for temporary increase of power and not for continuous conditions.



A: Bar for the mechanical fitting of the fans
B: Fans
C: Terminal box for the fans

If the transformer room is small or poorly ventilated, we suggest to use forced ventilation. This is also necessary when the average annual temperature is higher than 20°C or when there are frequent transformer overloads. To avoid affecting the natural convection in the room, an air extractor may be installed in the upper opening, possibly controlled by a thermostat.
Installation of an air extraction system, switched on by a thermostat or directly by the protection relay of the CRT.
Advised air flow is 3,5 - 4,0 m³ / min of fresh air every kW of losses, referred to 120°C



ATTENTION: an unsufficient air flow reduces the expected life of the CRT. Increasing the temperature of the devices can cause the intervention of the protection relay. The user should always specify any operating or ambient condition that could cause restrictions in the availability of ventilation flow. Insufficient air flow reduces the nominal rating of the CRT.

BAHRA TBS TECHNOLOGY

PROTECTION AGAINST OVERVOLTAGES

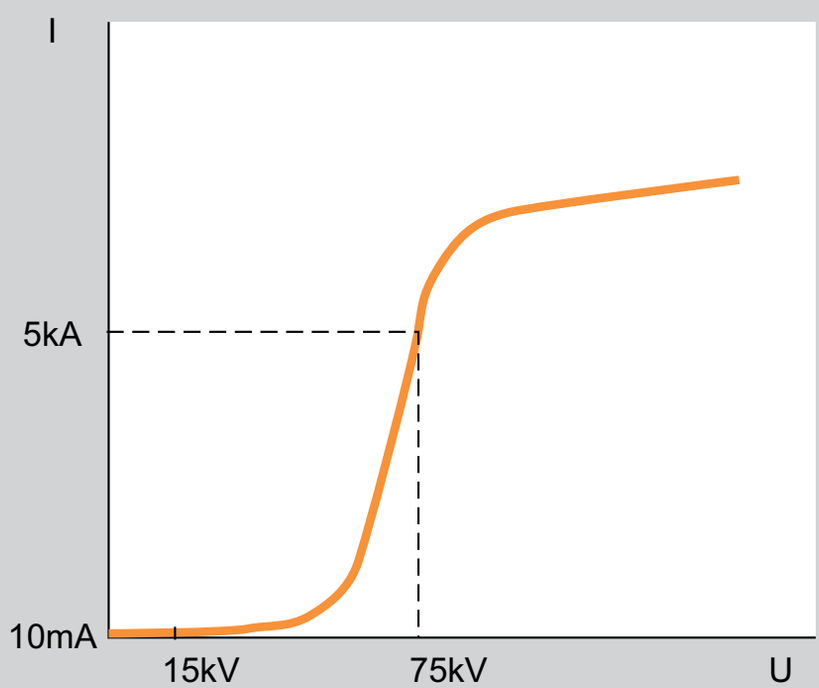
Transformers may be affected by transient induced overvoltages on the net to which they are connected. These overvoltages, due to direct or indirect lightning strikes or to electrical operation on units installed on the LV side, can stress the transformer dielectric causing its rapid ageing and its consequent possible damage as well as failure of the transformer.
The most critical conditions normally occur when the voltage feeding the transformer is cut by non-automatic circuit breakers which interrupt the currents.
The harmful effects of an overvoltage depend on the peak value and the speed variation voltage, being factors leading to an irregular distribution of the stresses in the windings. The risk of exposure to overvoltages is, in the first instance, linked to the place of installation and then to the following factors:

- type of HV distribution network and type of LV network (above or underground);
- whether there are any overvoltage limitation devices;
- length and type of mains/transformer connection;
- type of equipment connected and operation conditions;
- quality of the earth and cabin connections.

Faults caused by overvoltages affect the insulation of the transformer and its components. They can be divided into:

- faults between the turns of the same winding (most frequent case);
- faults between windings;
- faults between the stressed winding and a conductor part (core or metal structure).

Surge arresters may be used to efficiently protect transformers against overvoltages
For more information on surge arresters see the chapter dedicated to accessories



Example of a characteristic curve of a Zinc Oxide (ZnO) arrester for 20kV mains with "impulse" 125 kV insulation level.

BAHRA TBS TECHNOLOGY

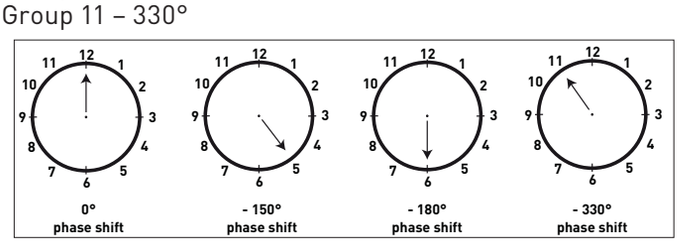
VECTORIAL GROUPS

Internal windings can be star, triangle or zigzag connected. Depending on the connection type, the system of induced voltages on the low-voltage side is out of phase, with respect to the system of the primary voltages, by angles which are multiples of 30°.
The winding connection method is identified by 3 letters (uppercase for high voltage winding, the winding having the highest rated voltage and lower case for low-voltage winding, the winding having the lowes rated voltage):

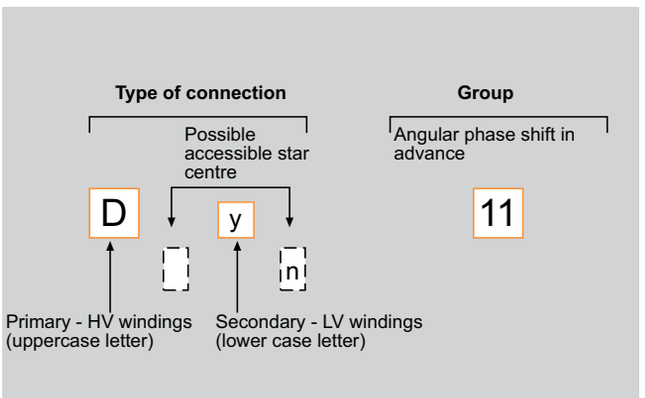
Y - star connection
D - triangle connection
Z - zigzag connection

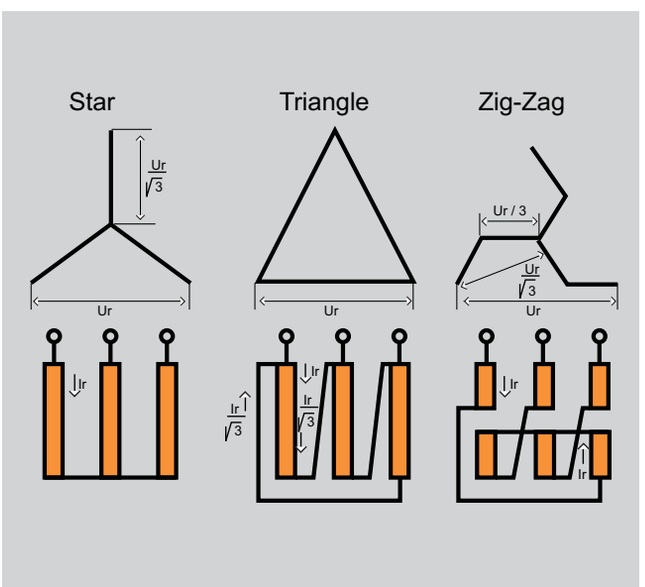
Associated with these letters some numbers represent the phase shift, dividing it into 4 groups:

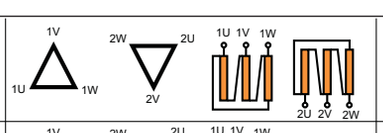
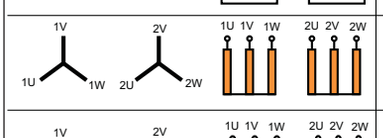
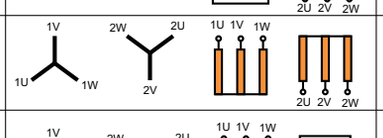
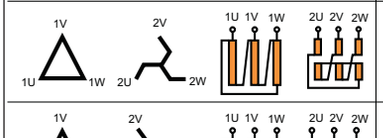
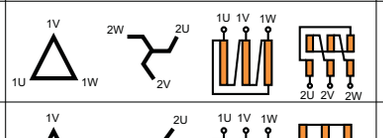
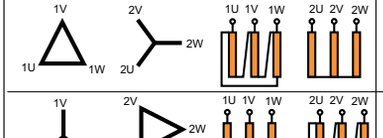
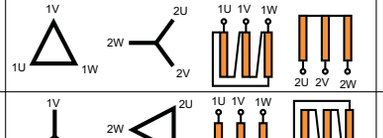
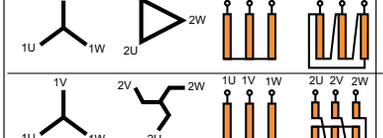
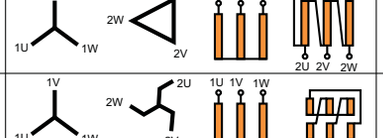
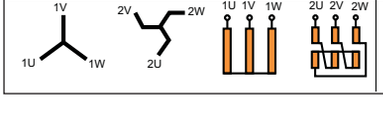
Group 0 – no phase shift
Group 5 – 150°
Group 6 – 180°
Group 11 – 330°



The winding which receives active power from the supply source is referred to as "primary winding" and delivers active power to a load refered to "secondary winding". These terms have no significance as to which of the windings has the higher rated voltage and should not be used except in the context of direction of active power flow.





	Dd0		Dd6
	Yy0		Yy6
	Dz0		Dz6
	Dy11		Dy5
	Yd11		Yd5
	Yz11		Yz5

NL - Bahra TBS transformers
INSULATION CLASS 17.5 kV, COPPER WINDING

SR [kVA]	TBS CODE	Primary voltage [kV]	Secondary voltage [V]	Frequency [Hz]	Ambient Temperature [°C]	Temperature Rise [K]	Po [W]	Pk [W] a 120 °C	Io [%]	Uk [%]	LwA-Acoustic power [dB (A)]	Length (A) [mm]	"Width (B) [mm]"	"Height (C) [mm]"	"Ic - wheel centre line [mm]"	"R - wheel diameter [mm]"	Weight [kg]
160	TCCXBGHF600	13.8	400	60	50	90	850	1500	1.20	4	64	1200	750	1200	520	125	980
200	TCDXBGHF600	13.8	400	60	50	90	1000	1800	1.05	4	65	1400	750	1200	520	125	1130
250	TCEXBGHF600	13.8	400	60	50	90	1300	2400	1.00	4	67	1300	750	1200	520	125	1200
315	TCFXBGHF600	13.8	400	60	50	90	1400	3000	1.00	4	68	1400	750	1300	520	125	1440
400	TCGXBGHF600	13.8	400	60	50	90	1600	3600	1.00	4	69	1500	750	1300	520	125	1630
500	TCHXBGHF600	13.8	400	60	50	90	1450	4800	0.70	6	69	1500	750	1400	520	125	1690
630	TCIXBGHF600	13.8	400	60	50	90	1750	5800	0.65	6	70	1500	750	1500	670	160	2020
800	TCJXBGHF600	13.8	400	60	50	90	2100	6500	0.60	6	72	1600	750	1600	670	160	2380
1000	TCKXBGHF600	13.8	400	60	50	90	2500	7500	0.50	6	73	1600	850	1800	670	160	2730
1250	TCLXBGHF600	13.8	400	60	50	90	2750	9000	0.50	6	74	1600	1000	1900	820	160	3240
1500	TCQXBGHF600	13.8	400	60	50	90	3450	12200	0.45	6	76	1800	1310	2100	1070	200	3820
1600	TCMXBGHF600	13.8	400	60	50	90	3450	12700	0.40	6	76	1800	1310	2100	1070	200	3940
2000	TCNXBGHF600	13.8	400	60	50	90	4500	15000	0.40	6	79	1900	1310	2100	1070	200	4860
2500	TCOXBGHF600	13.8	400	60	50	90	5000	16400	0.35	6	80	2000	1310	2100	1070	200	5660
3000	TCRXBGHF600	13.8	400	60	50	90	6000	18500	0.30	6	81	2100	1310	2300	1070	200	6620
3150	TCPXBGHF600	13.8	400	60	50	90	6000	19500	0.30	6	81	2100	1310	2300	1070	200	6750

NL - Bahra TBS transformers
INSULATION CLASS 17.5 kV, ALUMINUM WINDING

SR [kVA]	TBS CODE	Primary voltage [kV]	Secondary voltage [V]	Frequency [Hz]	Ambient Temperature [°C]	Temperature Rise [K]	Po [W]	Pk [W] a 120 °C	Io [%]	Uk [%]	LwA-Acoustic power [dB (A)]	Length (A) [mm]	"Width (B) [mm]"	"Height (C) [mm]"	"Ic - wheel centre line [mm]"	"R - wheel diameter [mm]"	Weight [kg]
160	TACXBGHF600	13.8	400	60	50	90	1100	1800	1.2	4	66	1400	750	1300	520	125	990
200	TADXBGHF600	13.8	400	60	50	90	1100	2400	1.1	4	67	1400	750	1300	520	125	1030
250	TAEXBGHF600	13.8	400	60	50	90	1300	2800	1	4	68	1400	750	1300	670	125	1180
315	TAFXBGHF600	13.8	400	60	50	90	1500	3100	0.9	4	69	1500	750	1400	670	125	1330
400	TAGXBGHF600	13.8	400	60	50	90	1800	4000	0.8	4	70	1500	750	1500	670	125	1560
500	TAHXBGHF600	13.8	400	60	50	90	1600	6000	0.7	6	69	1500	750	1700	670	125	1510
630	TAIXBGHF600	13.8	400	60	50	90	1900	6500	0.65	6	71	1500	750	1700	670	125	1760
800	TAJXBGHF600	13.8	400	60	50	90	2300	7500	0.6	6	72	1600	750	1700	670	160	2120
1000	TAKXBGHF600	13.8	400	60	50	90	2600	9400	0.5	6	74	1600	850	2000	670	160	2420
1250	TALXBGHF600	13.8	400	60	50	90	3200	10000	0.5	6	75	1700	850	2000	670	160	2960
1500	TAQXBGHF600	13.8	400	60	50	90	2900	14500	0.4	6	68	1800	1000	2200	670	160	3440
1600	TAMXBGHF600	13.8	400	60	50	90	3500	14500	0.4	6	77	1800	1000	2200	670	160	3420
2000	TANXBGHF600	13.8	400	60	50	90	4400	16000	0.4	6	79	1900	1310	2300	1070	200	4250
2500	TAOXBGHF600	13.8	400	60	50	90	5200	18500	0.35	6	80	2000	1310	2400	1070	200	5120
3000	TARXBGHF600	13.8	400	60	50	90	6700	20500	0.3	6	82	2200	1310	2500	1070	200	6220
3150	TAPXBGHF600	13.8	400	60	50	90	7200	21500	0.3	6	82	2200	1310	2500	1070	200	6260

Copper windings available on request *** For information on enclosure see p.22**

NL - Bahra TBS transformers
INSULATION CLASS 12 kV, ALUMINUM WINDING

SR [kVA]	TBS CODE	Primary voltage [kV]	Secondary voltage [V]	Frequency [Hz]	Ambient Temperature [°C]	Temperature Rise [K]	Po [W]	Pk [W] a 120 °C	Io [%]	Uk [%]	LwA-Acoustic power [dB (A)]	Length (A) [mm]	"Width (B) [mm]"	"Height (C) [mm]"	"Ic - wheel centre line [mm]"	"R - wheel diameter [mm]"	Weight [kg]
100	TABCBAHD500	10	400	50	40	100	440	2000	1,9	4	59	1000	600	1100	520	125	550
100	TABCBAGD500	10	400	50	40	100	420	1900	1,9	6	59	1000	600	1100	520	125	550
160	TACCBAHD500	10	400	50	40	100	610	2700	1,7	4	62	1100	600	1200	520	125	750
160	TACCBAGD500	10	400	50	40	100	550	2700	1,7	6	62	1100	600	1200	520	125	750
200	TADCBAHD500	10	400	50	40	100	720	3150	1,5	4	63	1150	620	1200	520	125	800
200	TADCBAGD500	10	400	50	40	100	680	3500	1,5	6	63	1150	620	1200	520	125	800
250	TAECBAHD500	10	400	50	40	100	820	3500	1,2	4	65	1250	630	1270	520	125	950
250	TAECBAGD500	10	400	50	40	100	750	3700	1,2	6	65	1250	630	1220	520	125	950
315	TAFCBAHD500	10	400	50	40	100	880	4400	1,1	4	67	1200	750	1300	670	125	1050
315	TAFCBAGD500	10	400	50	40	100	850	4600	1,1	6	67	1250	750	1250	670	125	1000
400	TAGCBAHD500	10	400	50	40	100	1150	4900	1	4	68	1250	750	1370	670	125	1250
400	TAGCBAGD500	10	400	50	40	100	1000	5400	1	6	68	1300	750	1320	670	125	1200
500	TAHCBAHD500	10	400	50	40	100	1300	6500	0,9	4	69	1250	750	1550	670	125	1450
500	TAHCBAGD500	10	400	50	40	100	1200	6700	0,9	6	69	1300	750	1500	670	125	1400
630	TAICBAHD500	10	400	50	40	100	1500	7300	0,8	4	70	1350	850	1600	670	160	1650
630	TAICBAGD500	10	400	50	40	100	1450	7600	0,8	6	70	1500	850	1590	670	160	1600
800	TAJCBAHD500	10	400	50	40	100	1750	9400	0,8	6	71	1500	850	1740	670	160	1950
1000	TAKCBAHD500	10	400	50	40	100	2000	10000	0,7	6	73	1550	1000	1820	820	160	2300
1250	TALCBAHD500	10	400	50	40	100	2300	12700	0,6	6	74	1550	1000	2000	820	160	2700
1600	TAMCBAHD500	10	400	50	40	100	2800	14000	0,5	6	76	1650	1000	2180	820	160	3300
2000	TANCBAHD500	10	400	50	40	100	3300	18000	0,5	6	79	1800	1310	2260	1070	200	4000
2500	TAOCBAHD500	10	400	50	40	100	4300	21000	0,4	6	81	2050	1310	2390	1070	200	4800
3150	TAPCBAHD500	10	400	50	40	100	4600	26000	0,4	7	83	2150	1310	2400	1070	200	5400

NL - Bahra TBS transformers
INSULATION CLASS 17.5 kV, ALUMINUM WINDING

SR [kVA]	TBS CODE	Primary voltage [kV]	Secondary voltage [V]	Frequency [Hz]	Ambient Temperature [°C]	Temperature Rise [K]	Po [W]	Pk [W] a 120 °C	Io [%]	Uk [%]	LwA-Acoustic power [dB (A)]	Length (A) [mm]	"Width (B) [mm]"	"Height (C) [mm]"	"Ic - wheel centre line [mm]"	"R - wheel diameter [mm]"	Weight [kg]
100	TABEBAGF500	15	400	50	40	100	430	1900	2	6	59	1000	600	1090	520	125	600
160	TACEBAGF500	15	400	50	40	100	570	2800	1,7	6	62	1200	630	1210	520	125	750
200	TAFEBAGF500	15	400	50	40	100	680	3600	1,5	6	63	1250	630	1230	520	125	800
250	TAEEBAGF500	15	400	50	40	100	750	3650	1,3	6	65	1250	640	1240	520	125	950
315	TAFEBAGF500	15	400	50	40	100	880	4500	1,2	6	67	1250	750	1300	670	125	1050
400	TAGEBAGF500	15	400	50	40	100	1000	5200	1,1	6	67	1350	750	1390	670	125	1250
500	TAHEBAGF500	15	400	50	40	100	1200	6700	1	6	69	1350	750	1520	670	125	1400
630	TAIEBAGF500	15	400	50	40	100	1600	7800	1	6	70	1500	850	1630	670	160	1700
800	TAJEBAGF500	15	400	50	40	100	1780	9300	0,9	6	71	1500	850	1780	670	160	2000
1000	TAKEBAGF500	15	400	50	40	100	2000	10800	0,8	6	73	1550	1000	1870	820	160	2300
1250	TALEBAGF500	15	400	50	40	100	2350	12600	0,7	6	74	1550	1000	2010	820	160	2750
1600	TAMEBAGF500	15	400	50	40	100	2750	15500	0,6	6	76	1650	1000	2190	820	160	3300
2000	TANEBAGF500	15	400	50	40	100	3350	18500	0,6	6	79	1800	1310	2250	1070	200	4000
2500	TAOEBAGF500	15	400	50	40	100	4300	21800	0,5	6	81	1950	1310	2320	1070	200	4950
3150	TAPEBAGF500	15	400	50	40	100	4700	26000	0,4	7	83	2150	1310	2350	1070	200	5750

Copper windings available on request *** For information on enclosure see p.22**

NL - Bahra TBS transformers
INSULATION CLASS 24 kV, ALUMINUM WINDING

SR [kVA]	TBS CODE	Primary voltage [kV]	Secondary voltage [V]	Frequency [Hz]	Ambient Temperature [°C]	Temperature Rise [K]	Po [W]	Pk [W] a 120 °C	Io [%]	Uk [%]	LwA-Acoustic power [dB (A)]	Length (A) [mm]	"Width (B) [mm]"	"Height (C) [mm]"	"Ic - wheel centre line [mm]"	"R - wheel diameter [mm]"	Weight [kg]
100	TABFBAGH500	20	400	50	40	100	540	1750	2,1	4	59	1200	600	1160	520	125	650
100	TABFBAHH500	20	400	50	40	100	480	2000	2,1	6	59	1050	600	1110	520	125	600
160	TACFBAGH500	20	400	50	40	100	750	2500	1,8	4	62	1250	640	1260	520	125	900
160	TACFBAHH500	20	400	50	40	100	650	2800	1,8	6	62	1250	640	1240	520	125	800
200	TADFBAGH500	20	400	50	40	100	900	2900	1,7	4	63	1350	640	1320	520	125	1050
200	TADFBAHH500	20	400	50	40	100	800	3600	1,7	6	63	1250	640	1250	520	125	900
250	TAEFBAGH500	20	400	50	40	100	1000	3450	1,5	4	65	1350	640	1360	520	125	1150
250	TAEFBAHH500	20	400	50	40	100	850	3700	1,5	6	65	1350	640	1260	520	125	1000
315	TAFFBAGH500	20	400	50	40	100	1150	4500	1,4	4	67	1350	750	1450	670	125	1350
315	TAFFBAHH500	20	400	50	40	100	950	4500	1,4	6	67	1350	750	1350	670	125	1200
400	TAGFBAGH500	20	400	50	40	100	1360	4900	1,3	4	68	1450	750	1530	670	125	1500
400	TAGFBAHH500	20	400	50	40	100	1150	5400	1,3	6	68	1500	750	1440	670	125	1350
500	TAHFBAGH500	20	400	50	40	100	1580	6400	1,2	4	69	1450	750	1610	670	125	1650
500	TAHFBAHH500	20	400	50	40	100	1350	6700	1,2	6	69	1500	750	1560	670	125	1500
630	TAIFBAGH500	20	400	50	40	100	1950	6900	1,1	4	70	1500	850	1690	670	160	2000
630	TAIFBAHH500	20	400	50	40	100	1650	7800	1,1	6	70	1500	850	1650	670	160	1800
800	TAJFBAHH500	20	400	50	40	100	1850	9300	1	6	71	1550	850	1810	670	160	2100
1000	TAKFBAHH500	20	400	50	40	100	2200	10800	0,9	6	73	1650	1000	1890	820	160	2500
1250	TALEBAGD500	20	400	50	40	100	2600	12800	0,8	6	74	1650	1000	2030	820	160	2900
1600	TAMFBAHH500	20	400	50	40	100	2950	15500	0,7	6	76	1750	1000	2200	820	160	3550
2000	TANFBAHH500	20	400	50	40	100	3800	18600	0,6	6	79	1900	1310	2270	1070	200	4300
2500	TAOFBAHH500	20	400	50	40	100	4800	22000	0,5	6	81	1950	1310	2350	1070	200	5250
3150	TAPFBAHH500	20	400	50	40	100	5100	26000	0,5	7	83	2250	1310	2400	1070	200	6250

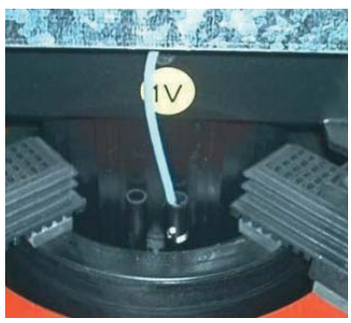
NL - Bahra TBS transformers
INSULATION CLASS 36 kV, ALUMINUM WINDING

SR [kVA]	TBS CODE	Primary voltage [kV]	Secondary voltage [V]	Frequency [Hz]	Ambient Temperature [°C]	Temperature Rise [K]	Po [W]	Pk [W] a 120 °C	Io [%]	Uk [%]	LwA-Acoustic power [dB (A)]	Length (A) [mm]	"Width (B) [mm]"	"Height (C) [mm]"	"Ic - wheel centre line [mm]"	"R - wheel diameter [mm]"	Weight [kg]
315	TAFQBAGJ500	33	400	50	40	100	1300	4500	1,4	6	69	1600	820	1580	670	125	1550
400	TAGQBAGJ500	33	400	50	40	100	1500	5800	1,3	6	70	1600	880	1620	670	160	1650
500	TAHQBAGJ500	33	400	50	40	100	1700	6600	1,2	6	71	1650	890	1750	670	160	1900
630	TAIQBAGJ500	33	400	50	40	100	2000	7500	1	6	73	1650	900	1760	670	160	2200
800	TAJQBAGJ500	33	400	50	40	100	2450	9700	0,9	6	74	1750	920	1920	670	160	2650
1000	TAKQBAGJ500	33	400	50	40	100	2600	11300	0,8	7	75	1900	1000	2040	820	160	2950
1250	TALQBAGJ500	33	400	50	40	100	2900	14000	0,7	8	76	1950	1020	2180	820	160	3450
1600	TAMQBAGJ500	33	400	50	40	100	3400	16000	0,6	8	77	2050	1030	2220	820	160	4000
2000	TANQBAGJ500	33	400	50	40	100	4200	18000	0,5	8	79	2100	1310	2290	1070	200	4800
2500	TAOQBAGJ500	33	400	50	40	100	5200	22000	0,5	8	80	2300	1310	2350	1070	200	5950

Copper windings available on request *** For information on enclosure see p.22**

BAHRA TBS TRANSFORMERS

INSTALLATION ACCESSORIES



Ventilation bars

The ventilation bars temporarily increase the transformer rated power (under normal service conditions).
According to standard IEC 60076-1, a transformer is called AN even if it is equipped with ventilation bars for temporary use.
If a transformer is requested AF, please contact Bahra TBS.

Rating (kVA)	ΔPower (%)	Notes
100 - 315	+ 40	Temporary increase at rated conditions (60Hz)
400 - 500	+ 40	
630 - 1000	+ 40	
1250 - 2000	+ 40	
2500 - 3150	+ 40	

Temperature measurement probes

Probes are supplied mounted on the transformer and wired to the Aluminum IP66 junction box.

Type	Rating (kVA)	N°	Δt (°C)	Installation
Pt100	≤2000	3	-	on the LV (3) windings
Pt100	≥2500	3	-	on the LV (3) windings
Pt100	≤2000	3+1	-	on the LV (3) windings + on the core (1)
Pt100	≥2500	3+1	-	on the LV (3) windings + on the core (1)
PTC	-	3+3	130-140	on the LV (3 pairs) windings for alarm and trip.
PTC	-	3+3	110-120	on the LV (3 pairs) windings for alarm and trip.
PTC	-	3+3+3	130-140-90	on the LV (3 pairs) windings for alarm, trip and fan control.

Temperature control devices

Central units are supplied unassembled

Type	Description
T154	temperature control for 4 Pt100 probes
MT200L	temperature control for 4 Pt100 probes
T 119	temperature control for PTC probes
T119DIN	temperature control for PTC probes, preset for DIN rail mounting
NT935AD	temperature control for 4 Pt100 probe with analogue and digital output
VRT200	fan control
AT100	fan control

Surge arrester kit

HV*(kV)	Ur (kV)
6	9
10-11	12
15	18
20	24

* other values of HV on request
Ur: rated voltage of surge arrester

Rubber supports (anti vibration)

Rating (kVA)	Description
≤1600	4 antivibration pads supplied for mounting under the transformer wheels
≥2000	4 antivibration pads supplied for mounting under the transformer wheels

Wheels in "Cast Iron" on request

Cupal plates

Cupal is a bimetal sheet made of one copper sheet and one Aluminum sheet welded together through a special mechanical procedure.

Rating (kVA)	Description
≤160	40 x 40 CUPAL plate
≥ 200 and ≤ 400	50 x 50 CUPAL plate
≥ 500 and ≤ 800	60 x 60 CUPAL plate
1000	80 x 80 CUPAL plate
1250	100 x 100 CUPAL plate
≥ 1600	120 x 120 CUPAL plate

** The codes refer to a single CUPAL plate

Example:
- For a transformer rated 1250 kVA, the correct CUPAL plate is item 030011
- Quantity calculation: 2 plates x 4 BT terminals = 8 CUPAL plates

Relay Box

Available upon request.

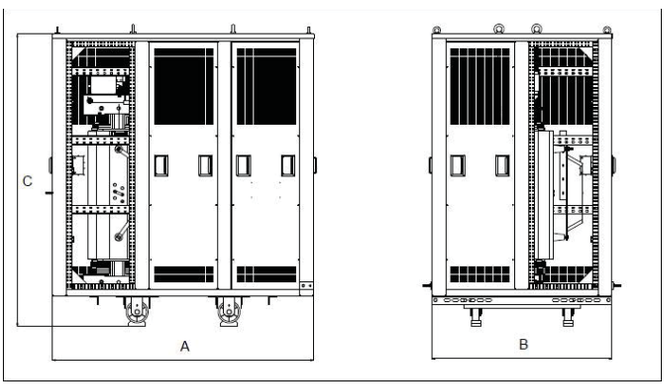
BAHRA TBS TRANSFORMERS

INSTALLATION ACCESSORIES

ENCLOSURES

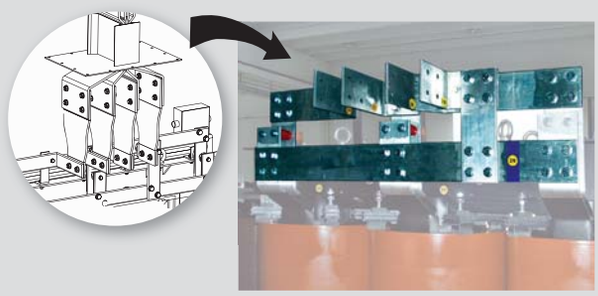
RAL 7035 colour

AREL door lock on the box, Cat. Nos. 230076

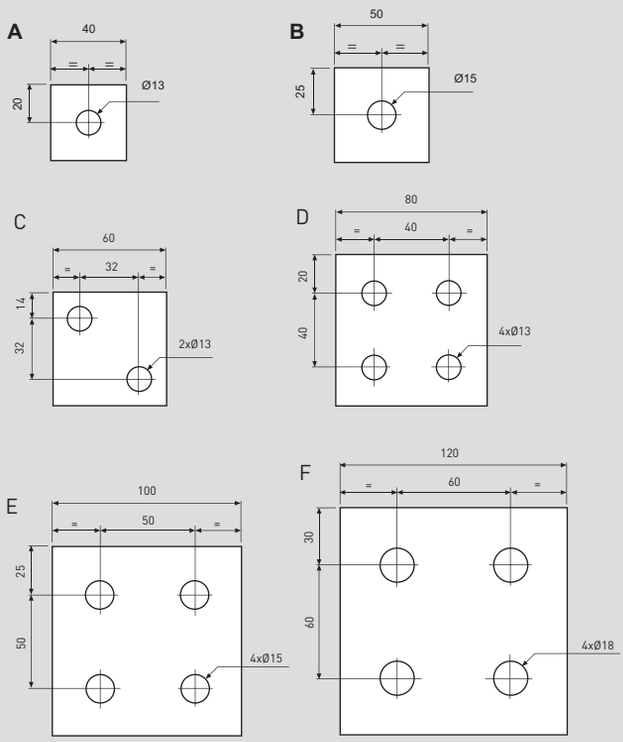


TYPES OF ENCLOSURES

Drawing number	Enclosure type	IP	A (Length)	B (width)	C (Height)	Mass in kg
23K181317A1	1	31	1800	1350	2200	370
23K181317Z1	1	21	1800	1350	2200	370
23K201321A1	2	31	2000	1350	2650	490
23K201321Z1	2	21	2000	1350	2650	490
23K231423A1	3	31	2300	1450	2850	540
23K231423Z1	3	21	2300	1450	2850	540
23K251423A1	4	31	2500	1450	2850	590
23K251423Z1	4	21	2500	1450	2850	590
23K271525A1	5	31	2700	1550	3050	620
23K271525A2	5	21	2700	1550	3050	620



SIZES AND DRILLING OF LV CONNECTION TERMINALS



DRILLING STANDARD

In case LV connection terminals are made from Aluminum, special CUPAL bimetallic plates can be supplied for the connection of copper cables or bars.

	NL - RL	
Drawing	Rating (kVA)	Thickness (mm)
A	100	4
	160	4
B	200	5
	250	5
	315	5
	400	5
C	500	6
	630	8
	800	8
D	1000	8
E	1250	8
F	-	-
	1600	10
	2000	12
	2500	16
	3150	20

BAHRA TBS GUIDELINES

INSTALLATION AND MAINTENANCE

TABLE OF CONTENTS

- Safety guidelines
- Rating plate
- Transport, receipt and storage
- Installation
- Commissioning
- Maintenance
- Additional information
- Technical glossary

SAFETY GUIDELINES

A cast resin transformer is an electrical equipment. It must be installed, protected and used in compliance with the existing national and international Standards and Regulations.
The possible improper installation and use of a cast resin transformer may cause risks of electric shock or fire.

Please, read this installation manually carefully before: lifting, moving or energising the transformer.

Every operation on the transformer must be performed when the transformer is not energised.

Do not get close to the cast resin transformer before having connected the windings to earth.

Before operating on the CRT, make sure that the transformer cannot be put undervoltage without your permission.

Do not energised the transformer before having connected the core to earth.

Do not energised the transformer before having carefully and completely inspected it.

Do not access the transformer's operation area or remove the protection devices when the transformer is undervoltage.

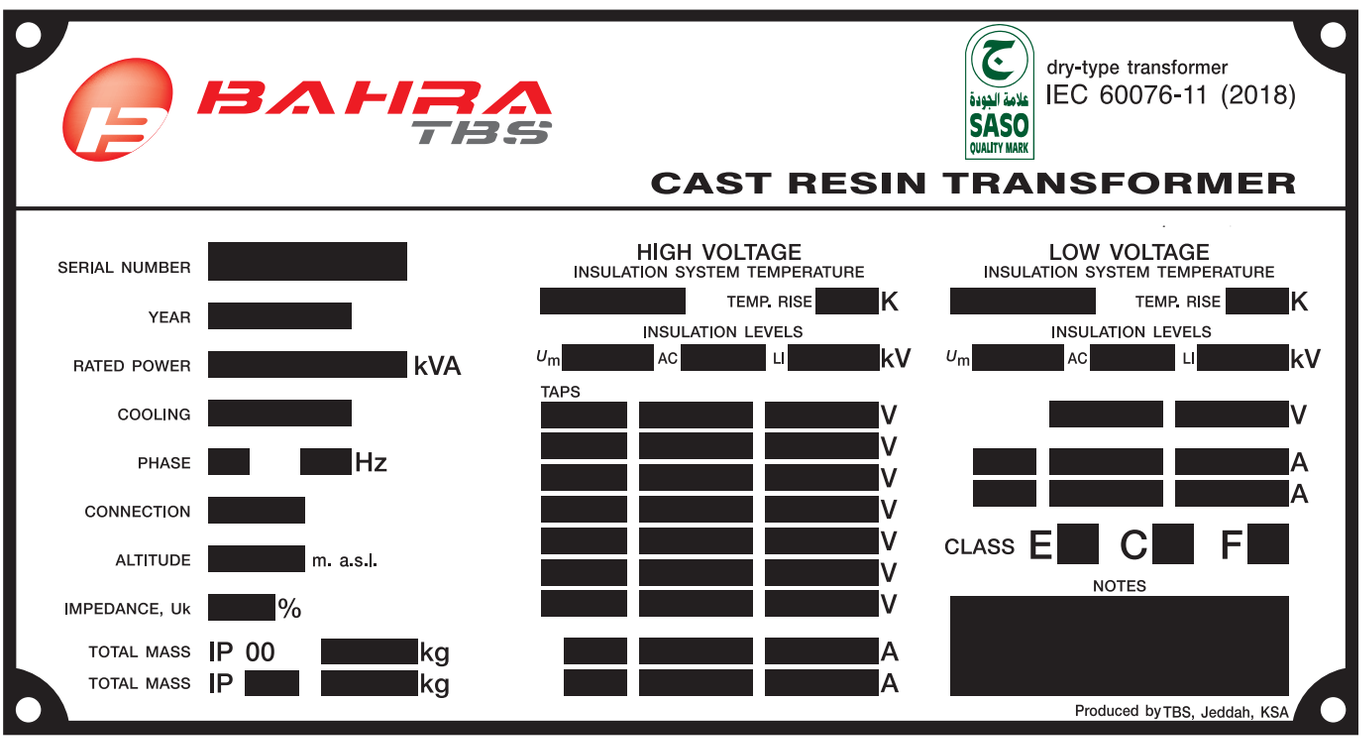
Each transformer generates a magnetic field. For this reason, any carrier of metallic devices as pacemakers should not get closer than 3 m to an energised transformer.

This transformer must be installed according to the installation directions and preferably by a skilled and qualified HV electrician.
Do not open, disassemble, alter or modify the transformer with the exception of special indications reported in the Installation Manual.
All Bahra TBS products must be opened and repaired only by personnel trained and authorized by Bahra TBS.
Bahra TBS is not responsible for any non-authorized opening or repair.

RATING PLATE

RATING PLATE

A rating plate showing nominal values and serial number is applied on each transformer.



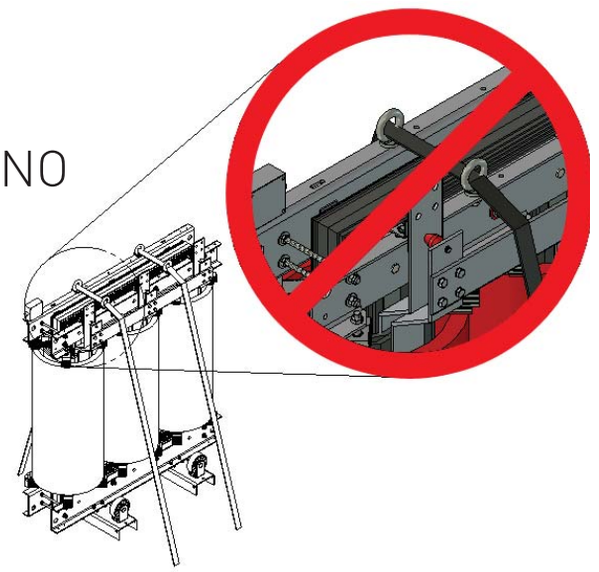
Conditions for the correct operation of the transformer

- Respect of all the instructions reported in this manual;
- operation of the transformer in accordance with the rating plate data;
- earth connection of the transformer with the correct terminals;
- protection of the transformer against: chemical agents, pollution, atmospheric pollution, sun radiation, vegetation and animals that could influence the normal operating conditions;
- protection of the transformer against mechanical damages during installation and operation;
- protection against overvoltages.

TRANSPORT, RECEIPT AND STORAGE

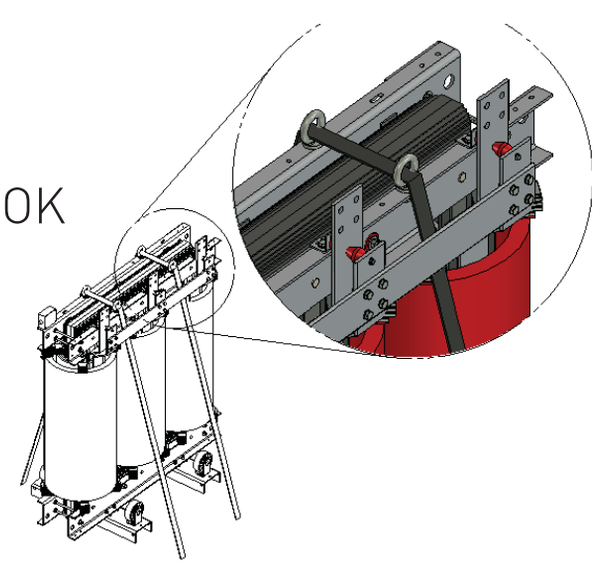
During transport, the transformers must be adequately fixed as indicated in the explanatory images. HV and LV connections must not be stressed by the retaining straps.

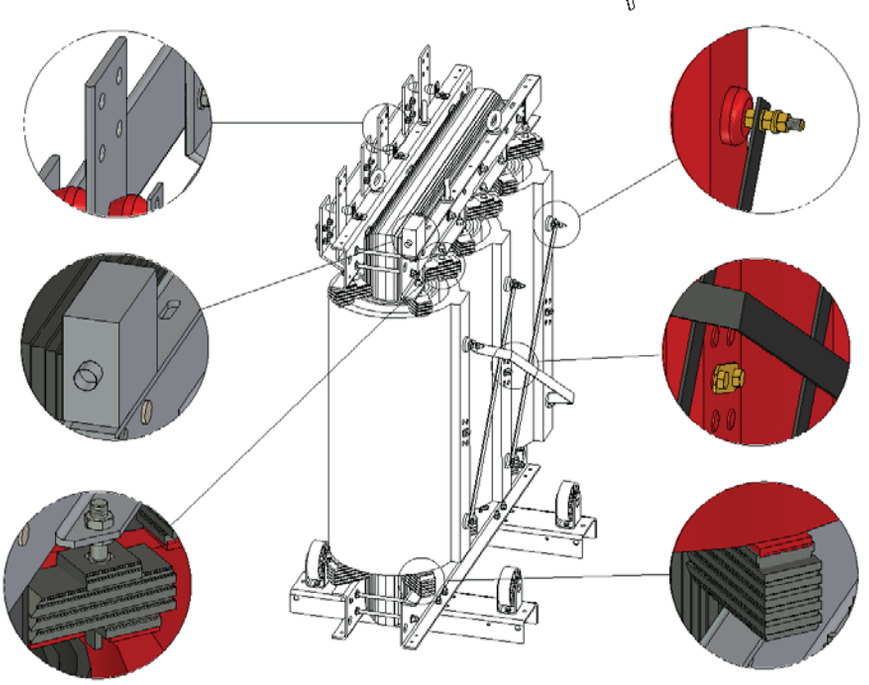
Once the transformer is at its destination, it is highly recommended to carefully examine it.
In particular the following details have to be verified: HV and LV terminals and connections, presence of scratches and/or cracks on the windings of HV and their centering with respect to the windings of LV, integrity of the protection enclosure (if present), presence of impurities, dirt, foreign body, moisture or water.



It has to be verified that the data on the rating plate are the same data reported on shipping documents and test reports of the transformer.
It has to be verified that each transformer is provided with contractual accessories such as rollers, temperature sensors, control thermometer, etc. ...

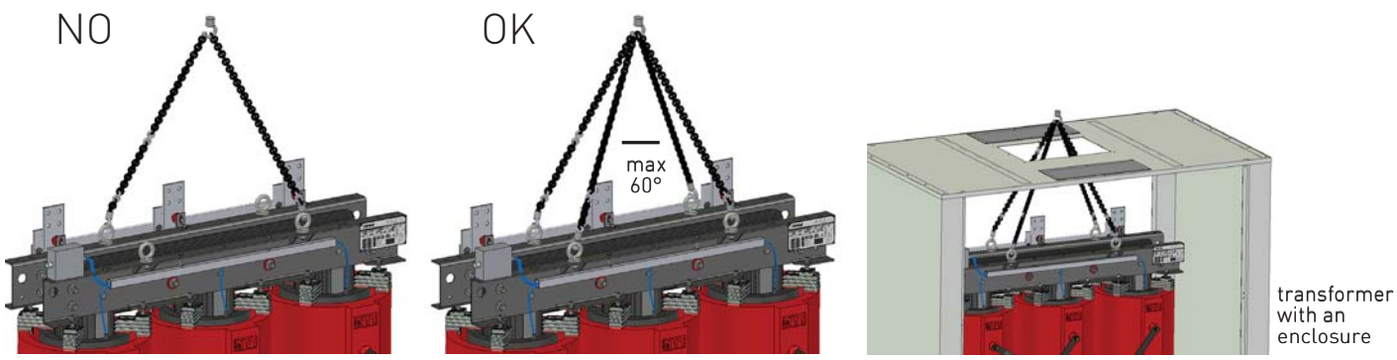
Any non conformity must be recorded on the delivery note and notified to the forewarding agent or to Bahra TBS.
If after 5 days no report of anomalies and / or defects will be received by Bahra TBS, we will consider that the transformer has been delivered in perfect condition.



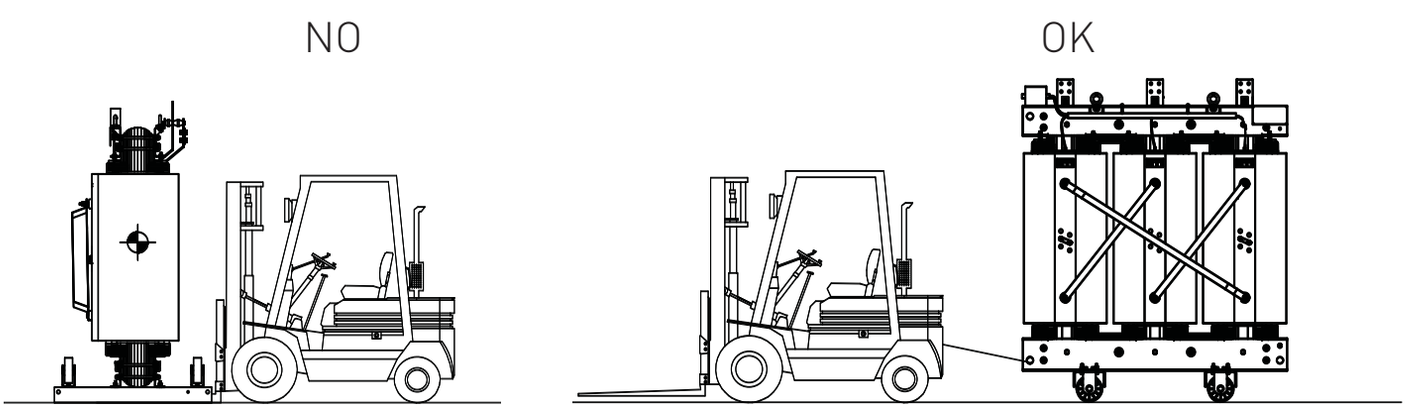


- **LIFTING THE TRANSFORMER**

Use all 4 eye bolts during lifting. Do not allow that the angle between the ropes to exceed 60°.
Gradually increase the tension on the lifting cables to avoid sudden shock or stress to the transformer.
If the transformer is supplied with an enclosure, remove the top window for the attachment of the ropes.



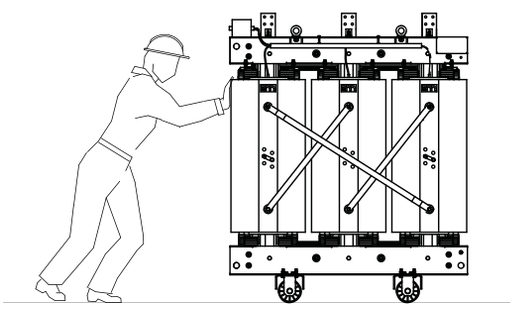
Do not leave the transformer elevated for prolonged periods.
Move the transformer only in vertical position.
Lift the transformer avoiding improper lifting (that may cause it to tip over): be careful about the high centre of gravity of the transformer.
It is prohibited to lift the transformer by inserting the forks of the forklift in the upper part of the core.



- **MOVING THE TRANSFORMER**

The transformer (with or without enclosure) must be moved using the track or towing holes where the proper holes are located.

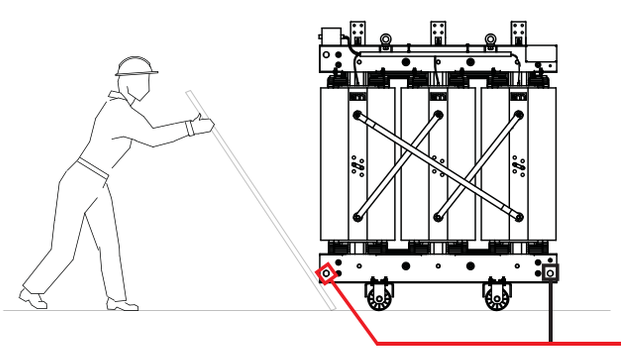
NO



Do not move the transformers by applying force on the windings or on their connections.

It is recommended to avoid moving the transformer on the rollers more than 10 m.

OK



Movement can be made only in two directions, according to the rollers orientation.

...or towing holes for horizontal moving

- **STORING THE TRANSFORMER**

If the transformer is not installed immediately, it has to be protected against water, dust, humidity and sunlight even if provided with enclosure.
In case of storage the packaging supplied with the transformer must not be removed.

The temperature during storage and installation must not decrease below -25°C (unless otherwise agreed order stage). After a long storage at very low temperatures or in an environment with high humidity, the transformer must be dried before being placed in service.

INSTALLATION

During the operations for the connection and installation, always protect the windings to avoid external parts such as bolts, washers, cable parts, etc. following into the windings and jeopardizing the insulation capability of the transformer.

Dry type cast resin transformers are designed for indoor installations, in a site protected from direct sunlight, in clean and dry environments, without risk of water intrusion.

Standard installation must be:
1. At a sea level height not above 1000 m.
2. At a temperature of the cooling air not exceeding the following values :
   a. 20°C yearly average
   b. 30°C warmest month average
   c. 40°C maximum
3. According to all other normal operating conditions as per IEC 60076-11 Standard.

During the installation refer to the safety rules existing in your country.

- **INSTALLATION EXAMPLES**

The cable connections of Medium and Low Voltage can be done with cables coming from the bottom or the top. Some examples are listed below.

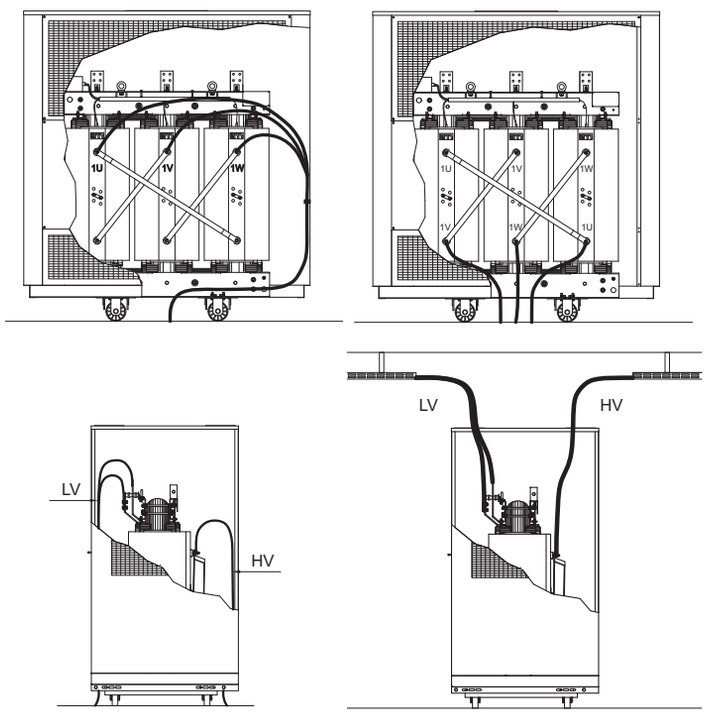
- **Installation in protection enclosure (Fig.1)**

- **Installation without protection enclosure/box (IP00) (Fig.2)**

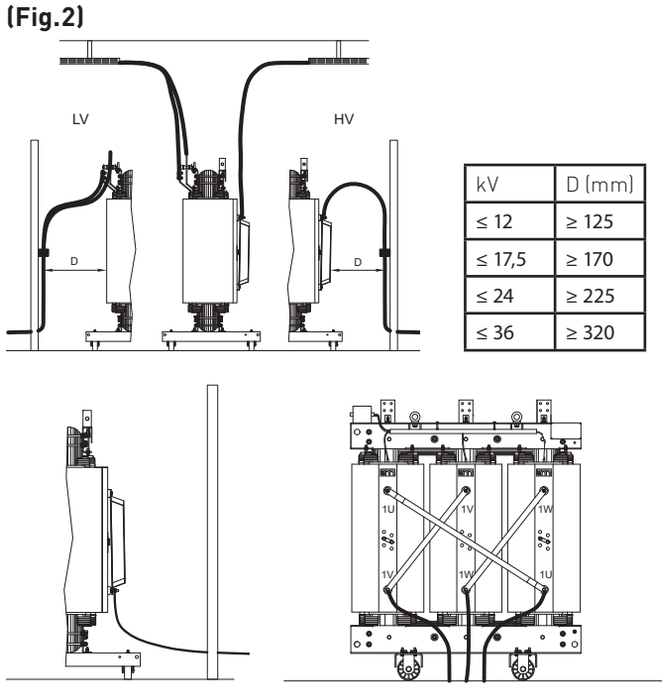
Between HV and LV connections and transformers windings and delta connections, the minimum distances shown in the table must be respected.
HV and LV cables must always be supported to avoid mechanical stress on the terminals.

HV cables, even if shielded , must not pass inside delta connection on HV side.

Installation in protection enclosure (Fig.1)



Installation without protection enclosure/box (IP00) (Fig.2)



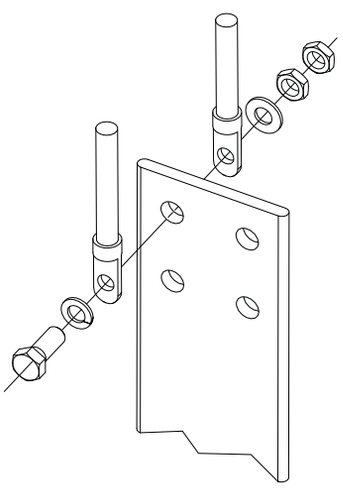
kV	D (mm)
≤ 12	≥ 125
≤ 17,5	≥ 170
≤ 24	≥ 225
≤ 36	≥ 320

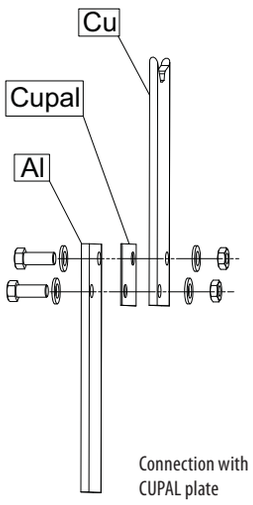
HV cable from	Sequence of the phases	Activities to be performed
Top	U - V - W	None
Bottom	V - W - U	Move the bolts from the top to the bottom terminals

- **CONNECTIONS ON THE LOW VOLTAGE SIDE – LV**

LV terminals are positioned on the upper part of the transformer and they are in Aluminum as standard. We recommend to make the cable connection with tinned-copper cable terminals, connecting one or two cables in each hole.

In the case of connections with busbar it is necessary to use flexible connections to mechanically isolate the transformer from busbars. In order to prevent corrosion caused by the direct connection between copper and Aluminum, it is necessary to use **CUPAL** intermediate plates (supplied on request) when connecting untreated copper busbars to the LV Aluminum terminals.

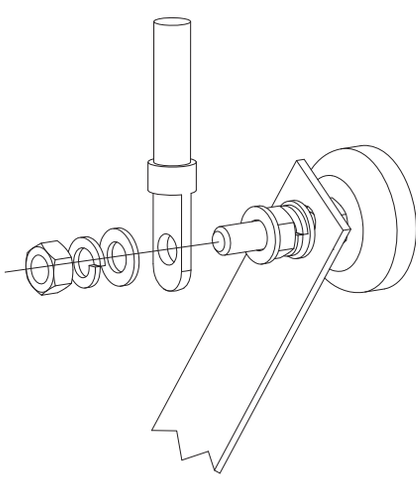




Connection with CUPAL plate

- **CONNECTIONS ON THE HIGH VOLTAGE SIDE – HV**

The HV terminals positioned on the opposite side to the LV terminals, are made with brass bolts placed at the two ends of the winding.
In case of connection of cables from the bottom, the upper pins can be inserted on the lower end by inverting the sequence of phases in accordance to the example previously reported in the figure.



Do not replace the brass bolts with bolts of a different material: this could alter the connections

• TIGHTENING TORQUE FOR ELECTRICAL AND MECHANICAL CONNECTIONS

Tighten screws and bolts of electrical and mechanical connections in accordance with the values reported in the table: it is recommended to re-test after a few hours of operation to eliminate the effects of any adjustments.
During the operations of clamping always use two wrenches to prevent distortion or damage.

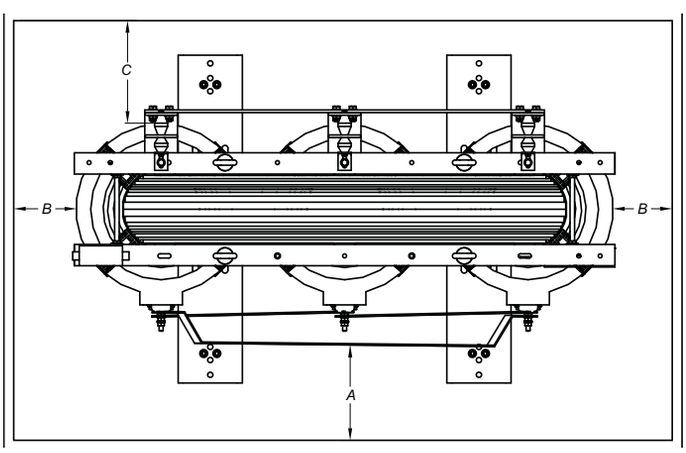
	Electrical connection [Nm]		Mechanical connection	
Screw/Bolt	Steel	Brass	[Nm]	(mm)
M6	10-15	5-10	20	10
M8	30-40	10-15	35	13
M10	50-60	20-30	45	17
M12	60-70	40-50	60	19
M14	90-100	60-70	100	22
M16	120-130	80-90	150	24
M18	-	-	200	27
M20	-	-	270	30
M22	-	-	360	32
M24	-	-	460	36

• POSITIONING

Cast resin transformers do not ensure contact insulation.

It is absolutely forbidden to touch the cast HV coils while the transformer is energised.

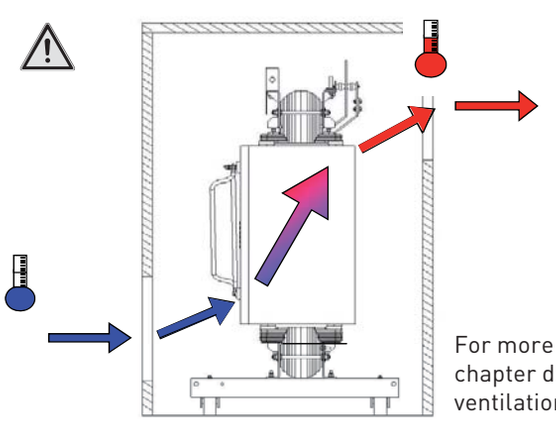
Therefore the transformer must always be installed in a metal enclosure, inside a cage or in a room with doors enabling access only when the transformer is de-energised.
Inside this electrical enclosure the transformer has to be positioned complying with minimal insulation distance from the walls. They are related to the insulation class shown in the Rating plate.



kV	A (mm)	B (mm)	C (mm)
≤ 12	≥ 125	≥ 60	(*)
≤ 17,5	≥ 170	≥ 80	(*)
≤ 24	≥ 225	≥ 120	(*)
≤ 36	≥ 320	≥ 200	(*)

C=B except when there is a voltage switch present on the LV side whereby C = A. In order to prevent horizontal movement of the transformer the mounting direction of the wheels can be modified.

• VENTILATION



For more details see chapter dedicated to ventilation page 14 - 15

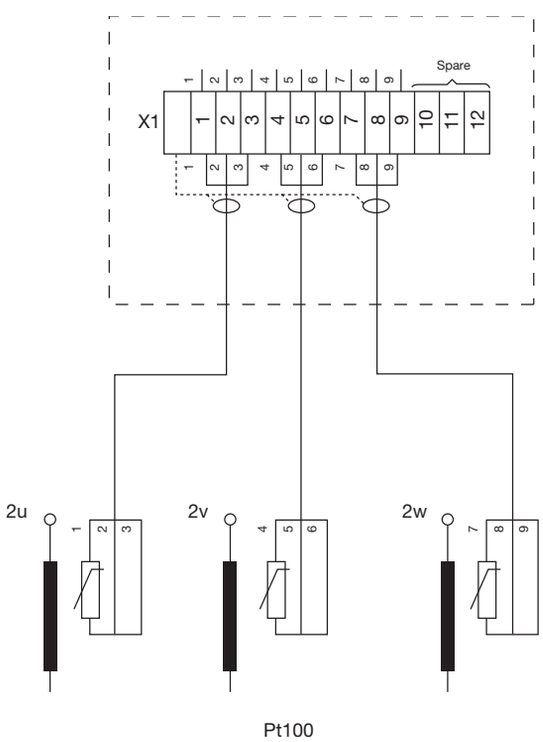
- **PROTECTION AGAINST OVERVOLTAGES**

To protect the transformer from overvoltage at power frequency or of atmospheric origin, adequate surge arresters must be installed. They need to have technical characteristics depending on the level of insulation of the transformer and on the characteristics of the HV distribution system.
Possible equipment for the correction of the power factor connected close to the transformer must be equipped with limiters for the inrush current in order to prevent the generation of transient overvoltages.

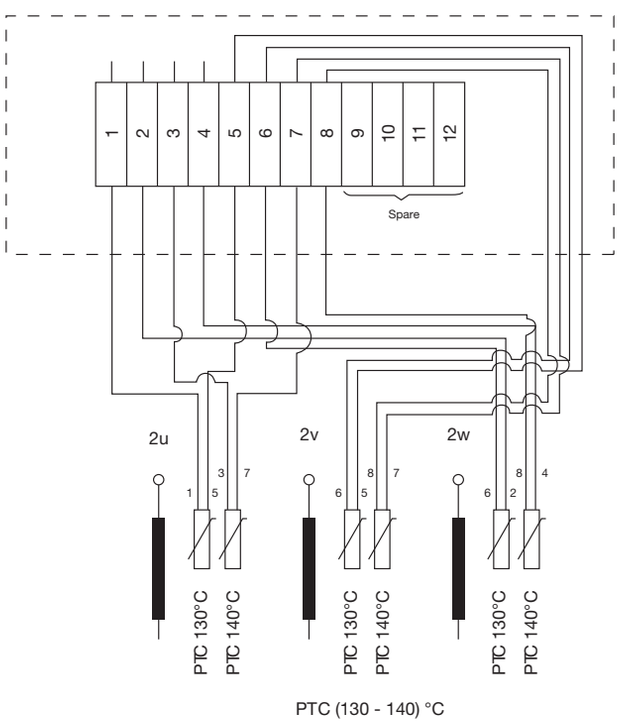
- **TEMPERATURE MONITORING SYSTEMS**

In standard execution the transformers are equipped with Pt100 temperature probes, realized in accordance with the IEC 60751 Standards.

Connection of the probes:



Pt100



PTC (130 - 140) °C

Spare terminals
These are the recommended settings when the transformer is equipped with a temperature monitor device:
Recommended setting:

Recommended setting for transformer equipped with a temperature monitor device		
Class	**Alarm (°C)**	**Trip (°C)**
180°C (H)	140	155
155°C (F)	130	140
130°C (B)	110	120

Electrical connection diagram, number and function of the electrical contacts, and terminals numeration are detailed on the manuals of the temperature control devices.

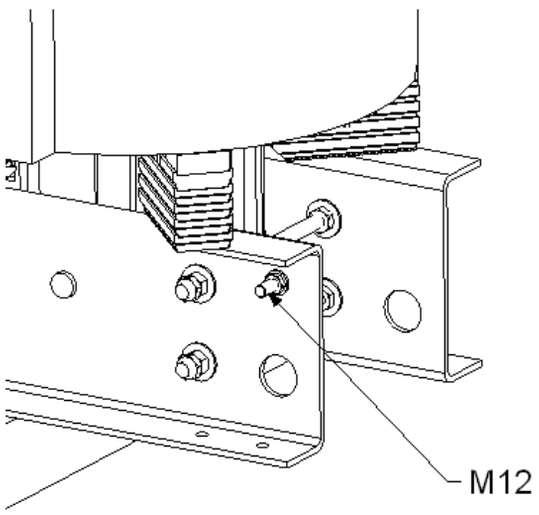
COMMISSIONING

Bahra TBS is not responsible for the installation of the transformer. Checks need to be done before energised the transformer.

- **EARTH CONNECTION**

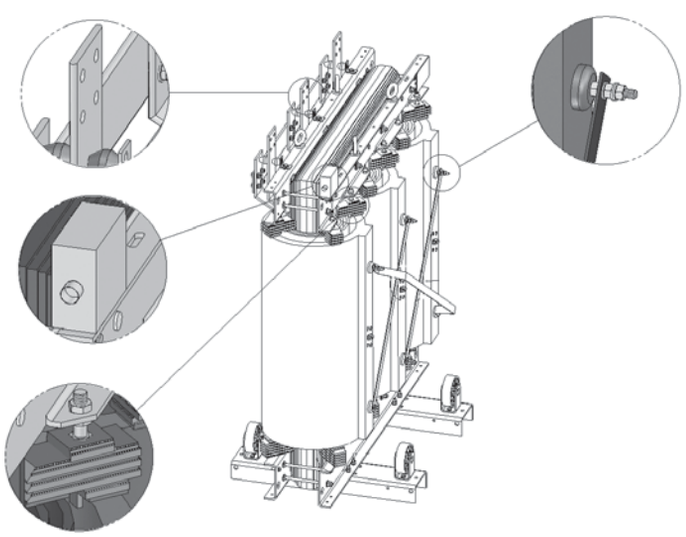
The earth conductor must be connected to the appropriate terminals which are on the transformer core.
The size of earth conductor must be defined according to fault current and to the current standards.
In any case the earth conductor should never be lower than the following sections:
- copper: 16 mm^2
- Aluminum 35 mm^2
- Steel 50 mm^2

Insulation distances between earth conductor and live parts must always be respected.



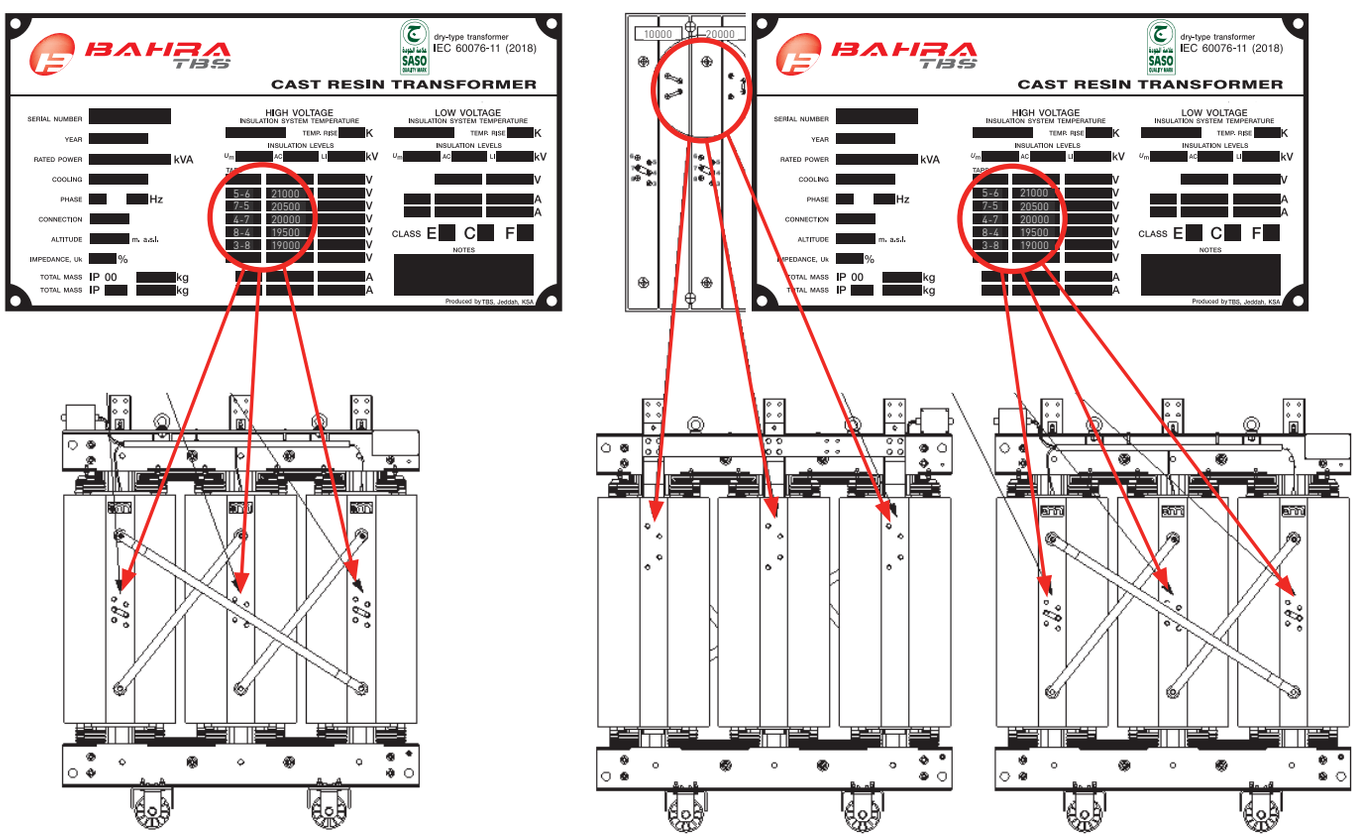
- **HV AND LV CONNECTIONS**

1. Verify the mutual position of LV and HV windings which must be according to our drawings. Verify that the compression bolts are centred on the spacers. The spacers must be slightly pressed.
2. Check the connections between cables and HV terminals and between cables or flexibles and LV terminals. Tightening torques must be the ones indicated in the table.
3. Verify the correct operation of the temperature control device.
4. If the transformer is equipped with fans, check that fans are correctly positioned and that they work in the right direction.



- **TAPPINGS FOR VOLTAGE SETTING ON HV WINDINGS**

The variation of the nominal HV supplied by the electrical authority can be compensated by the tappings setting in order to keep the nominal LV required and detailed on the rating plate. The voltage setting is made by changing the position of the plates on the tappings.
Standard transformers are equipped with 5 tappings: ±5% in steps of 2.5%.
Before operating on the tappings and modifying the voltage setting, it is necessary that the transformer is off-load.
For transformers with one or two primary voltage windings, the voltage setting indications are detailed on the rating plate.



Tappings for voltage setting on HV windings

It is important to set the same tappings on all three HV windings in order to avoid possible damages to the transformer.

Rating plate are located in the standard version on the front of the HV windings

• CLEANING

If the transformer has been stored for a long period, clean carefully LV and HV windings from dust, dirt and possible condensation.
Clean the HV and LV windings from dust deposits, dirt and condensation.
Use a vacuum cleaner to avoid dispersion of dirt and dust on the transformer.
Make sure the room is dry, clean, with sufficient ventilation and without the risk of ingress of water.
Do not attach accessories or ducts to the windings and the core of the transformer.

• MEASUREMENT OF INSULATION RESISTANCE

The measurement must be performed with a Megohmmeter (Megger), working up to 5000V.
HV and LV terminals must be disconnected from the electrical system, during the measurement.
The measured values should be approximately as follows:
• 5000 V for 60 S : Terminals HV to LV ≥ 20 MΩ
• 5000 V for 60 S : Terminals HV to Earth ≥ 10 MΩ (With LV Terminals short and Ground)
• 2500 V for 60 S : Terminals LV to Earth ≥ 10 MΩ (With HV Terminals short and Ground)

If the measured values are significantly lower, dry the transformer and, if necessary, contact the after sales department.

• ENERGIZING

When the transformer is connected to the electrical system, some sparkles could be visible close to the magnetic core. This physical phenomenon does not influence the correct working of the transformer and it is not related to the quality.

If the protection systems are not correctly set, inrush current will open the circuit breaker which protects the transformer.
This can generate high voltages which can damage the windings.
For this reason, it is recomended to activate the second harmonic restraint.

After checking the installation and ensuring that no object/tool has been left on the transformer, it is possible to close the circuit breaker on the HV side.
After energizing the transformer from the HV side, close the LV circuit breaker.

MAINTENANCE

In normal operating conditions cast resin transformers do not require specific maintenance except for that indicated in the following table. All the operations performed must be recorded in order to be shown to Bahra TBS in case of necessity.

Maintaining within recommended timescales will help to prevent break downs.

- **INDICATIVE TABLE ON THE MAIN MAINTENANCE OPERATIONS**

Pos.	Control activity	Frequency of checks	Tools to be used	Result
1	Correct operation of the temperature sensors Pt100 / PTC	Every 6 months and after exceptional events	Hot air tool for simulated heating	Normal behaviour of the different temperature sensors
2	Correct operation of the temperature control device	Every 6 months and after exceptional events.	Hot air tool for simulated heating	Simulated alarm and trip
			Follow the instructions given in the installation manuals	
3	Cleaning of the windings from dust, dirt, grease and possible foreign bodies	Yearly. If the environment is particularly dusty, the frequency must be adequately increased	Clean, dry compressed air, maximum pressure 3 bar Dry rag	The ventilation gaps between the windings must be completely clean and open
4	Cleaning of the windings from condensation	After a period with no applied voltage	Heat by short circuit up to 80 ° C	External and internal surfaces of the windings perfectly dry
5	Tightening of the bolts of HV and LV terminals and of all the electrical connections	Yearly / after exceptional events	Torque wrench	Tightening torque according to page 31
6	Measurement of insulation resistance to earth of the windings	After a period with no applied voltage	Megohmmeter (Megger)	See page 35
7	Verify that each couple of LV and HV windings is perfectly aligned	After exceptional events such as accidental shock or short circuit downstream of the transformer.	Metro	Uniform centering
8	Tightening of the upper spacer	Yearly / after exceptional events	Torque wrench	Tightening torque between 20 and 40 Nm
9	Tightening of mechanical parts and fixing to the floor	Yearly and after exceptional events	Torque wrench	Tightening torque according to what is indicated in the table page 31

• GUIDE FOR TROUBLE-SHOOTING

Pos.	Problem	Possible reason	Corrective action
1	Overtemperature of a single winding	Load is not distributed uniformly	Check the position of the connection on the tappings
		Faulty temperature sensors or temperature control device	Replace the faulty piece
2	General overheating	High ambient temperature	Possible damaged fans Clean possible openings of the room or of the box which have been blocked Check as per pag 31
3	Overheating in the core	Eddy currents in the magnetic core, due to a damage on the insulation of the ties	Contact Technical Assistance service After Sales.
4	Abnormal noise	Primary voltage too high	Verify that the voltage on the off-load secondary windings is lower or equal to the one written on the rating plate. Check as per pag 35
	Abnormal noise	Rigid connection with the Busbar Rigid connection with the floor. Bolts of tie rods the lens nucleus	Insert flexible connections between transformer and Busbar. Insert anti-vibration pads under the rollers. Tighten loose bolts of tie rods.
5	Intervention of the alarm and tripping relay of the temperature control device, due to overtemperature	Faulty temperature sensors or temperature control device	Replace the faulty piece
		Load current higher than the nominal value on the rating plate / high content of harmonics in the load current.	Reduce the load in order to have the nominal rated current or install the air circulation system
		Difficult or not enough ventilation air flow	Check as per pag 31
		Possible poor electrical contact of the temperature sensors	Check, clean and tighten all contacts of the sensors
6	Untimely intervention of the electrical system protections due to transformer insertion	The setting of the HV circuit breaker for the CRT insertion current is too low	Modify the protection setting paying attention to the H2 control (second harmonic)

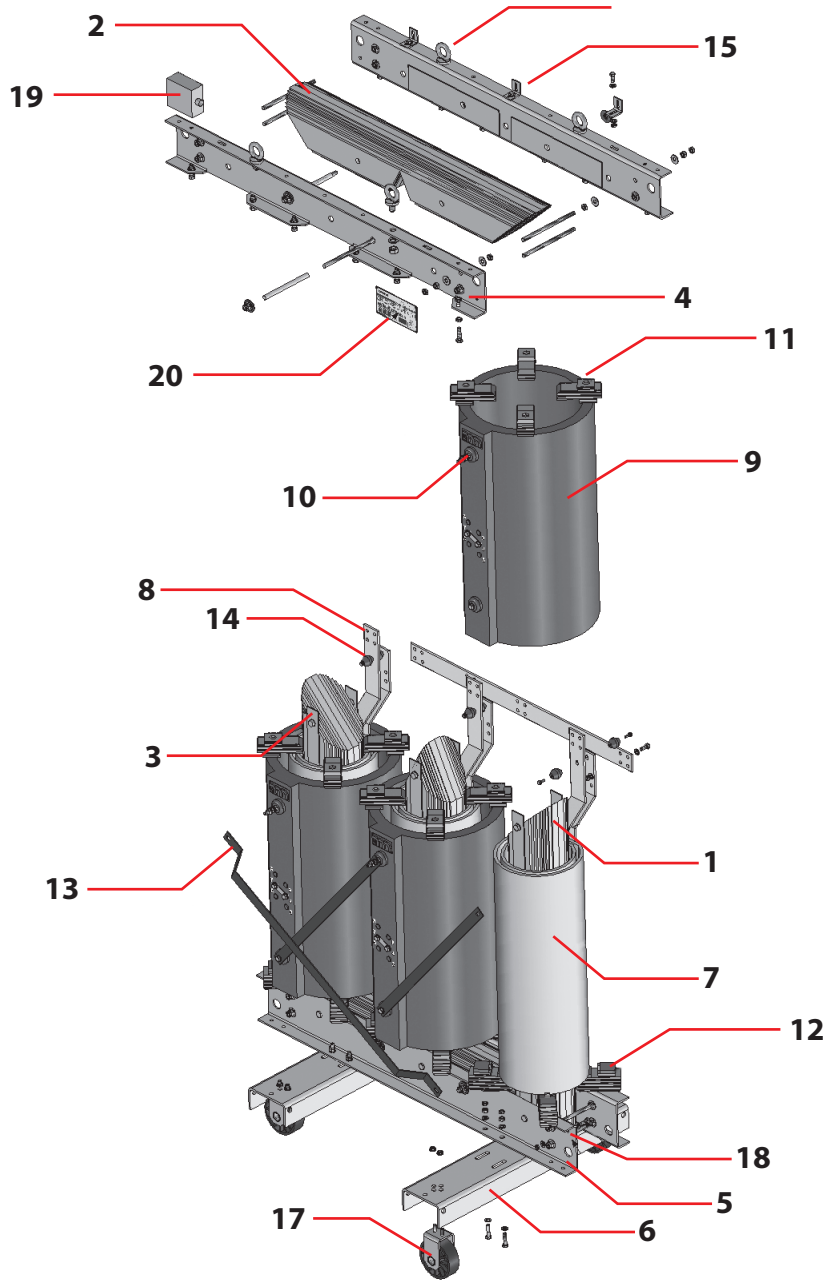
• CUSTOMER CARE

For any information or spare parts do not hesitate to get in contact with our customer service.
Call: +966 800 124 8111 / 9200 111 27 or send a mail to: sales@bahra-tbs.com

Do not forget the serial number of your transformer.

ADDITIONAL INFORMATION

- **EXPLODED DIAGRAM OF A CAST RESIN TRANSFORMER**



1. Magnetic core
2. Upper yoke
3. Core lifting rods
4. Upper core clamps
5. Lower core clamps
6. Trucks
7. LV windings
8. LV terminals
9. HV windings
10. HV terminals
11. Upper spacer
12. Lower spacer
13. HV delta connection
14. Insulators lv terminals
15. Insulator supports
16. Lifting eyes
17. Bi-directional wheels
18. Connection earthing
19. Auxiliary circuit box for probes
20. Rating plate

TECHNICAL GLOSSARY

Rated Power Sr [kVA]
rated power is the conventional value of the power assigned to a winding which, together with the rated voltage, allows us to determine the rated current.

Rated voltage of a winding Ur [kV or V]
voltage assigned to be applied, or developed at no-load, between the terminals of an winding. For a three-phase winding it is the voltage between line terminals

HV (high-voltage) winding
The winding having the highest rated voltage

LV (low-voltage) winding
The winding having the lowest rated voltage

Primary winding
A winding which, in service, receives active power from the supply network

Secondary winding
A winding which, in service, delivers active power to the load circuit

Connection symbol
a conventional notation indicating the connections of the high-voltage and low-voltage windings and their relative phase displacement expressed as a combination of letters and clock-hour figure
The star, delta, or zigzag connection of a set of phase windings of a three-phase transformer shall be indicated by the capital letters Y, D or Z for the high-voltage (HV) winding and small letters y, d or z for the low-voltage (LV) winding.
Letter symbols for the different windings of a transformer are noted in descending order of rated voltage independently of the intended power flow.

Short-circuit voltage Uk(%)
is the voltage to be applied between the winding line terminals so that the rated current circulates between them when the terminals of the other winding are in short-circuit. This voltage may be divided into a resistive component and an inductive component.
This voltage value allows calculation of the short circuit current (Icc) at the secondary terminals if the impedance upstream is neglected, according to the formula: **Icc = 100 *In/Uk**
The transformer impedance is also calculated with this magnitude. It is necessary to calculate this short-circuit current in the Low-Voltage distribution system according to the formula: **Z =Uk % * Vn / 100*In**
The transformer short-circuit currents are a function of the transformer power and are standardised on the values 4% and 6%.

No-load current (I_0)
is the magnetic circuit magnetisation current which is established in a winding when this is supplied at rated voltage and frequency (the other winding is open circuit). This current value is expressed in % of the transformer rated current. The magnetic circuit is made up of insulated laminations.

Inrush current (x In)
is the pick-up current peak which occurs when the transformer is powered. Its initial value can be even 8 – 10 times the winding rated current. The pick-up current of a transformer must be known to determine the calibrations for the associated protection devices.

Noise [dB(A)]
is caused by magnetostriction of the magnetic circuit laminations. The noise is a function of the transformer magnetic work induction and the quality of the laminations. The noise level can be expressed in terms of **sound power LwA - Acoustic power [dB(A)]** and is independent of the load.

No-load loss Po[W]
represent the active power absorbed by the transformer when the rated voltage is applied at the rated frequency to one of the two windings and with the other winding with open circuit. No-load losses, also called iron losses, are independent of the load and are equivalent to the sum of the losses caused by the hysterisis and the eddy currents (Foucault).

Load loss Pk [W] at 120°C
are instead the losses due to the ohmic currents on the main circuits, to the additional losses in the windings and to the losses on the metallic masses. These losses are proportional to the square of the load current and are expressed at a standardised reference current of 75°C for oil transformers and 120°C for cast resin transformers.

Routine test
a test to which each individual transformer is subjected

Type test
a test made on a transformer which is representative of other transformers, to demonstrate that these transformers comply with the specified requirements not covered by the routine tests: a transformer is considered to be representative of others if it is built to the same drawings using the same techniques and materials in the same factory

Special test
a test other than a type test or a routine test, agreed by the manufacturer and the purchaser

NOTES

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