Bowers Electricals Ltd
Bowers Group of Companies

Cast Resin Transformers

Installation, Operation & Maintenance Manual

2021

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Bowers Group of Companies are proud to be members of:

CAST RESIN TRANSFORMER

Installation, Operation & Maintenance Manual

CONTENT

1. INSTRUCTION FOR USE

This manual constitutes the instructions for use and maintenance of three-phase and single phase dry type transformers, including autotransformers(1) and dry type reactors(2). This manual contains instructions on how to use the transformer in respect of human health and safety. All personnel responsible for system design, installation, use and maintenance of the machine must consult the instructions contained in this manual in order to obtain best results and ensure utmost safety. The manual must always be kept with the equipment, stored with care and made available to all interested personnel.

- CAUTION: BEFORE INSTALLING THE TRANSFORMER, ALWAYS CONSULT THE INSTRUCTION MANUAL AND TECHNICAL SPECIFICATIONS OF THE TRANSFORMER!
- THIS MANUAL IS INTENDED FOR TRAINED PERSONNEL

The technical data sheets, assembly drawings, wiring diagrams and other specific documentation pertaining to the purchased transformer are an integral part of this manual.

(1)An autotransformer is a special type of transformer with only one winding
(2)A dry type reactor is an electrical machine, the scope of which is to limit the short-circuit currents in the power networks.

2. GENERAL AND SAFETY INFORMATION

2.1 Applicability

This manual applies to all dry type transformers with cast resin or air insulation, both with protection class IP00 and with protective cabinet IPXX.

This manual is intended exclusively for qualified technicians, trained on both technical and safety aspects. Bowers is not liable for operations performed by personnel without the necessary professional qualifications.

2.2 Definitions

The following definitions apply for the purposes of this manual:

Transformer:

Static electric machine with two or more windings, which, by way of electromagnetic induction, transforms a voltage and alternate current system into another system generally having different voltage and current values, of the same frequency, for the purpose of transmitting the electrical power.

Regulatory references:

European standard EN 60076-11, Standard IEC 60076-11.

This manual does not replace or relieve in any way the obligation to strictly comply with all laws and standards in force in the country of installation and use.

Classification of transformers based on type of cooling:

- **AN**: cooling through natural air circulation
- **AF**: cooling through forced air circulation (transformers with fans)

Identification of windings

Medium voltage winding: winding with the higher rated voltage "MV"; in the three-phase system the phases are indicated by 1U, 1V, 1W or alternatively A, B, C.

Low voltage winding: winding with the lower rated voltage "LV"; in the three-phase system the phases are indicated by 2U, 2V, 2W or alternatively a, b, c.

Rating plate data

Each transformer is equipped with its own rating plate containing the serial number, year of manufacture, all electrical information required and set out by the standards. The plate must remain unaltered over time and must not be modified, removed or damaged.

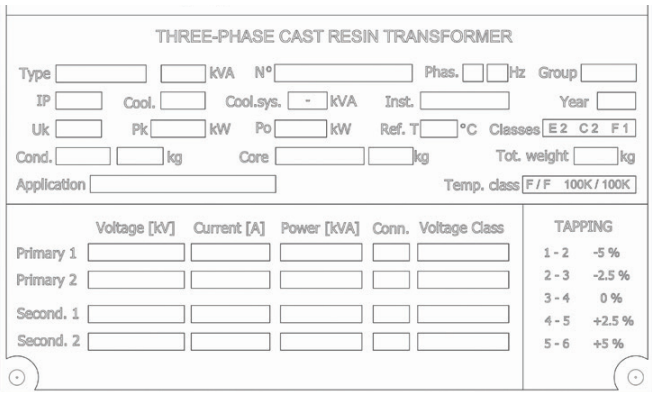
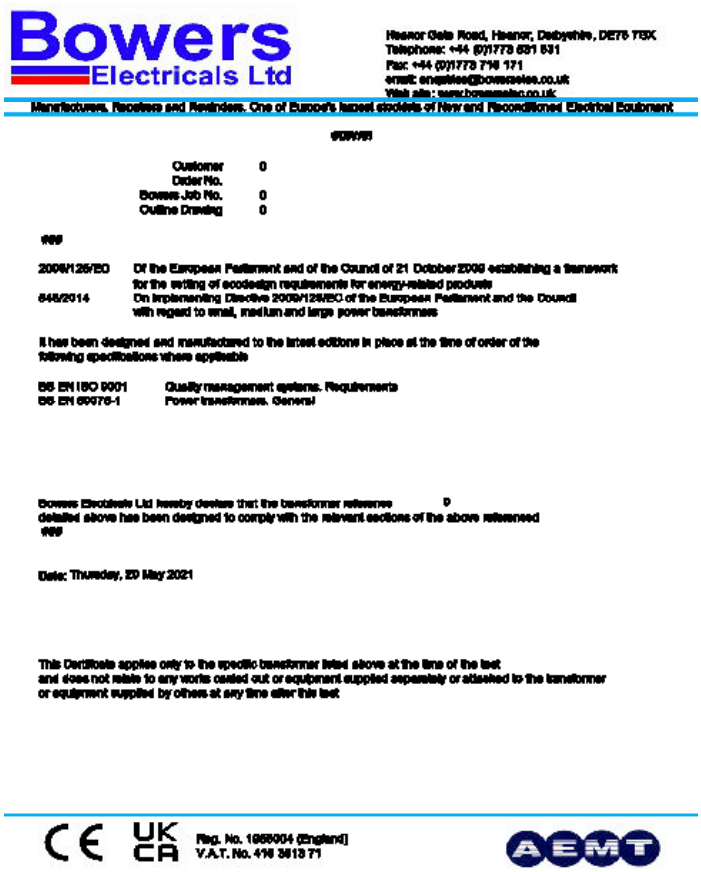


Figure 1: rating plate

Declaration of conformity with European Directives

For each transformer, a declaration of conformity is issued attesting to the positive outcome of testing as provided for by standards in force and the integrity of the equipment; where provided for, the CE marking will be indicated.



Bowers Electricals Ltd

Manufacturers, Repairers and Reminders. One of Europe's largest stockists of New and Reconditioned Electrical Equipment

Customer 0
Order No.
Bowers Job No. 0
Outline Drawing 0

2009/125/EC Of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products
548/2014 On implementing Directive 2009/125/EC of the European Parliament and the Council with regard to small, medium and large power transformers

It has been designed and manufactured to the latest editions in place at the time of order of the following specifications where applicable

BS EN ISO 9001 Quality management systems. Requirements
BS EN 60076-1 Power transformers. General

Bowers Electricals Ltd hereby declare that the transformer reference 0 detailed above has been designed to comply with the relevant sections of the above referenced

Date: Thursday, 20 May 2021

This Certificate applies only to the specific transformer listed above at the time of the test and does not relate to any works carried out or equipment supplied separately or attached to the transformer or equipment supplied by others at any time after this test

Reg. No. 1959004 (England)
V.A.T. No. 416 3613 71

Figure 2: declaration of conformity

Selection and qualification of personnel

Person professionally capable and having the necessary knowledge to perform certain operations on the electrical machines, independently and safely.

Qualification	Definition
Operator	The user's personnel exposed to the transformer and electrical systems powered thereby. The operator must not perform any works on the transformer and systems. Should the operator detect a malfunction or fault, they are obliged to inform a person of reference (person in charge of safety or maintenance).
Electrical maintenance technician	Qualified technician able to perform preventive/corrective maintenance activities on all electrical parts of the equipment subject to maintenance or repair. Qualified technician able to access all parts of the machine for visual inspection, check the condition of the equipment, make adjustments and calibrations. Qualified technician able to: • place the transformer in safe conditions, isolating it from external power supplies; • regulate the transformer and electrical systems to carry out maintenance, repairs and replace worn or damaged parts; • read wiring diagrams and check the correct execution of the operating cycle. They can operate in the presence of voltage inside electrical cabinets, junction boxes, monitoring equipment etc., only if they are an "expert person" (PEI). (See standard EN50110-1). In systems powered by medium voltage, it is expressly prohibited to perform works in the presence of voltage, the system must first be placed in safe conditions.

Qualification	Definition
Mechanical maintenance technician	Qualified technician able to perform preventive/corrective maintenance activities on all mechanical parts of the equipment subject to maintenance or repair. Qualified technician able to access all mechanical parts of the machine to perform visual inspections, check the condition of the equipment, make adjustments and calibrations. Qualified technician able to: • work on mechanical parts to carry out adjustments, maintenance and repairs; • read pneumatic diagrams, hydraulic diagrams, technical drawings and spare parts lists. Note: they are not authorised to work on energized electrical systems (if present). Works carried out by the mechanical maintenance technician are always subject to the works carried out by the electrical maintenance technician to ensure the safe condition of the equipment.
Manufacturer's technician	Qualified technician authorised by the Manufacturer and/or their distributor to perform complex operations insofar as they are familiar with the constructive characteristics of the equipment. This person intervenes in accordance with the requests of the user.
Carrier	Person responsible for transporting the transformer from the Manufacturer to the user. During transport, the transformer is placed in safe conditions, the carrier is responsible for ensuring the absence of risks associated with dynamic stresses on the equipment during its transportation. The carrier is responsible for guaranteeing the absence of damage to the equipment during its transportation.
Installer	Qualified technician responsible for positioning, connecting and commissioning the transformer. Once installation is complete, they will issue documentation attesting to correct installation and a test certificate (if required by legislation in force in the country of installation).

Table 1 of qualifications.

2.3 Warnings and main safety precautions

Transformers are electric machines that can operate with high and potentially lethal voltage levels. Failure to comply with legislation and safety procedures may cause accidents and the death of operators.

DO NOT TOUCH, RISK OF DEATH. ALL OPERATIONS ON THE TRANSFORMER MUST BE CARRIED OUT IN THE TOTAL ABSENCE OF VOLTAGE AND ONLY AFTER HAVING CONNECTED ALL METAL PARTS TO THE EARTH POTENTIAL USING THE SPECIAL INSULATING RODS

ALL WORKS MUST BE PERFORMED BY QUALIFIED TECHNICIANS PROPERLY TRAINED ON THE RISKS AND HAZARDS OF THE EQUIPMENT. THE TRANSFORMER MUST NOT BE TAMPERED WITH, FAILING WHICH ALL WARRANTIES SHALL BE INVALIDATED.

Failure to comply with the instructions provided in these instructions for use, as well as transport, installation and programming operations performed by unqualified personnel and not in compliance with the provided instructions, may compromise the correct operation of the equipment and cause serious damage to persons, property or the environment.
Under no circumstances may Bowers be held liable for consequences resulting from the violation of standards in force, the instructions in this manual or for consequences owing to the insufficient training of professional figures.

Choosing the transformer

The transformer, cables and electrical clearances must be selected by the system designer, based on the technical characteristics of the installation site (distribution, conversion, generation, elevator, etc.). **Moreover, it must be checked whether or not the installation site presents electrical phenomena that is anomalous or incompatible with the technical construction specifications of the transformer, for example the presence of harmonics, transitory overvoltages, overloads, low or high frequency phenomena, voltage interruptions, etc.**

Should the aforementioned phenomena be found, contact BOWERS BEFORE PLACING THE TRANSFORMER INTO OPERATION.

Installation site

The transformer installation site must be compatible with its correct operation. Environments that are dusty, humid or with characteristics that may compromise the proper operation of the transformer must be avoided.

In the case of particularly aggressive environments, SEA is able to provide special solutions.
Following is a list of the **prohibition and hazard pictograms** used in this manual and on the transformer itself, for the purpose of warning personnel regarding the presence of operations hazardous to their own and others' safety.

SYMBOL	DESCRIPTION
	Access is prohibited to all UNAUTHORISED persons

Table 2 prohibition symbols.

SYMBOL	DESCRIPTION
	General hazard
	Electrocution hazard

Table 3 hazard symbols.

In order to satisfy all safety requirements, during all works on the transformer, the operator is also **obliged to wear the personal protective equipment** required in the place of installation. The following table provides a non-exhaustive list of the possible personal protective equipment.

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	Work overalls must be worn		Safety gloves must be worn
	Safety footwear must be worn		A helmet must be worn
			A harness must be worn

The transformer, in certain circumstances and in the case of improper use, may expose the user and persons to potential risks. Following is a list of the main safety warnings, non-compliance with which may compromise the safety of persons and cause damage to the surrounding environment:

- All assembly, electrical connection, commissioning, functional testing and maintenance operations must be performed by qualified, trained and instructed personnel, in particular in relation to electrical risks. Bowers shall not be liable for works and operations carried out incorrectly by unqualified personnel.
- It is prohibited for NON-qualified personnel to use and service the transformer.
- The warnings and safety precautions contained in these instructions must be carefully observed, as must the legal provisions in force on the matter of worker health and safety in the country where the equipment is used.
- The provisions and instructions issued by the local company supplying the electrical energy must be complied with.
- The transformer must NOT be used for scopes other than the transformation of electrical energy; all other uses different to the intended use shall be considered improper and therefore hazardous.
- It is the user's responsibility to assess, in accordance with legislation in force, the exposure of personnel to electrical and magnetic fields generated by the equipment and by the electrical conductors in the installation site, and, if necessary, limit access to qualified personnel only and apply appropriate signage specifying the risk and prohibition. By way of example:

- Always respect the hazard signs where used.
- Any attempts to modify or repair the equipment by personnel that has NOT been authorised by Bowers. and has NOT been trained on safety standards, is prohibited. Only original spare parts and accessories or those expressly authorised by Bowers may be used in order to maintain the safety conditions. The use of different components may compromise the safety and operation of the equipment!
- It is prohibited to tamper with or remove guards and safety devices.

- Each transformer is equipped with one or more rating plates: all electrical values reported thereon must be respected during installation and operation.
- It is prohibited to change the factory settings of transformer monitoring instruments without the prior authorisation and instruction of Bowers.
- If the transformer or its parts are disposed of, the used material must always be disposed of in accordance with standards in force in the country of use.

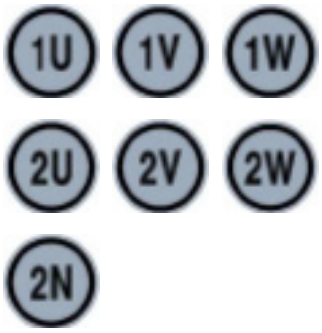
HAZARD SYMBOL	ANCHORAGE FOR TRANSPORT	GROUNDING	TORQUE	PRIMARY AND SECONDARY WINDING PHASES
				

Table 5: list of adhesives installed on transformer

Temporary works at height, with height greater than 2 metres:

For works for the installation and electrical connection of the transformers, which require the operator to work at height (height > 2 m), the user is responsible for providing all necessary means in order to operate in safety (gangways, scaffolding, aerial work platforms, etc.). If they cannot be performed in safe conditions and in suitable ergonomic conditions, choose suitable work equipment most able to guarantee safe work conditions in compliance with the following criteria:

a) Priority to collective protective measures with respect to personal protective measures;

b) Ratings of work equipment compatible with the nature of the works to be performed, the foreseeable stresses and risk-free circulation.

2.4 Transformer switching

Inrush / outrush transients in a transformer are critical operations insofar as they subject the machine to dielectric stress, which may reduce the equipment's service life. To this end, refer to the provisions laid down by standard IEC60076-1 point 13:

"Transformer switching with reduced loads or with low power factor (inductive loads) with vacuum interrupters and with SF6 may subject the transformer to potentially damaging voltage transients with frequencies up to the MHz and voltages higher than the withstand strength of the transformer. The mitigation measures, albeit not part of the transformer, may include means to increase damping through shut-down resistors-capacitors (snubbers), inrush resistors in interrupters, or switching under load. If specified by the buyer, the manufacturer must provide details of the natural resonance frequencies and/or parameters of the high-frequency transformer model."

For this reason, switching operations must be reduced to the minimum necessary and not repeated at frequent intervals. Protective means should also be adopted such as surge arrestors, installed alongside the power terminals.

In general, the resonance frequencies of the dry type transformer windings are within the range 3-500 kHz inclusive. This indicative value, in case of particular need, can be expressed on the purchased transformer through a special test, which must be requested when placing the order.

NOTE: more information is available in the IEEE C57.142 Guidelines in relation to a description of the recurrence and mitigation of switching transients produced by the transformer, the switching devices and system interaction.

3. TRANSPORT

Transport by truck

Before leaving Bowers, the transformer is covered with a protective insulating film (figure 5) to prevent the deposit of any dirt and/or possible dripping. Transport mainly takes place on trucks by road. Fixing occurs by means of ropes anchored to the holes of the casing in such a way as not to interfere with or damage the accessories or other parts of the transformer, as per the following detail.

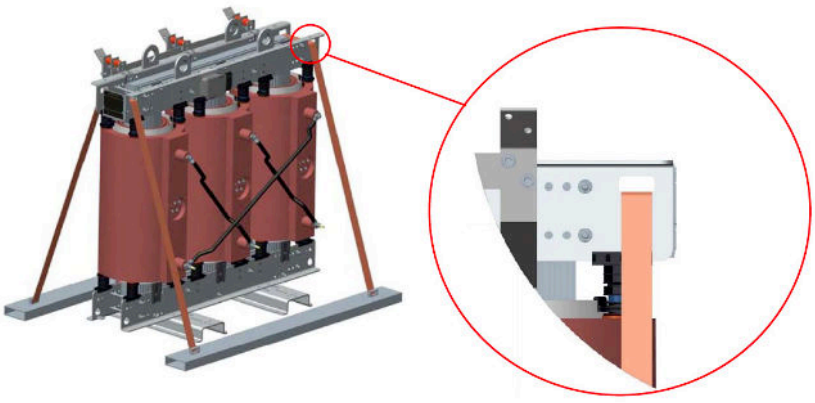


Figure 3: hooks for transport

Transport in wooden crates

In case of particular need, the transformer can be delivered in a wooden crate with its barrier bag (Figure 4), also suitable for transport via sea. Fixing occurs by anchoring the carriage of the transformer to the wooden crate and to the additional ropes, thus more securely blocking the casing and the base.

Figure 4: wooden crate with barrier bag.

Figure 5: package with protective film

The transformer is a delicate component that must be transported with care!
When the transformer arrives at the site, the following checks must be made:
- check that the transformer and its dismantled parts are integral
- take photos to document the arrival of the transformer and any dismantled parts
- check that all parcels received correspond to the waybill
- check that no parts of the transformer have been tampered with
- visually inspect the internal and external connections
- if the transformer is packaged in a wooden crate, check its integrity before uploading and opening it
If damage is found or if any accessories are missing, the carrier must immediately be notified and a note must be made on the waybill; the written claim containing photos of the damage must be send preferably on the same day and in any case by the next day, to
BOWERS ELECTRICALS

3.1 Speed limits during transport and load fixing (Directive 2014/47/EU)

The transformer and its components must:

- allow handling and transport in safe conditions
- be packaged and secured to the transport means correctly in such a way as to avoid deterioration

During transport of the machine and/or its elements, sudden movements and hazards caused by instability should not be possible. During transport, the carrier is responsible for the safety of persons or property, also for that attributable to the load itself.

See the provisions set out in relation to transport in accordance with that reported in DIRECTIVE 2014/47/EU and in particular provisions regarding the fixing of the load (art. 13). Provisions set out by the European agreement on the transport of dangerous goods by road (ADR) must also be respected when applicable.

3.2 Shock recorder (further to client request)

If a SHOCK RECORDER is to be used during transport, the equipment will be installed on a special support plate. When the transformer arrives at the site:

- the device must be removed
- the date and time of removal must be indicated on the instrument's label
- the instrument must be sent to Bowers. to assess the recorded data.

The shock recorder is part of the shipment; if it is missing or damaged, the client must file an inspection notification and send it to Bowers.

As an alternative to the shock recorder, if requested, a SHOCK DETECTOR can be installed. This device contains a coloured liquid in suspension, if the transformer is subjected to impact greater than a specific level g during transport, the impact causes the liquid to spill, thus providing an indication. However, unlike the recorder, which constantly tracks the entire period of transport, the shock detector only provides an indication of whether or not impact occurred.

Orientation of device on transformer

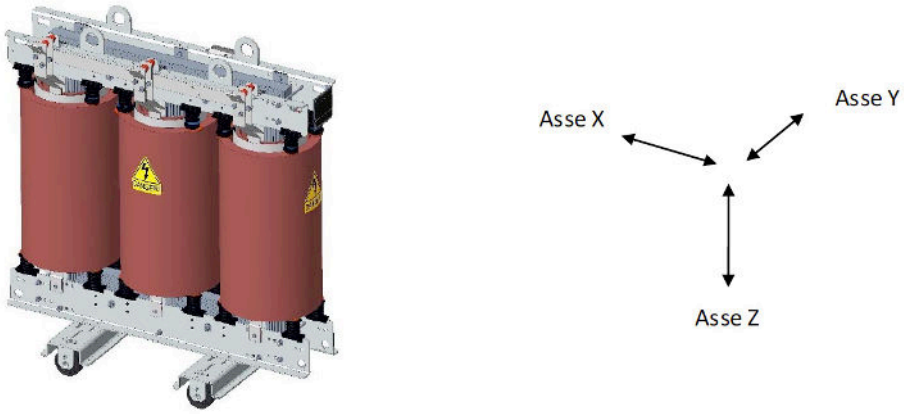


Figure 6: shock recorder.

Note that the shock recorder provides an indication of possible impacts that may have occurred during transport, it does not provide information regarding any damage or defects in the transformer. The integrity and/or any damage effectively incurred on the transformer can be verified by the manufacturer by examining the recordings made, their intensity and/or by requesting several instrumental tests or inspections.

4. HANDLING

The transformer is a fragile component that must be handled with care. For handling, use only the intended devices, **do not pull or push the transformer on the coils, connections or connected parts thereof**. During lifting, especially during the descent stage, high travel speeds must be avoided to prevent impacts that may damage the transformer.

When lifting, hauling and rotating the machine, use only the devices indicated below:

NOTE:
- Lifting and handling operations must be carried out by specialised personnel trained on how to use the lifting equipment and aware of the risks to which they are exposed.
- It is mandatory to always wear personal protective equipment and ensure third parties respect the prohibitions (it is prohibited for personnel to transit under the loading/handling area).
- Handling operations must be carried out only on a flat, level surface.
- Avoid impacts

4.1 IP00 Transformers

The lifting lugs of the transformer are suited for lifting with crane or bridge crane; check the rating plate for exact information regarding the total weight. The lifting lugs on the transformer and indicated in the assembly drawing should always be used in accordance with the following instructions.

4.2 Cabinet transformer

Depending on the rating of the transformer and for constructive reasons, the transformer may be fitted with lifting lugs accessible directly from the roof of the cabinet, through the same lifting lugs positioned on the transformer casing. In this last case, a hatch will be inserted on the roof of the cabinet allowing direct access to the lifting lugs.

Each lifting lug must be connected with its own rope. The hook on the end of the rope must have a safety device preventing it from accidentally slipping out of the lifting lug.

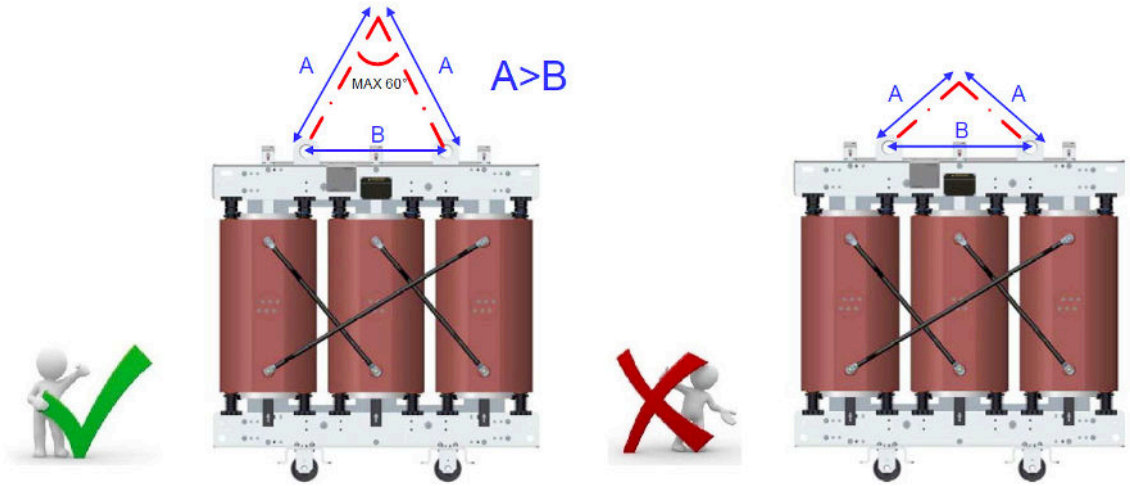


Figure 7: lifting lugs.

- *It is prohibited to lift other loads through the transformer*
- *The ropes and lifting accessories must be selected with a SUITABLE CAPACITY based on the weight to be lifted and the four ropes. They must NEVER be bent at angles greater than 60°.*
- *It is strictly prohibited to use only some of the lifting lugs.*

Lifting with forklift

The transformer can also be lifted with a SUITABLE forklift, using the carriage fitted to the base (see following figure). If possible, avoid lifting the transformer from the medium voltage side to avoid bending the connecting tubes of the triangle. For more details regarding the set-up, see the assembly drawing supplied by Bowers for the transformer.

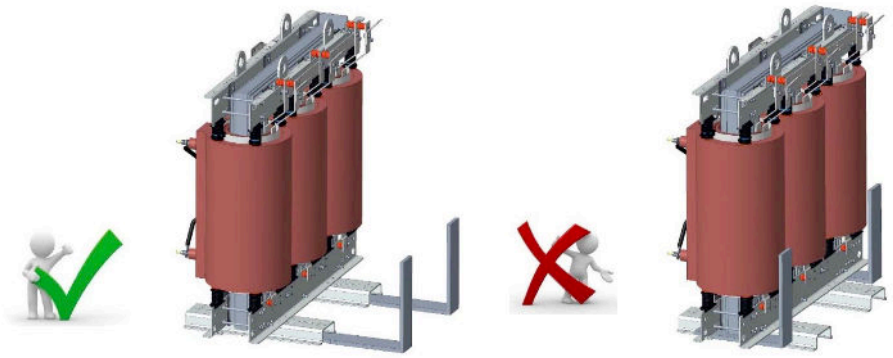


Figure 8: Carriage.

In this case also, any impacts that may damage the transformer must be avoided.

4.3 Wheel fixing

- lift the transformer with a bridge crane using suitable ropes with adequate capacity, as indicated on the rating plate of your transformer, or using hydraulic/mechanical cylinders
- ensure the lifting components are those indicated in the assembly drawing supplied with the transformer
- the transformer is equipped with 4 holes on the carriage for the installation of wheels
- position the wheels in the desired direction and secure them to the carriage (see detail below)
- the single wheel and/or wheel support may be quite heavy. Handle in accordance with the specific instructions.

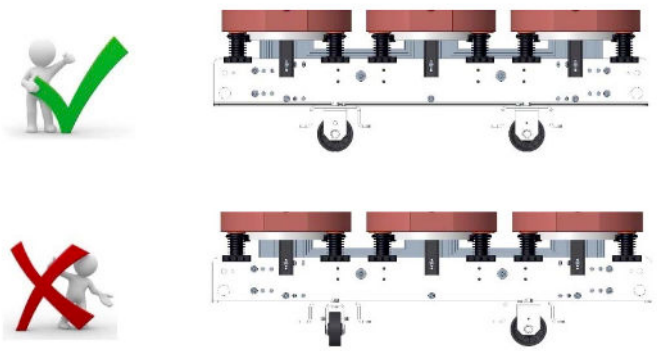


Figure 9: Wheel Arrangement.

4.4 Haulage hooks

Once the wheels have been installed, the transformer can be dragged, always on a flat surface, both longwise and crosswise using only the holes in the bottom casing (see the assembly drawing for details) as indicated in the following figure.

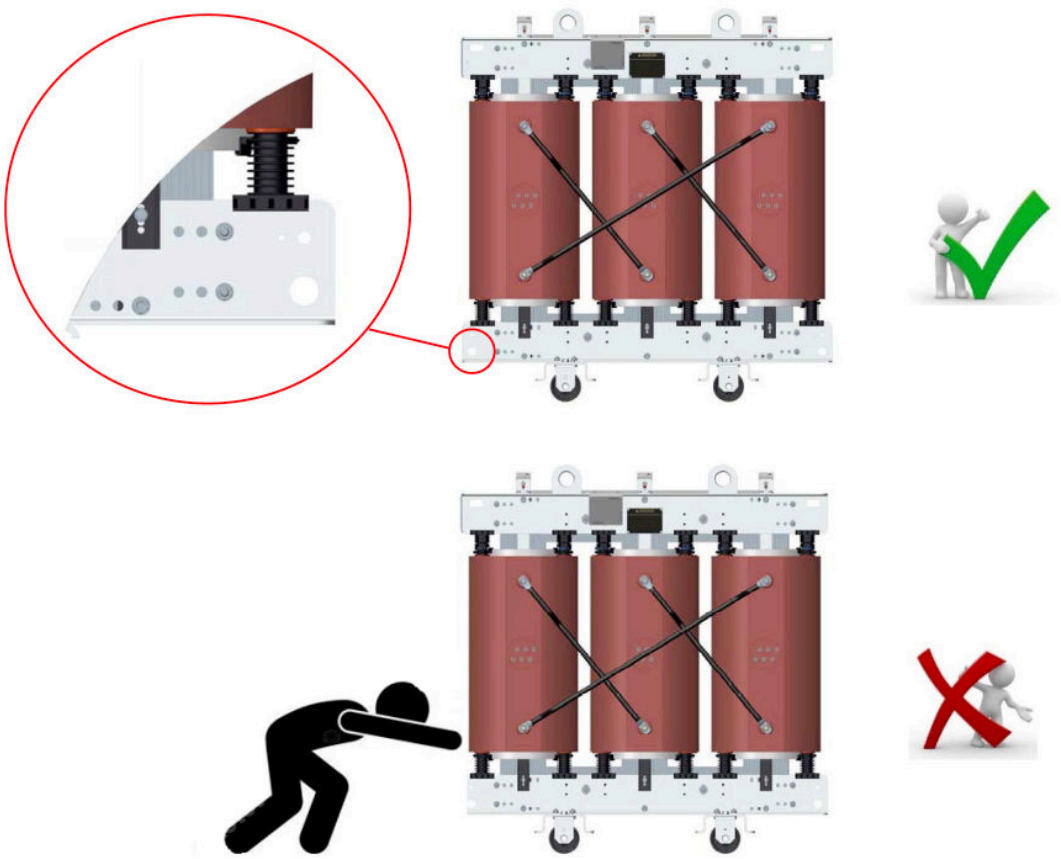


Figure 10: haulage hooks.

NOTE: When shifting and lifting the transformer, take care not to damage the accessories and other components!
CAUTION
- The wheels are rated in accordance with the weight of the transformer.
- Do not move with additional loads!
- Use minimum speed when hauling the transformer!
- The cement base must be suitably resistant, level, clean, free of holes, gravel and be perfectly smooth

5 Inspection after transport and handling

Stage	Definition	Necessary tools
General all-round visual inspection	Circle the transformer, inspect at 500 mm intervals from the bottom up. There must be no visible scratches, no shifting, no changes with respect to the new and tested transformer and with respect to the annexed assembly drawing.	Alcohol, a clean rag, meter, wrench, compressor
Coils inspection	Visually inspect the outer surface of the coils. There must be no scratches, dirt or dust deposits	
Inspect the internal medium voltage connections	Check the triangle connections using a meter, there must be no bending and no damage to the heat-shrinking part. The connections must be intact and be consistent with the assembling drawing.	
Inspect the low voltage connections	Visually inspect the low voltage bars, there must be no bending or damage.	
Check the tightness of the coils	Visually inspect the coil supports, the indicator must be positioned on the second line of reference (see para. 5.1). There must be no abnormal positions	
Cleaning	Check that the surfaces of the transformer are clean, there must be no dust deposits	

Table 6: post-transport checks.

5.1 Supports for medium voltage coils

Visually inspect the condition of the medium voltage coil supports after the transport and handling of the transformer. The standard tightness of the upper supports, performed by Bowers, requires the indicator to be positioned on the second line of reference, as per the following image. If anomalies are found following the previously described operations, proceed to tighten the supports according to the following procedure.

- Check the size of the inner/outer ring nuts on the upper installed supports.
- Find two wrenches of the same size.
- The first wrench is used to keep the outer ring nut still, the second is used to turn the inner ring nut until it reaches the second line of reference of the indicator.
- Perform the previous operation on all remaining supports

An example of correct final tightness is shown in the following image.

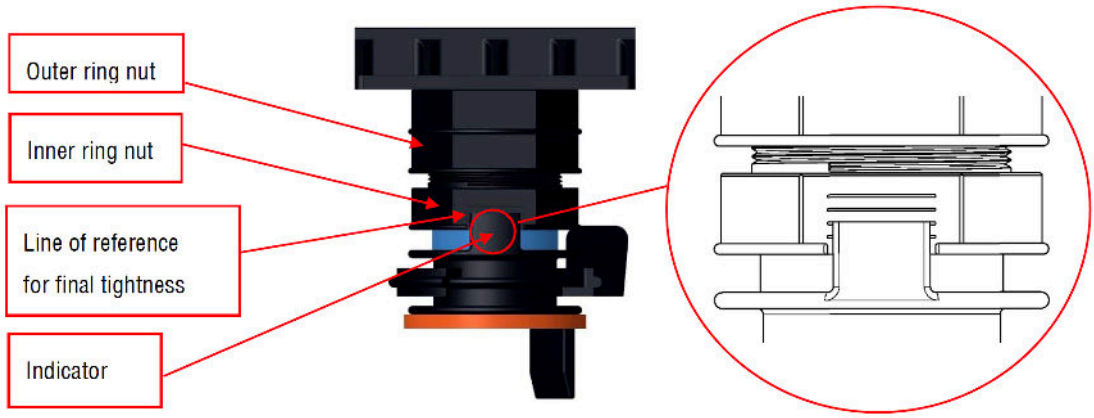


Figure 11: supports for MV coils.

IMPORTANT:
- never leave tools or metal objects on the transformer!

6. STORAGE INSTRUCTIONS

The transformers may not necessarily be immediately placed into service after delivery and therefore will need to be stored for a certain period. Dry type transformers are suitable for indoor installation, whereas outdoor installation is only allowed for versions with a protective cabinet having a suitable level of protection. The storage period is considered to begin the moment the transformer leaves the Bowers premises. Following is the list of operations to be performed:

- The transformers must be stored only in indoor, dry and well-ventilated places
- Storage temperature between -50°C and 40°C inclusive
- Avoid dusty environments
- Avoid humid environments
- Protect the transformer against accidental impact
- If the MV is fitted with plug-in bushings, keep the cover of the bushing for the entire period of storage.

Long-term storage in environments where the minimum temperature is less than -50°C must always be notified and previously authorised by the Bowers technical service.

If the transformer is stored with its packaging, insert drying salts to absorb the moisture.

7. INSTALLATION

INFORMATION FOR INSTALLATION

- *All installation operations must be performed by qualified technical personnel that has been trained on the risks and hazards that may arise during the operations.*
- *The safety warnings laid down in these instructions must be respected.*
- *Bowers denies all liability for any injury or damage caused to persons, property and to the transformer itself, following works performed by untrained and/or uninformed personnel.*
- *All works must be carried out in safe conditions in accordance with regulations in force.*
- *It is mandatory to wear personal protective equipment and to ensure prohibition signs are obeyed by any third parties.*

The client shall be responsible for checking that the network and installation site are suited to the transformer and under no circumstances may situations arise whereby the design limits of the machine are exceeded.

The following must be avoided:

- *repeated inrush / outrush currents in brief time periods*
- *overvoltages beyond the limits of insulation*
- *high frequency resonance phenomena*
- *voltage or current harmonics beyond the design limits*
- *pollution in the installation site, which may cause corrosion*
- *dust deposits that may cause a reduction in dielectric strength*
- *installations in non-compliant environments*
- *uses other than those indicated in the purchase specifications <u>the machine must also be suitably protected against surges/overvoltage using specific active or passive systems.</u>*

CAUTION

-Always keep the transformer on a NON-sloping surface during all assembly/ installation operations!

- Block wheel movement after positioning.

- Never use the transformer as a resting surface for screws, washers, wrenches and various materials: <u>forgetfulness can lead to discharge</u>

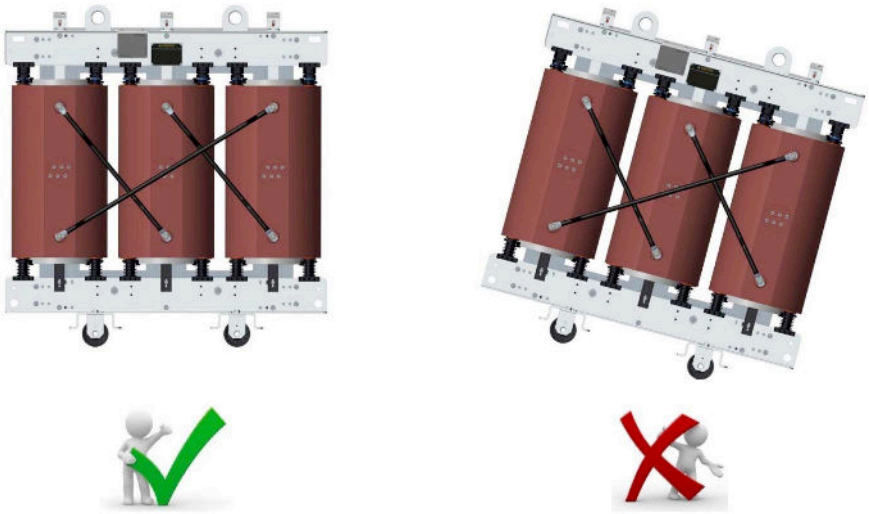


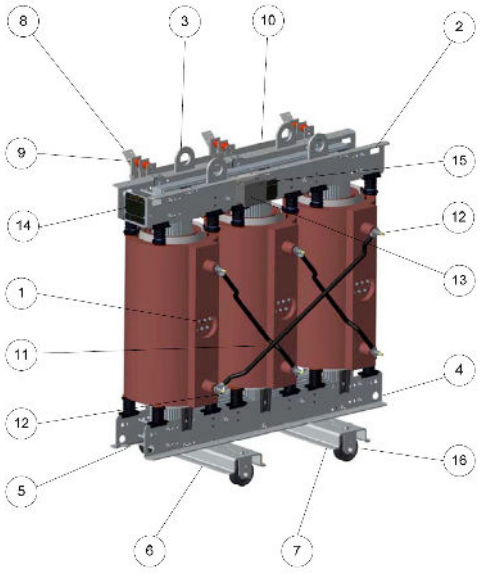
Figure 12: transformer positioning

Before starting assembly operations, check that any parts delivered disassembled are present on-site. Unless otherwise specified in the rating plate or data sheet, consider the following provisions:

- the transformer must not be installed at altitudes greater than 1000 metres a.s.l. (unless otherwise specified in the technical data sheet of the transformer)
- maximum ambient temperature +40°C
- minimum ambient temperature -50°C

7.1 Standard accessories

Transformers in version IP00 standard are supplied with the accessories and components indicated in the following figure.



Key:

1) Switching terminal block
2) Anchor holes for transport
3) Lifting lugs
4) Haulage hooks
5) Grounding terminals
6) Carriage
7) Holes for floor anchoring
8) LV line bar
9) Spacer bushings
10) LV star centre
11) MV triangle
12) MV connection terminals
13) Auxiliary terminal block
14) Rating plate
15) Connection diagram
16) Omni-wheels

Figure 13: Accessories

7.2 Optional accessories and components

The transformer may also include additional components / accessories if requested by the client when placing the order:

- PT100 temperature probe on LV windings
- PT100 temperature probe on core
- PTC probe
- Grounding spheres MV-LV side
- Temperature control unit
- Forced ventilation system with control unit for temperature monitoring
- Dial thermometer
- Set of plug-in / cone terminals
- Set of surge arrestors
- Set of vibration dampers
- Set of infra-red sensors
- Thermostat
- Protective cabinet

Contact Bowers for further technical information regarding the non-standard accessories available for your transformer.

7.3 Installation of vibration dampers

Further to a client request, vibration dampers can also be supplied fixed to the transformer carriage (a), or rested directly under the transformer wheel (b). Both must be properly anchored to the floor by means of the holes in the mounting plate.

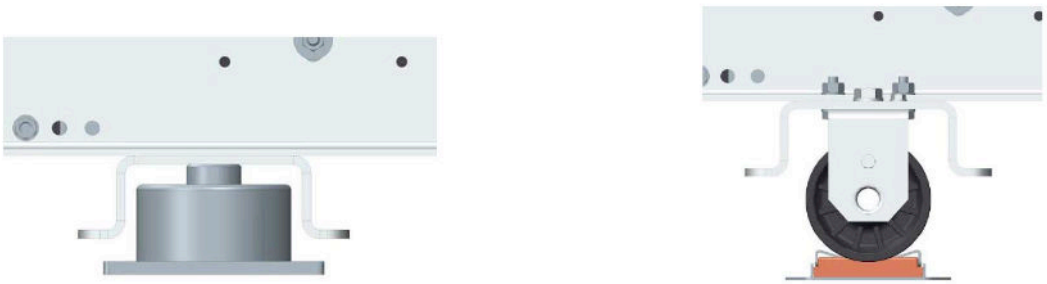


Figure 14: vibration dampers.

7.4 Installation room

The room must allow (in addition to that establi shed by regulations):

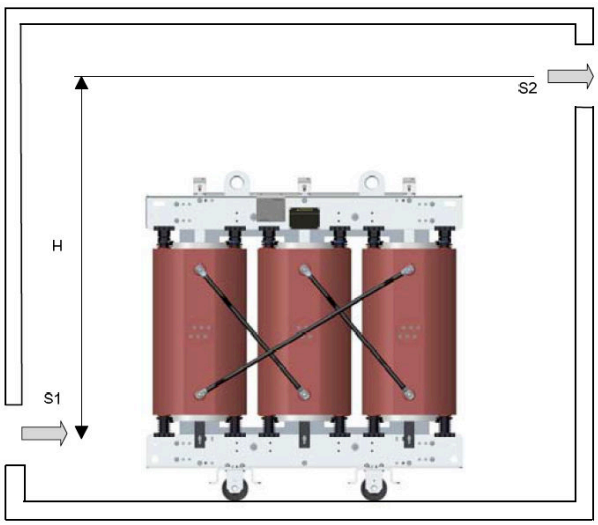
- absence of dripping and flood risks
- compliance with the clearances of the energized parts (the surface of the outer winding must be considered an energized part)
- visibility and accessibility of installed accessories
- suitable ventilation
- maximum temperature 40 °C (unless otherwise specified by the client)
- minimum temperature -25 °C (unless otherwise specified by the client)
- installation altitude < 1000 m
- flooring or rail support suited to the weight of the transformer
- absence of conductive dust or chemical substances

7.5 Ventilation

During normal operation, the transformer produces heat due to the losses in the windings and in the core. Installation rooms must be suitably sized in order that the heat produced is properly eliminated, thus preventing excessively high temperatures.

7.5.1 Natural ventilation version IP00

The installation site must be suitably ventilated to ensure best operating conditions for the transformer. In natural air cooling (AN), openings are normally carved into the front side opposite the door (S1) to facilitate the flow of fresh air from the outside, while the hot air is expelled through openings carved onto the ceiling side (S2) at a height (H).
A fresh air intake equal to 5 cubic metres per minute must be guaranteed for each kW of loss. To guarantee best ventilation, values S1, S2 and H must be calculated as follows:



Example calculation:

Ptot=sum of no-load losses and load losses (in kW) and any other losses due to other equipment installed in the same site

S1 = net air intake area in m2

S2= net air outlet area (excluding any grid surfaces) in m2

H = height between two openings in metres.

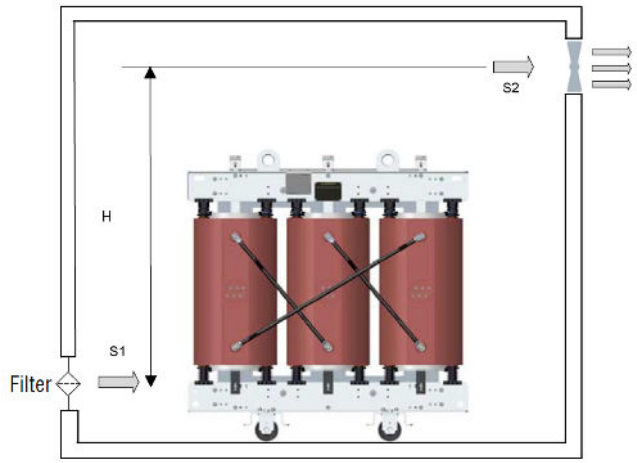
Refers to an average yearly temperature of 20°C

Figure 15: Natural Ventilation.

The ingress of small animals, foreign impurities, water, dust or other contaminants through the ventilation openings and supply ducts must be prevented.

7.5.2 Forced ventilation version IP00

Forced ventilation of the installation site is applied when the transformer is installed in an environment with scarce air circulation and when the average yearly temperature is greater than 20°C. In this case it is possible to install an air extractor on the opening in the top part of the room, in order to extract the hot air due to losses by the transformer and any other equipment therein.



Example calculation:

Ptot=sum of no-load losses and load losses (in kW) and any other losses due to other equipment installed in the same site

S1 = net air intake area in m2

S2= net air outlet area (excluding any grid surfaces) in m2, by the client

H = height between two openings in metres.

Fan flow rate = 0.11* Ptot (m3/s)

S1 0,22* Pto (Note: filter necessary)

Refers to an average yearly temperature of 20°C

Figure 16: Forced Ventilation.

7.6 Connection on MV side

The medium voltage terminals are composed of threaded brass pins, located in both the upper and lower part of the outer winding. The terminals are identified by the marking 1U-1V-1W or equivalent adhesive markings. The client can make the connection in either the lower part or upper part depending on need. The medium voltage cables can only be connected in one of the following configurations:

- CONNECTION IN LOWER PART: the cables must follow the order from left to right 1U,1V,1W
- CONNECTION IN UPPER PART: the cables must be inverted and follow the order 1V,1W,1U

In any case, the terminal markings must be respected.

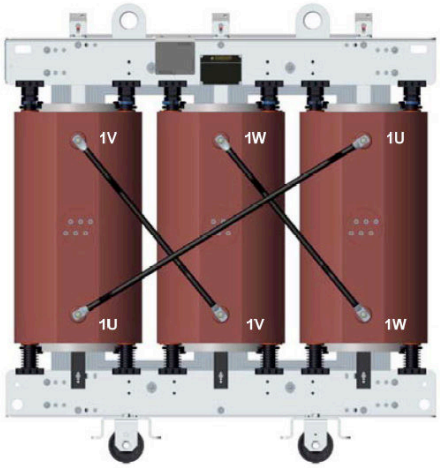


Figure 17: phase arrangement MV side.

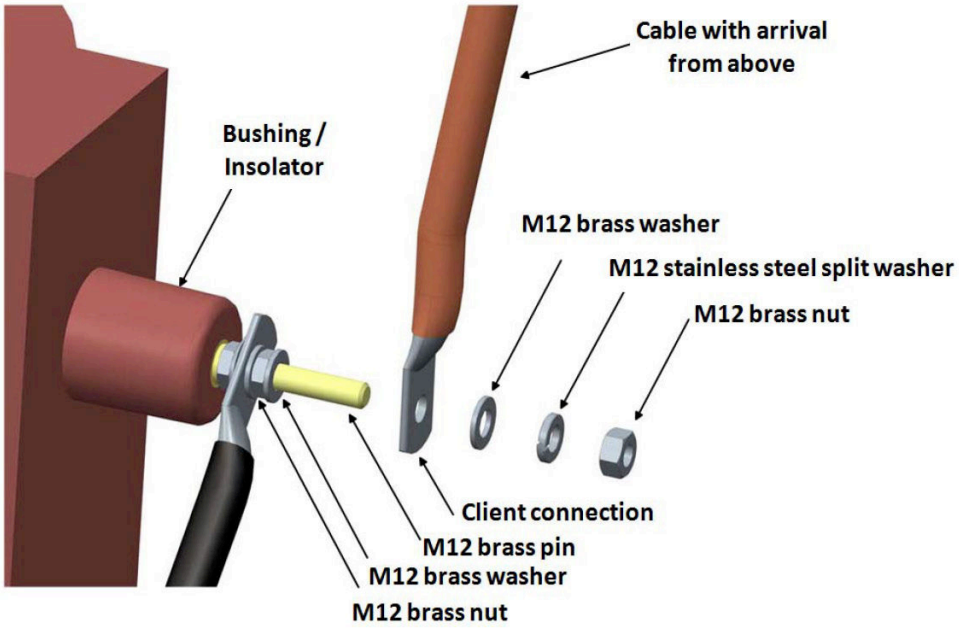
CAUTION: the terminals do not have a mechanical function. Support the cables using suitable structures that do not transmit stress to them.

CAUTION: the cables to connect the MV line must only be connected in the upper part or lower part of the transformer. They must never be connected crosswise.

The cable lugs must be assembled on the brass pins according to the layout illustrated in the following figure.
General rule:

- Position and firmly secure the connection so that the weight of the cables or any possible electrodynamic strain does not strain the brass terminals of the coils
- The minimum clearances are indicated in the standard IEC 60076-3 based on the insulation class of the transformer. In any case a minimum cooling distance of at least 150 mm from the transformer must be maintained, see table 10.
- The cable lug is blocked on the threaded pin of the terminal between the two flat washers, as shown in the figure (a) and (b).
- The applicable tightening torque is indicated in Table 7.

(a) Upper line connection



(b) Lower line connection

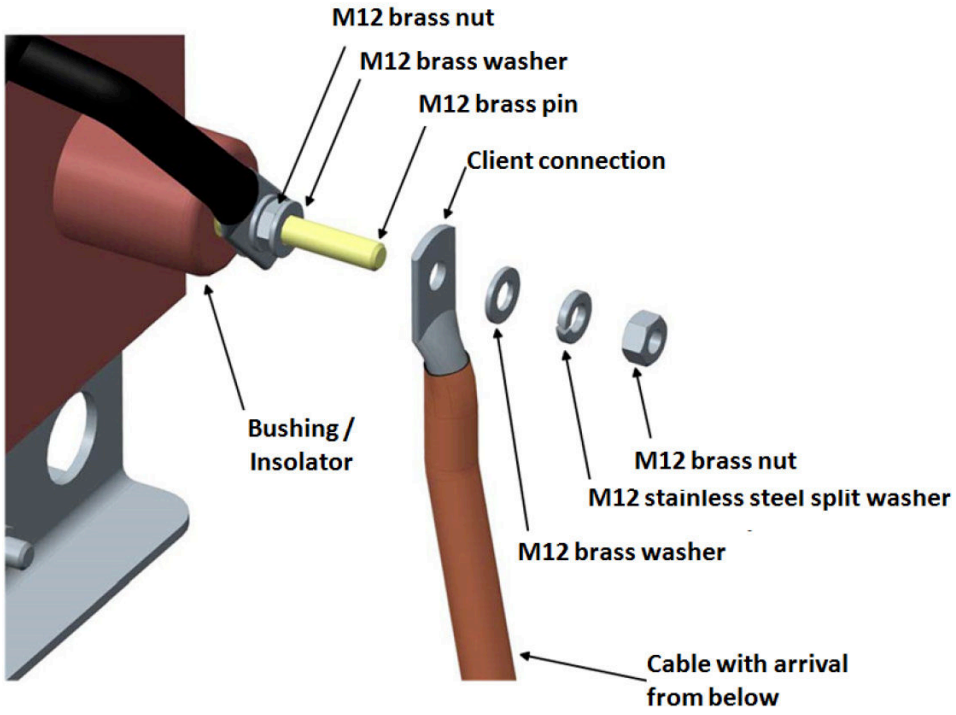


Figure 18: MV connections

7.6.1 Tightening torques

The tightening torque of all electrical type connections (current-bearing) must be made with a torque wrench calibrated in accordance with the torque values indicated in table 7 and table 8.
All surfaces characterising electrical contacts must be cleaned and brushed in order to remove any traces of oxide from the surfaces and protect them against any future oxidation before their coupling.
The tightening torque indicated in table 7 is applied to the brass bolts in the MV line connections shown in paragraph 7.6 figures (a) and (b). Table 8 indicates the applicable tightening torque on the brass plate in the MV switching terminal block.

MV connections	
screw	**Torque(Nm)**
M10	20
M12	35
M16	80

Table 7

MV switching terminal block	
screw	**Torque(Nm)**
M8	10
M12	35
M16	80

Table 8

Pay attention to the following symbols on the windings of your transformer.

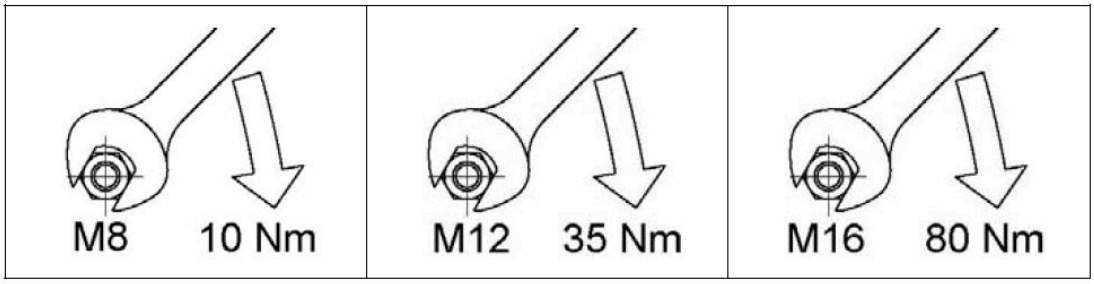


Figure 19: symbols

At the end of the operation, all surfaces characterising the electrical contacts must be covered with an anti-oxidising lubricant.

7.7 MV side connections with plug-in terminals

Check the instructions in their box to connect the plug-in cables (mobile parts). The plug ratings must be selected based on the type of cable used. The information needed for the correct definition of the plugs is:

- wire gauge
- diameter on insulator
- outer cable diameter

7.8 Connection on LV side

For the connection to the low voltage bars, the same rules apply as those for the medium voltage side.

To prevent oxidation/corrosion between the contact surfaces and improve electrical conductivity, before installation, couple the terminals as follows. All surfaces characterising electrical contacts must be cleaned, brushed and covered with a suitable antioxidant lubricant in order to remove any traces of oxide from the surfaces and protect them against any future oxidation before their coupling:

- clean the two contact surfaces with sand paper, first coarse, then fine
- apply electrical contact grease on the entire surface to be coupled (see figure below)
- in case of aluminium-copper couplings, insert a copper-plated aluminium (cupal) plate between the two joints, then cover it with electrical contact grease.
- tighten the two joints with screws, nuts and washers of a suitable rating based on the tightening torque indicated in Table 9.
- when the connection has been made, cover all the bolts with electrical contact grease to limit oxidation

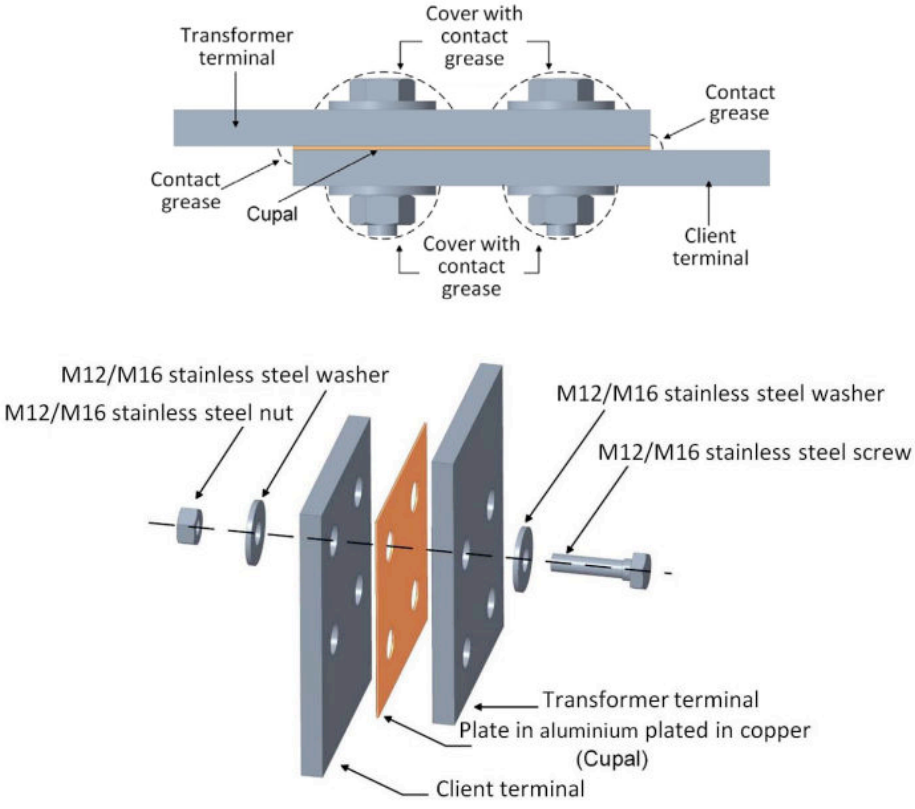
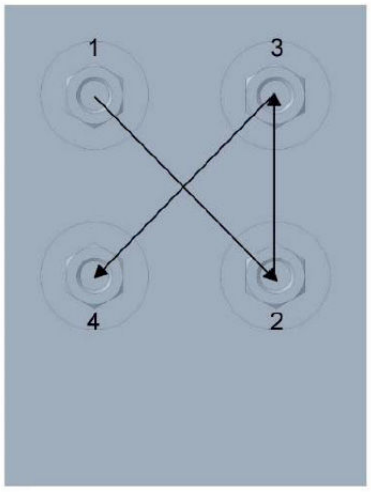


Figure 20: Terminals.

Tightening sequence for screws and nuts

The tightening sequence of screws and nuts must respect the following diagram:



NOTE

Step 1: fix screws 1-2-3-4 at 60% of the torque

Step 2: fix screws 1-2-3-4 at 80% of the torque

Step 3: fix screws 1-2-3-4 at 100% of the torque

Figure 21: Bolt Fixing

7.8.1 Tightening torques

Material	Hole Ø (mm)	screw	nut	Washer (flat)	Tightening torque (Nm)
Al , Cu	13	M12	M12	M12	85 Nm
Al , Cu	18	M16	M16	M16	150 Nm

Table 9: Tightening Torques

7.9 Ground connection

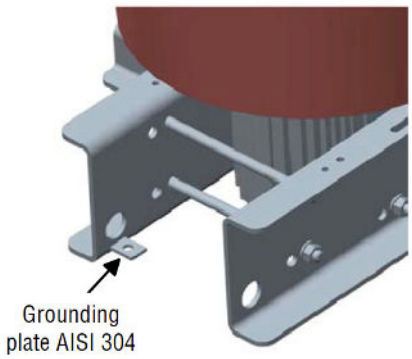
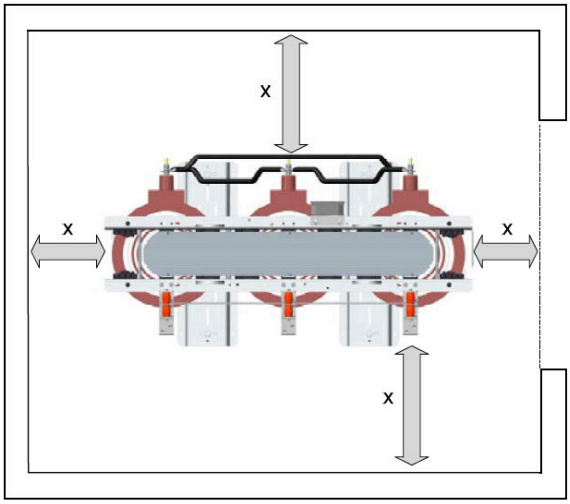


Figure 22: Ground Connection

Each transformer is equipped with two grounding plates positioned on opposite corners of the lower casing. One of these must be connected to an efficient grounding system with a copper braid having a wire gauge of at least 16 mm2. In any case, follow any provisions in force for your system.

7.10 Clearances in IP00

During installation, the positioning of the transformer in version IP00 must respect the minimum wall clearances based on the envisaged insulation voltage and cooling conditions, as indicated in the following table. If it is not possible to respect the indicated clearances, consult the SEA technical service. In regards to the clearances, no object must be positioned at a shorter distance to avoid the risk of electric discharges.

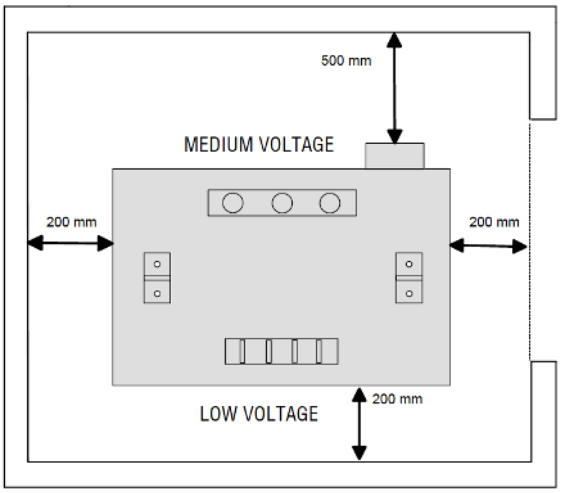


CAUTION:
THE TRANSFORMER COILS AND CONNECTIONS MUST BE CONSIDERED ENERGIZED PARTS!

Figure 23: clearances in IP00

Max Um (kV)	Peak value of lightning impulse (kV)	Minimum electrical clearance (mm)	Minimum cooling clearance [X] (mm)
3.6	20	60	150
	40	60	150
7.2	40	60	150
	60	90	150
	75	120	150
12	60	120	150
	75	120	150
	95	160	160
17.5	75	120	150
	95	160	160
	125	220	220
24	95	160	160
	125	220	220
	150	280	280
36	145	270	270
	170	320	320
	200	380	380
52	250	480	480

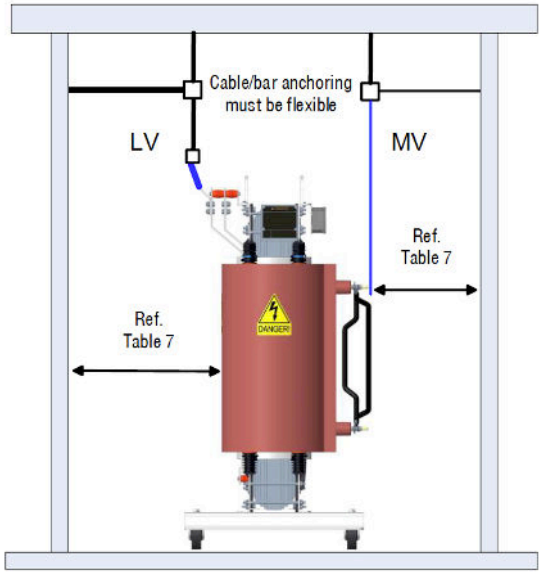
Table 10: Clearances as per IEC 60076-3



If your transformer is equipped with a protective cabinet with IP from x1...x3 (e.g. with protection level IP31), it cannot be installed outdoors. Consider that the minimum clearances between the walls of the room must be respected as per Figure 24. In any case, the technical sizing of the room must be such as to guarantee the cooling of the equipment.
Note: the standard protection level of the cabinet floor is normally IP21.

Figure 24: Clearances in Cabinet

7.12 Positioning of terminals



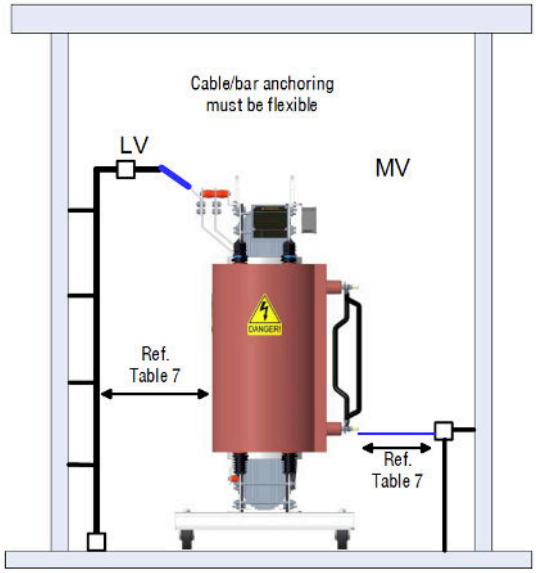


Figure 25: Upper MV/LV connection.

Figure 26: Lower MV/LV connection.

The cables and/or busbars must be firmly secured to the terminals of the transformer in order to avoid any mechanical strain on the terminals: this may compromise the correct operation of your transformer. The connections to the LV and MV terminals of the transformer can be made both from above and below (see Figure 25 and Figure 26). SEA provides standard terminals with MV output below and LV output above; any variations in the positioning of the terminals must be communicated when placing the order. When making the connection, a certain clearance must be maintained between the cables and the energized parts of the transformer, as indicated in Table 10.

Where there is a protective cabinet, the cables and/or busbars must be properly anchored to the structure. The connections to the transformer bars must be made using bars with flexible joints so as to avoid mechanical strain on the terminals.

Bowers cabinets are fitted with openings on the floor and roof of the cabinet in correspondence of the medium and low voltage, suitably closed by a bolted aluminium plate, or with cable glands (not supplied standard) so that the user can connect from both below and above. The cabinet too is supplied standard with MV output below and LV output above.

If a cabinet with reduced width is required, the electrical clearances must nonetheless be respected. Select a suitable cable route!

CAUTION: do not pass in front of the triangle with the cables.

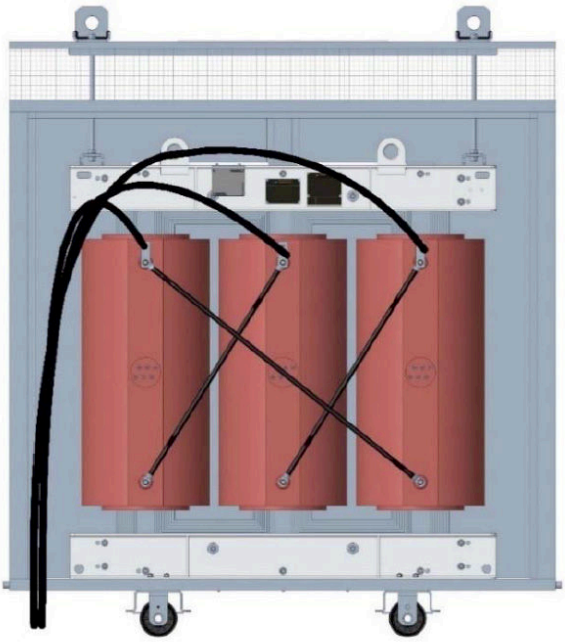


Figure 27: Cable Entry

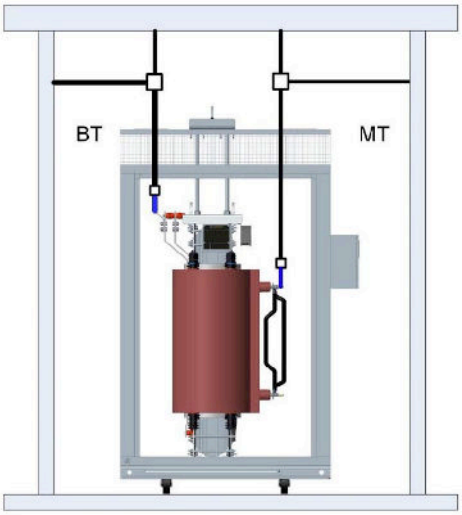


Figure 28: Upper MV/LV Connection

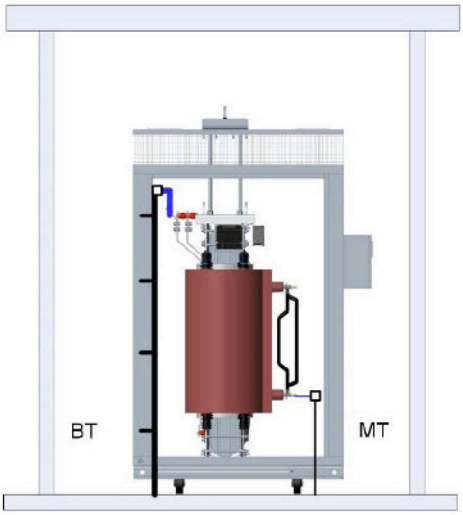


Figure 29: Lower MV/LV Connection

Note: the connection shown in Figure 29 considers that the LV cables inside the cabinet must be anchored to the front panel; for connections different to those proposed, contact the SEA technical service.

IMPORTANT:
When making the connection, a certain electrical clearance must be maintained between the cables and the energized parts of the transformer, as per table 10. Check the clearances before placing the transformer into operation and the level of initial protection.

IMPORTANT:
Check the clearances before placing the transformer into operation.

7.13 Variation of primary voltage

The transformer is normally equipped with a 3- or 5-step switching strip (see rating plate on transformer), created directly on the surface of the MV coil.

This strip contains 4 (or 6) terminals marked with numbers from 3 to 6 (8). Two of these terminals, one with odd numbers and one with even numbers, are connected to each other by a brass bar, see Figure 30. See the switching plate attached to the transformer to match the various connections and available voltages. Other types of configurations depend on the transformer make, check the assembly drawing supplied by Bowers.

IMPORTANT:
Disconnect the transformer from the network or place it on the ground before operating on the strip.

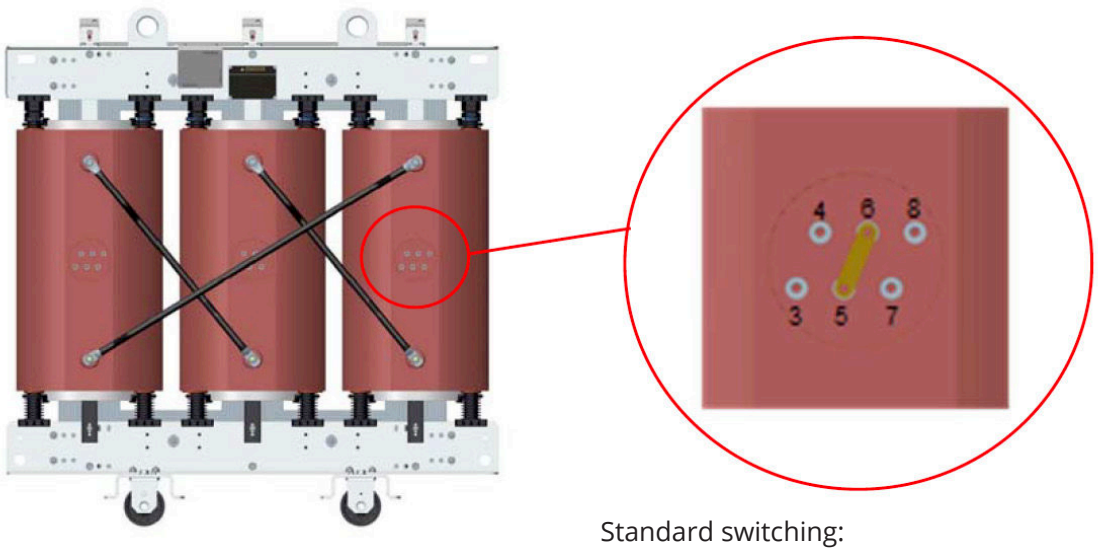


Figure 30: switching terminal block.

To change the position of the strip, proceed as follows:

- unscrew the screws securing the bar.
- reposition the bar as desired (see the switching plate, normally attached to the upper casing).
- Tighten the screws again, following the original assembly sequence (terminal / brass washer / bar /steel washer / spring washer / screw) using a torque wrench, see Table 8
- Check that on each strip, only two terminals are connected by one bar, only one even with only one odd.

Check that all tap terminals on the coils are connected on the same switching position. None must be left open or not fixed.

The position is selected so as to adapt the primary voltage of the transformer as much as possible to the available voltage in the system. With the same network voltage, the tap changer can be used to adjust the voltage on the LV side as follows:

- **Connection toward voltages higher than the rated voltage: the LV voltage is lowered;**
- **Connection toward voltages lower than the rated voltage: the LV voltage is increased.**

Note: the tap changer is properly connected when the voltage of the secondary winding (untapped) is equal to the value indicated in the rating plate (for example: for a transformer 20000±2 x 2,5%/400 V, after switching, the voltage should be 400 V)
Do not connect the strip on the less-than-rated voltage position, if the network supplies a higher-than-rated voltage.
Never use the tap changer to adjust the voltage of the untapped winding: in this case, the operating induction would be modified with the consequent possible increase in noise, no-load losses and core temperature.
Under no circumstances can the rated power be exceeded.

The transformer can be designed to work at one or more primary voltages: in all cases, it is always supplied with a rating plate that summarises all operating modes and relative connections. Following is a list of the possible primary voltage changes.

7.13.1 Series/parallel operation

In this case, the primary voltages are one double the other (for example: 20-10 kV). The transformer has a primary winding split into two perfectly identical parts, where they can be connected in series or parallel. Each section is fitted with its own switching strip.
The series/parallel connections are made externally to the coils, therefore the transformer is always supplied with the materials to make both connections. Store the materials for any future voltage changes.

Always remember to remove the “series” connection bar when making the “parallel” connection and vice versa.

7.14 Post-installation check

Stage	Criterion	Notes
Check ground connection on casing	Visual + multi-meter inspection. Check that there is a connection, of a suitable section, check the torque and electrical continuity.	Ground connection section conforms to system short-circuit current.
Ground connection section conforms to system short-circuit current.	Check that there is a connection, of a suitable section, check the torque and electrical continuity.	

Stage	Criterion	Notes
Check the tightening torques of the MV connections	Visual inspection, check the torque of the cable connections and triangle as per table 7.	
Check the tightening torques of the LV connections	Visual inspection, check the torque of the low voltage connections as per table 9.	
Check the tightening torques of the ground connections	Visual inspection, check the torque as per standard DIN 267 for screws in class 8.8	
Check the tightening torque of the terminal block	Visual inspection, check the torque as per standard DIN 267 for screws in class 8.8	
Check the cable anchoring	Visual inspection. The cables must be fixed to an independent structure and must not transmit any force to the transformer terminals.	
Check for activation of heaters	Visual inspection. Check values of thermostat settings	

Table 11: post-installation checks.

7.15 Installation environment checks

Stage	Mode	Criterion	Notes
Check that it is a filtered environment	Visual	Check that no dust, sand or other can be aspirated	
Check the air conditioning system	Visual	Check that the air conditioning system works and maintains a suitable temperature in accordance with the design specifications	Maximum ambient temperature: 40 °C. Mean daily maximum temperature: 30 ° C. Mean annual maximum temperature: 20 ° C
Check the clearances of equipment that may compromise correct cooling	Visual	Check that there are no hot air outlets, for example from the inverters	

Table 12: installation environment checks.

Check that there are no foreign bodies on the transformer.

8. COMMISSIONING

Before starting up the transformer, it is important to check the correct operation of the instruments/accessories installed on the transformer, so as to ensure their correct operation (see table below).

Refer to the diagram of the auxiliary circuits and the assembly drawing supplied by Bowers, which includes the layout and correct identification of all instruments envisaged on your transformer (temperature control unit, fans, fan control unit and any other accessories). Moreover, check that all the above guarantees a suitable safety clearance as indicated in table 10.

CAUTION
ALL THE FOLLOWING OPERATIONS MUST BE CARRIED OUT WITH THE TRANSFORMER DISCONNECTED FROM THE SUPPLY LINE WITH A SUITABLE AND SAFE GROUND CONNECTION (DE-ENERGIZED ELECTRICAL WORKS)! THE OPERATIONS MUST BE CARRIED OUT BY QUALIFIED TECHNICIANS WITH GOOD KNOWLEDGE OF BOTH ELECTRICAL SYSTEMS AND SAFETY REGULATIONS.

It is mandatory to wear personal protective equipment and to ensure prohibition signs are obeyed by any third parties!

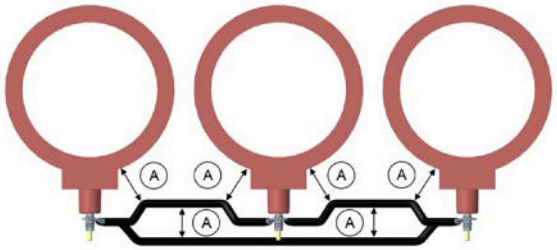
8.1 Preliminary checks

Component	Description of Check
Transformer	1) Check that the transformer is dry and clean. 2) Check the ground connection of the de-energized metal parts. 3) Check the electrical clearance of the energized parts to ground in accordance with table 10, and the cooling clearance. 4) Check the torque of the LV and MV terminals and respective strips (tap terminals), applying the following indicated tightening torque values. 5) Check that the position of the voltage change bars is the same on all three phases, as indicated on the plate. In case of a transformer with multiple voltages, also check that the position corresponds to the voltage of the system by which the transformer will be powered. 6) Check the correct operation of the interrupters installed to protect the transformer on the MV and LV side. 7) Check the correct calibration and operation of the overload and short-circuit protective relays. 8) Check the correct calibration and operation of the over-temperature protective relay (temperature control unit) and relative probes. 9) Check the operation of the fans and relative control circuit, if envisaged on-board the transformer or inside the box. 10) Check the general conditions of the transformer and proceed to measure the insulation resistance with a Mega-Ohm-meter at 2500 V. 11) Check that the transformer doesn't operate in over/under-excitation. The LV voltage must be the same as the design voltage
PT100 Probe Box	Check that: - the probes are inserted in their dedicated tubes, all at the same depth. - the cable is secured and cannot fall due to vibration. - the box is properly closed - the probe shielding is grounded (Multi-meter) - the terminals are properly tightened
Control Unit and Probes	Check the setting of the thermometer/control unit, the alarm and cut-off temperature and ventilation (if included) must be set based on the over-temperature envisaged for the transformer, according to table 15. Check that the installation and programming have been carried out in accordance with the manual.
MV Triange	Check that the MV triangle tube is not bent or damaged with respect to the original configuration made by BOWERS. The minimum clearance values between the connections must comply with table 14.

Component	Description of Check
Installation room	Check the temperature of the installation site before energizing the transformer, the temperature must not be less than -25°C

Table 13: preliminary checks.

BIRD'S EYE VIEW - MEDIUM VOLTAGE



Insulation levels (kV)	Minimum clearance (A)
1.1 – 3	20
3.6 – 10 – 40	45
7.2 – 20 – 60	55
12 – 28 – 75	65
17.5 – 38 – 95	75
24 – 50 – 125	95
36 – 70 – 170	120

Table 14: Electrical Clearances

	Class B (80° C)	Class F (100° C)	Class H (125° C)
Alarm	115 °C	140 °C	160 °C
Cut-off	125 °C	150 °C	170 °C
Ventilation (*)	75-55 °C	100-80 °C	120-100 °C
(*) the ventilation function is never considered in the dial thermometer. For the control units, refer to the diagrams and specific manual of the equipment insofar as the possible settings and modes vary depending on the make.			

Table 15: thermal protection setting values.

Note: the allocation of values (ON-OFF) is such as to avoid damaging on/off cycles around the set value. around the set value.

Insulation resistance measurements

The aim of this test is to measure the insulation resistance of the magnetic part of the transformer between the HV and LV windings.

Measuring instrument: Mega-Ohm-meter

Refer to the resistance values provided in the table based on the insulation class:

The measurement must be made with the MV and LV connections disconnected from the system, therefore before connecting the cables and/or busway. The measured resistance values must be in proximity of those indicated in table 16.

Minimum insulation resistance at 20 °C		
Insulation class (kV)	**Mega-Ohms**	**Voltage to be applied (for 1 minute)**
1.1	≥ 500	2500 V
3.6	≥ 750	2500 V
7.2	≥ 1000	5000 V
12	≥ 1000	5000 V
17.5	≥ 1000	5000 V
24	≥ 1000	5000 V
36	≥ 1000	5000 V

Table 16: insulation resistance.

If the values are significantly lower, the transformer must be dried, and if necessary, contact our service centre.

Closure of interrupter MV side

When the interrupter closes, the transformer emits a dry sound, which fades within a few seconds until stabilising. It is normal for the noise produced in the first few minutes to be louder than usual.

Check the coherence of the secondary voltages

Before closing the low voltage interrupter or making additional checks for the parallel with the other transformers,

it is necessary to:

- Using a voltmeter, check the value of the three phase-to-phase voltages and three star voltages.
- Using a sequence meter check the cyclical direction of the phases.

If the values correspond to those of the plate, it is possible to proceed with start-up or perform the checks for parallel operation.

8.2 Criteria for parallel connection with another transformer

If a parallel connection must be made with another transformer already in operation:

- Check the compatibility of the data on the transformer rating plates
- The transformers must have the same phase displacement and must be properly connected respecting the phase sequence and correct polarity.
- The transformers must have the same transformation ratio within the allowed tolerances.(±0.5%) they must be connected to the corresponding outlet at the same voltage.
- The transformers must have the same short-circuit impedance as a percentage of the allowed tolerances (±5%). Secondly, the ratios between the inductive and resistive part (x%/r%) must also be checked. The values must be within ±5%
- The power of transformers to be connected in parallel must never exceed the ratio between 0.5 and 2 (half or double the power)
- Use a voltmeter to check the correspondence of the phases by measuring the voltage between phase “one” of the transformer already in operation and phase “one” of the transformer to be connected in parallel. The value should be zero.
- Check the closure of the measuring circuit
- Connect the transformers respecting the polarity and phase sequence.

Do the same for phase 2 and phase 3.

Complete the commissioning of the transformer by closing the LV switch and energizing the electrical cabinet.

9. MAINTENANCE AND PERIODIC INSPECTIONS

Correct maintenance is essential to guarantee the long service life and best performance of the transformer. For this reason, Bowers has drawn up a series of checks and maintenance works to be carried out annually. The scheduled maintenance, however, does not completely satisfy all transformer needs: ordinary care is also required during the initial period, such as cleaning.

CAUTION
ALL THE FOLLOWING OPERATIONS MUST BE CARRIED OUT WITH THE TRANSFORMER DISCONNECTED FROM THE SUPPLY LINE WITH A SUITABLE AND SAFE GROUND CONNECTION (DE-ENERGIZED ELECTRICAL WORKS)!

THE OPERATIONS MUST BE CARRIED OUT BY QUALIFIED TECHNICIANS WITH GOOD KNOWLEDGE OF BOTH ELECTRICAL SYSTEMS AND SAFETY REGULATIONS.

It is mandatory to wear personal protective equipment and to ensure prohibition signs are obeyed by any third parties!

If the installation environment is particularly critical (dust, pollution, etc.) maintenance must be performed every three months. The more critical the situation, the more frequently maintenance must be carried out.

9.1 Routine annual maintenance

Resin-insulated transformers do not require excessive maintenance. A careful inspection of the transformer during its operation will allow the prevention of faults and extend the service life. In normal operating conditions, it is sufficient to carry out the following operations once per year:

COMPONENT	OPERATION	REGULARITY	INSTRUMENT
Windings and cooling ducts	Cleaning of MV/LV windings of any dust deposits, conden-sate and dirt. Cleaning of the cooling and ventilation ducts between the coils to avoid overheating during operation.	once per year (more than once in case of special events or conditions)	Low pressure dry compressed air. Clean and dry rags. (DO NOT use abrasives, solvents or substances that may compromise the opera-tion of the transformer)
Nuts and Bolts	Check the tightening torque of the MV and LV connections and bars of the tap terminals	once per year (more than once in case of special events or conditions)	Torque wrench (values as per table 7-table 8 – table 9)

COMPONENT	OPERATION	REGULARITY	INSTRUMENT
Thermal protections (control unit, resistance temperature detectors)	Check of correct operation of thermal protections (temperature probes and temperature control unit) as well as correct intervention of alarm and cut-off protections.	once per year (more than once in case of special events or conditions)	Hot air dryer to heat simulated temperature probe, maximum temperature 160°C
Bar ventilation grilles (and fans)	Operate the cooling devices to check their correct operation. Clean the impeller so as to eliminate any dust and dirt deposits	once per year (more than once in case of special events or conditions)	dry compressed air, fan control unit
Winding Insulation	Check the insulation between the windings and ground.	once per year (more than once in case of special events or conditions)	Megohmmeter, (values indicated in Table 166)
Note: if unavoidable deficiencies are found, contact our Service Centre immediately (see the end of this manual)			

Table 17: Maintenance.

NOTE: before performing any type of operation, check that the lighting in the workplace and/or inside the cabin is adequate; the lighting must be sufficient to allow the operator to perform switching operations and view the electrical parameters of the transformer, otherwise use suitable additional lighting devices.

9.2 Special maintenance

If the transformer operates in discontinuous service, before start-up and in particular, after long periods of storage, all pre-commissioning checks previously listed must be carried out. Alternatively, if the transformer operates in particularly humid conditions or in a polluted environment and is subject to frequent overloads, it is recommended to increase the frequency of maintenance works reported in Table 17 .

9.2.1 Magnetic core

If during normal operation the transformer emits a louder-than-usual noise, this may be due to the loosening of the tie rods on the yokes in the core, as per the following image. The upper and lower tie rods will therefore need to be properly tightened on both sides of the core, with the following torque values.

Screw	Tightening torque (Nm)
M12	69
M16	128
M20	332
M24	574

Table 18: torque values

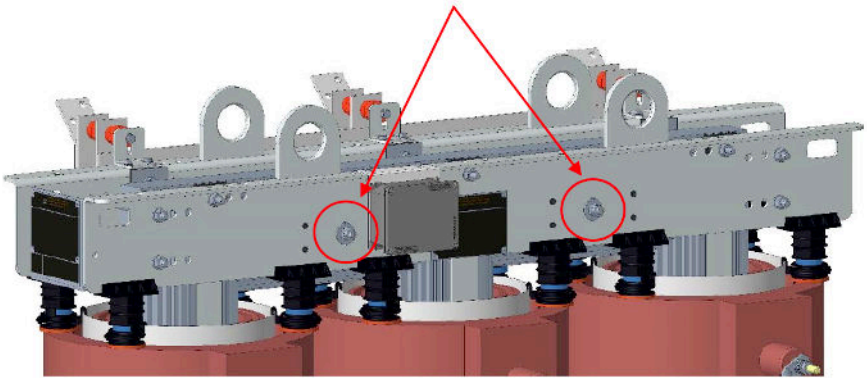


Figure 31: tie rods on core

10. ACCESSORY REPLACEMENT

10.1 PT100 probe replacement

CAUTION:
ALL THE FOLLOWING OPERATIONS MUST BE CARRIED OUT WITH THE TRANSFORMER DISCONNECTED FROM THE SUPPLY LINE WITH A SUITABLE AND SAFE GROUND CONNECTION (DE-ENERGIZED ELECTRICAL WORKS)!
it is mandatory to wear personal protective equipment and to ensure prohibition signs are obeyed by any third parties!

If one or more PT100 probes need to be replaced on the transformer, proceed as follows:

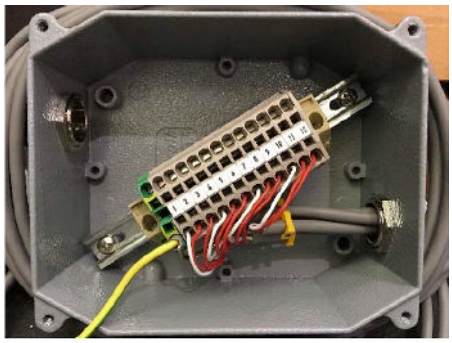


Figure 32: terminal block

Inside the auxiliary box with 4 installed probes:

- no.3 PT100 sensors on LV windings 2U – 2V – 2W
- no.1 sensor on core

wired in terminal block.

Sensor on core

To replace the sensor on the core, insert a scalpel/screwdriver in the section of panel corresponding to the sensor support, Figure 33. By prying it open with the scalpel/screwdriver, it is possible to extract the metal part securing the sensor to the core, Figure 34.

Leave the scalpel/screwdriver in the core so as to leave enough space to re-insert the sensor.

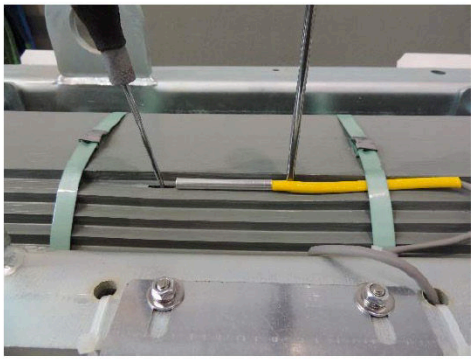


Figure 33:

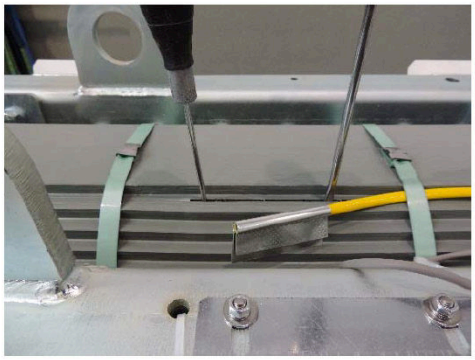


Figure 34:

It is now possible to replace the sensor: remove the sensor from the yellow protective tube and insert the new one.

IMPORTANT:
<u>the scalpel/screwdriver must be removed when the operation is complete!</u>

Sensors in windings

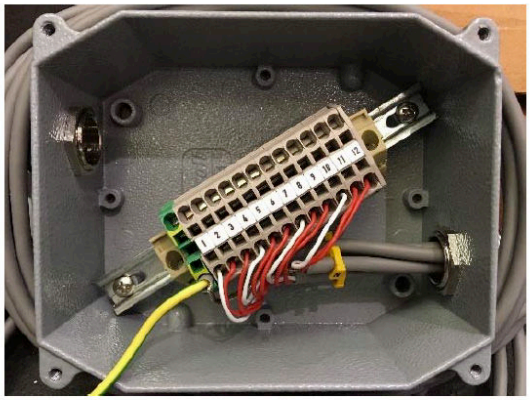


Figure 35:

To replace the sensors in the windings, the sensor must be extracted from the tube and replaced with a new one (Figure 36, Figure 37, Figure 38).
Finally, check that the shielded cable, connected to the output of the auxiliary box, is at least one metre away from the transformer's medium voltage cables.

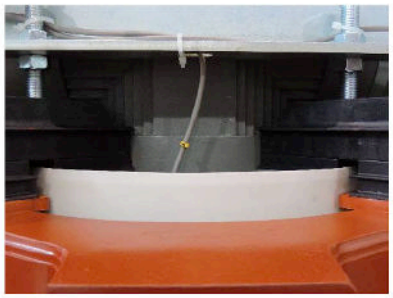


Figure 36

Figure 37

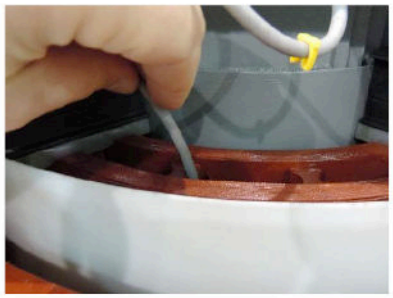


Figure 38

To replace the sensors in the windings, the sensor must be extracted from the tube and replaced with a new one (Figure 36, Figure 37, Figure 38).
Finally, check that the shielded cable, connected to the output of the auxiliary box, is at least one metre away from the transformer's medium voltage cables.

IMPORTANT:
- never leave bolts, tools or metal objects on the transformer!
- do not insert the probes in the high voltage winding

10.2 Control unit replacement

Proceed as follows to replace the control unit on the transformer:

Figure 39: Electrical Cabinet

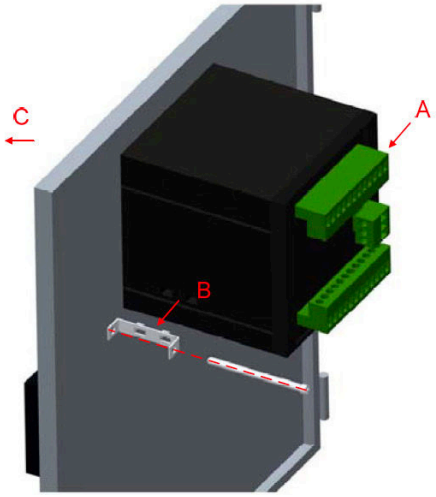


Figure 40: Control Unit Assembly

Open the electrical cabinet using the key found inside a plastic bag supplied with your transformer.

Following the indicated order:

A. Disconnect the connectors from the terminals in the rear part of the control unit.

B. Remove the fixing supports from both sides of the control unit.

C. Remove the device from the panel.

Repeat the same procedure to mount the new control unit.

10.3 Thermometer replacement

Disconnect the terminals inside the auxiliary box positioned on the casing and remove the thermometer dial. The new thermometer must be the same or equivalent to the previous one; properly connect the terminals as per the auxiliary diagram supplied by SEA S.p.A. and proceed to set the temperatures based on the insulation class envisaged for your transformer.

11. EXTENSION CORDS FOR PT100

Use extension cords for PT100 compliant with CEI 20.35 complete with shielding, with the following specifications:

- external diameter 12 mm
- operating temperature -50 / +90°C
- stiffness test 2000 Vac for 60”

11.1 Wire gauge for PT100 sensors

The client's connection cable must never have a wire gauge less than:

- 0.5 mm2 for lengths up to 30 m.
- 0.75 mm2 for lengths up to 50 m.
- 1 mm2 for lengths up to 100 m.

Beyond 100 m, the connection is still possible but is not advisable, not so much due to the error in measurement, but above all due to the chain of disturbances that can develop along the route.

All cables must be firmly anchored and comply with the electrical clearances as per table 10.

12. PROTECTIONS

12.1 Surge arrestors

It is recommended to install surge arrestors on the transformer, Bowers will need to be provided with the electrical values of the system network beforehand using the dedicated Bowers module. The required data must be provided by the system designer and integrally reported in the module.

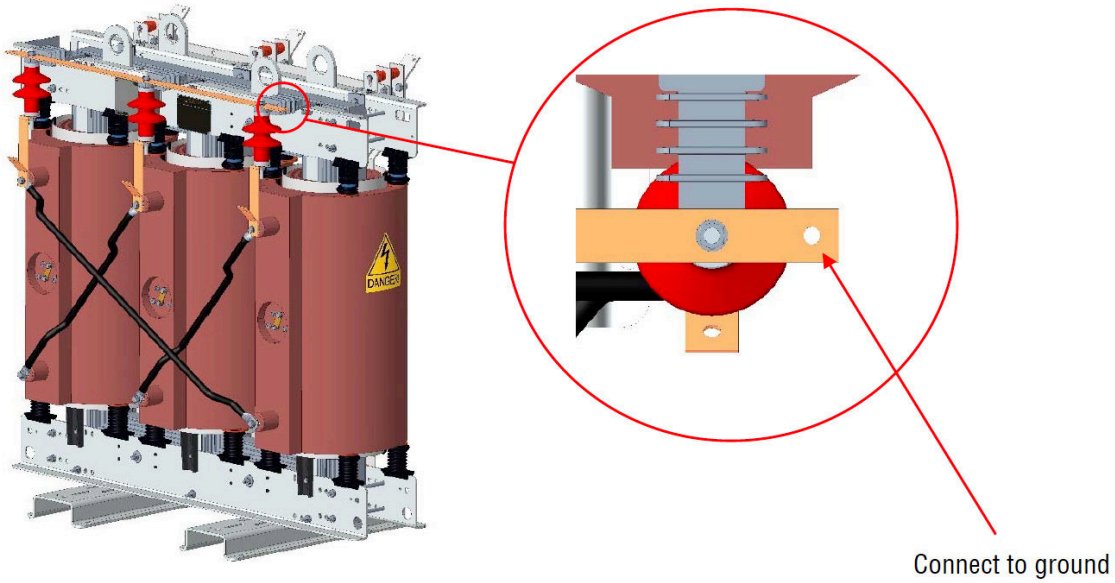


Figure 41: Surge Arrestors

13. ALLOWABLE CONTINUOUS LOAD

The Bowers transformer is rated and constructed to work at the rated power indicated on the rating plate and at the temperature defined in the standard IEC 60076-11:

- maximum temperature: 40 °C
- mean daily temperature: 30°C
- mean annual temperature: 20°C

The service life of the transformer depends, in particular, on the duration of its insulation, which is in turn strictly linked to the load cycle to which it is subjected.

Overloads are nonetheless allowed, without these compromising the operation and service life of the transformer, provided they are compensated by a customary load less than the rated power.

Below we illustrate the graphs (natural cooling AN and forced cooling AF), which indicate the maximum allowable continuous load based on the ambient temperature, compatible with the normal service life of the transformer.

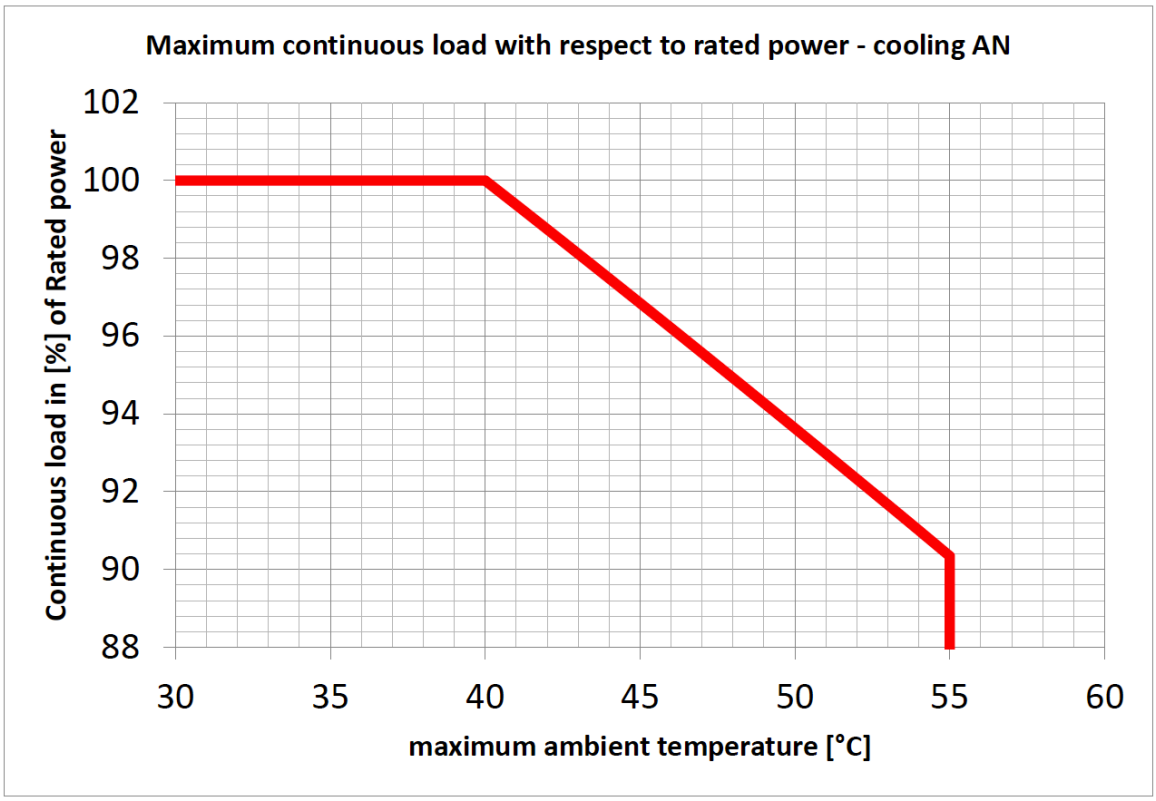


Figure 42: graph of continuous load with cooling AN.

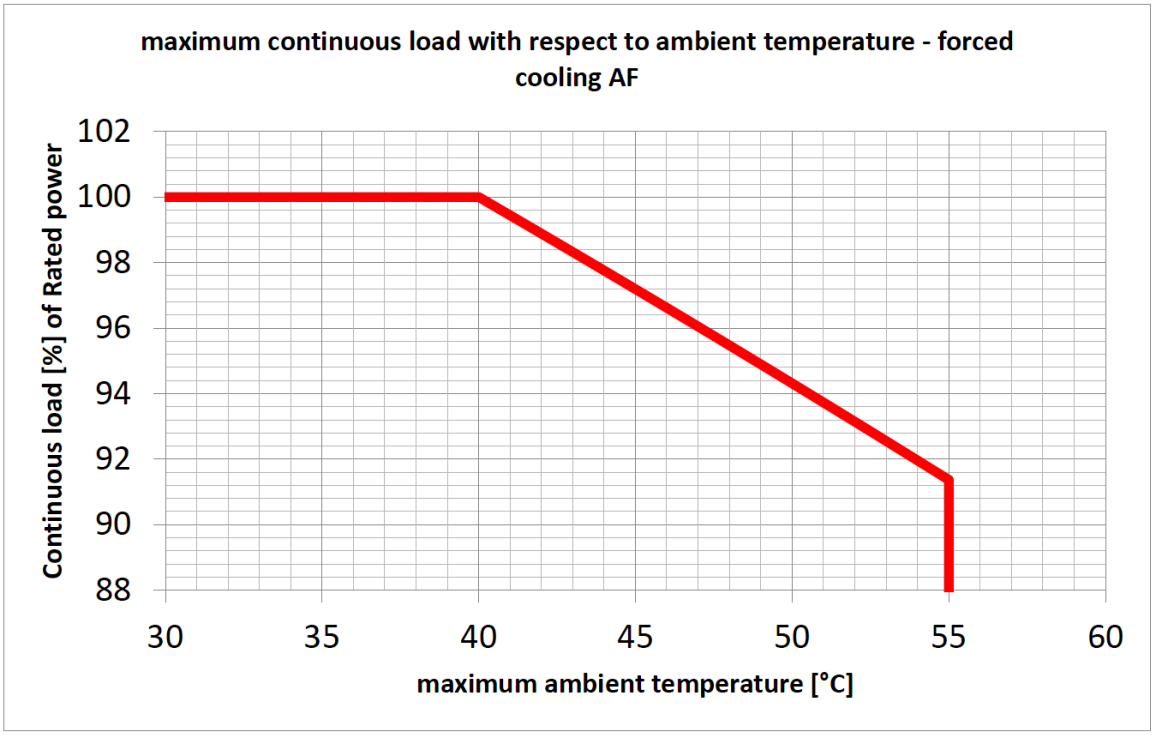


Figure 43: graph of continuous load with cooling AF .

It is possible to use a transformer rated for a maximum ambient temperature of 40°C also at higher temperatures: in this case, the power must be reduced as indicated in the following table.

MAXIMUM AMBIENT TEMPERATURE °C	ALLOWABLE LOAD
40	P_n
45	0.97x P_n
50	0.94x P_n
55	0.90x P_n

Table 19: loads and temperatures

14. TRANSFORMER AGEING

Transformers, during operation, suffer a reduction in their service life, known as ageing. Ageing expresses the natural degradation of the properties of the materials comprising the transformers, which is a function of time and ambient conditions, and in particular depends on the operating temperature of the insulating materials. A transformer, in the standard conditions envisaged by the standard (100% load, 20°C ambient temperature) has an expected service life of about 180,000 hours, equal to about 20 years. It must be pointed out that the ageing of materials is based on a statistical analysis of materials conducted in accordance with the standard IEC 60076-12, and does not consider exceptional events (for example overvoltages) or critical or inadequate installations. Therefore the indications provided below, albeit reflective of operational experience, must be considered as indicative and non-binding.

14.1 Installation environment

The temperature of the installation environment of a transformer is a critical factor in its service life. As can be seen in the graphs below, environments in which the air exchange is insufficient (ambient temperature higher than the design temperature) or characterised by overloads, may heavily impact the service life of the transformer.

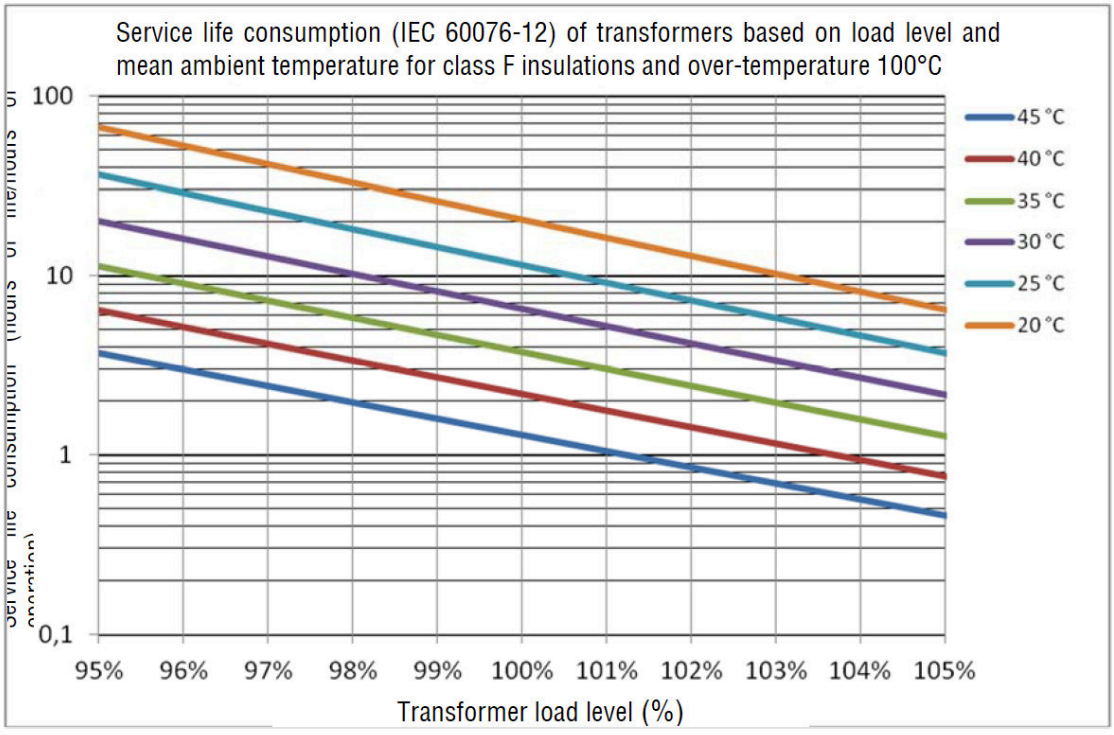


Figure 44: : expected service life of transformer with various loads

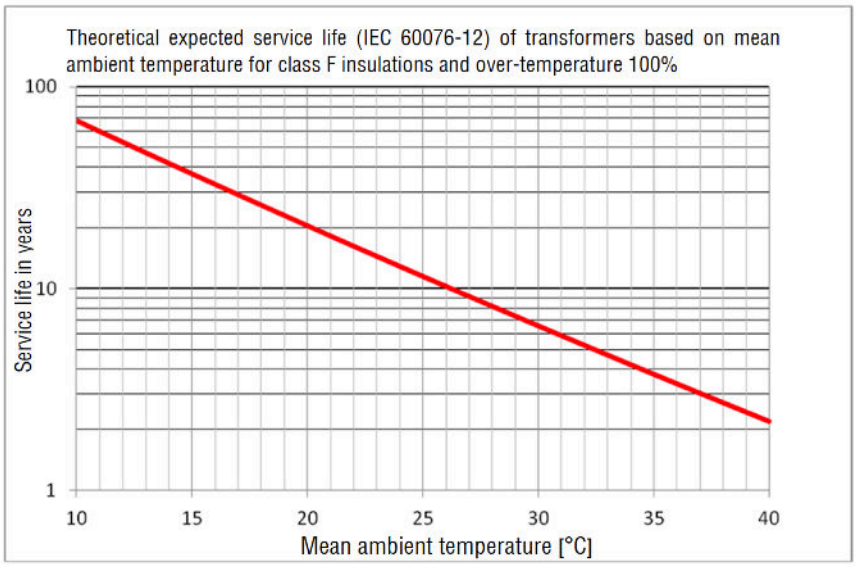


Figure 45: expected service life of transformer with rated load

14.2 Service life consumption

Abnormal situations may lead the transformer to operate in conditions different to the design conditions. In this case, the actual service life may vary with respect to the theoretical service life. The graph shows, as a function of the various ambient temperatures and different load levels, the rate of ageing for each hour of service in non-standard conditions, with respect to the theoretical service life (considered with unit ageing speed). For example, a transformer that operates at 100% of its load but at 40 °C will have an ageing rate equal to 10 hours for each hour of operation.

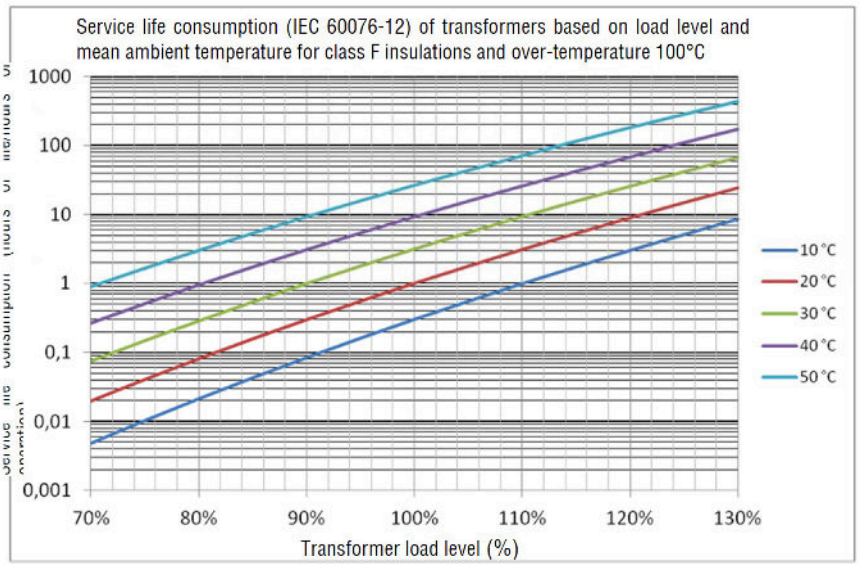


Figure 46: transformer service life consumption with various loads

15. ELECTROMAGNETIC COMPATIBILITY

Power transformers must be considered passive elements with regard to emissions and immunity to electromagnetic disturbances (see standard CEI EN 60076-1). To reduce interferences with other sensitive devices such as monitors, control units etc. to a minimum, it is recommended to follow the simple instructions below:

- Keep the cables of the three phases + neutral grouped together
- Do not lay power cables and signal cables in the same raceway
- Do not pass power cables near devices sensitive to electromagnetic fields
- Ground the shielding of signal cables
- Use electronic devices and transducers with a CE marking

16. DECOMMISSIONING AND DISPOSAL

At the end of their service life, transformers must be disposed of in accordance with applicable national laws in force in the country where the equipment is installed.

For illustrative purposes, and remembering that the producer of the waste is responsible for attributing the identification codes, following is a list of possible EWC codes indicating which are recyclable "R" and which are non-recyclable "D":

Main component	waste	EWC code	Type of disposal	% of incidence
Windings	Conductors	R	120199	7.607%
	Insulators	D	080410	1.036%
	Resin	D	080410	3.118%
Total Windings				11.761%
Core	Reinforcements	R	120199	8.574%
	Insulators	D	080410	0.332%
	Magnetic plate	R	120199	77.165%
Total Core				86.071%
Transformer	Accessories	R	120199	0.672%
	Conductors	R	120199	0.157%
	Insulators	D	080410	1.164%
	Bushings	D	080410	0.087%
Total Transformer				2.168%

Table 20: Materials

IMPORTANT:
In case of disposal of the transformer or its parts thereof, the provisions of national and/or local environmental laws must be respected. It is mandatory to comply with the environmental legislation in the country of installation and use of the transformer. Bowers denies all liability for incorrect disposal.
IMPORTANT:
Bowers denies all liability for any injury or damage caused to persons, the transformer or system, following works performed by unsuitably trained or uninformed personnel.

17. TROUBLESHOOTING GUIDE

PROBLEM	CAUSES	SOLUTION
Corrosion phenomena in connections	No Contact	Clean the connections with metallic brushes and apply electrical contact grease. Tighten the bolts in accordance with the tightening torques indicated in table 7, table 8 and table 9.
Temperature control unit trips (probes on windings).	Incorrect calibration	Check the calibration values as per table 15.
	Load distributed in non-symmetrical manner on transformer phases.	Measure the value of the output current from each phase of the transformer and rebalance the single-phase loads on the phases if necessary.
	Overload with respect to rated transformer value.	Measure the value of the output current from the transformer and compare it with the value on the rating plate. After which, decrease the load value to below the rated value of the transformer.
	Possible presence of harmonics in the distribution system	Contact the BOWERS technical service for advice.
	Possible overheating of room, insufficient aeration.	Check that the openings are not blocked either in the protective cabinet and/or in the cabin. And restore the air circulation.
Temperature control unit trips (probe on core).	Incorrect calibration.	Check the calibration values as per table 15.
	High parasitic currents due to possible ruptures in the insulation of the tie rods and/or plates and loosening of bolts used to tighten core	Check the condition of the insulation of the tie rods and check the tightening torques of the bolts in reference to the values indicated in table 18.
Corrosion phenomena in ground connection	Incorrect coupling.	Clean the connections with metallic brushes and apply electrical contact grease. Tighten the bolts properly.

PROBLEM	CAUSES	SOLUTION
Temperature control unit trips (probes on windings).	Supply voltage too high	Check LV voltage.
	Incorrect tap terminal	Check LV voltage.
	Possible damage to core due to accidental impact.	Contact Bowers Electricals Ltd.
	Presence of harmonics due to load.	Contact Bowers Electricals Ltd.
Increased core temperature.	The transformer is operating in conditions of overexcitement.	Check that the untapped winding voltage is not higher than the rated voltage. Check the regulation of the tap changer and reduce the system voltage.
	Loosening of yoke anchorage.	Tighten the magnetic pack using the torque wrench, see Table 18.
	Damage to core.	Contact Bowers for help.

Table 21: troubleshooting.

18. FAQ - FREQUENTLY ASKED QUESTIONS

1) Is it normal for the transformer to heat up?

- Yes, during normal load and no-load operation, the transformer heats up due to the losses. The reference temperature is limited to the values defined by the class of insulators used. (Class B = 130 °C / Class F = 155 °C / Class H = 180 °C)

- In no-load conditions the core always heats up and reaches the rated operating temperature.

- It is important to always check that the installation environment has the necessary characteristics to allow installation of the transformer as per paragraph 7.5.

2) What is the maximum core temperature?

The maximum allowable temperature for the core is 200 °C. In case of doubt, always check that the voltage on the untapped side is equal to the rated voltage with a maximum deviation of ± 2.5%.

3) Does the core temperature depend on the load?

No, the core temperature is independent of the load. The core heats up and produces noise regardless of the load.

4) Is it possible to use a transformer designed and constructed for a frequency of 50Hz at a frequency of 60Hz?

No, it cannot be used without a technical feasibility study.

- An insulator is classified based on the electrical, mechanical and thermal characteristics of a given material, in compliance with the standard IEC 60085 under denominations B F H.
- Table 21 (IEC 60076-11)

5) What is the difference between the probe temperature, the maximum temperature and the mean temperature of the windings?

Probe temperature: temperature measured in the windings at the point where the probe is positioned. This temperature must never exceed the limits set in the table 15.

Maximum temperature or hot spot: the maximum temperature in any part of the insulation system is called the hot spot temperature. This temperature is inside the winding and not directly measurable. This temperature must never exceed the limits of table 15, first column.

Mean overtemperature: difference between the mean temperature of the windings and the ambient temperature. This value must never exceed the limits of table 15, second column.

6) Is it important to know the ambient temperature where the transformer will be installed?

Yes, it is essential because it directly impacts on the heat exchange between the transformer and the surrounding environment. This information is essential for the design stage, and unless otherwise and specifically indicated by the constructive design, the temperature of the cooling air at the inlet of the cooling device must not exceed:

40 °C at any time;
30 °C monthly average of the hottest month;
20 °C yearly average.
and must not be less than

– 25 °C in the case of an outdoor transformer;
– 5 °C in the case of transformers in which both the transformer and the cooling means are indoors.

7) Is it important to know the maximum altitude where the transformer will be installed?

Yes, it is essential because it directly impacts on both the heat exchange between the transformer and the environment and its insulating capacity.
In normal conditions, unless otherwise specified, the maximum altitude at which the transformer can be installed is 1000 m.

8) What is the electrostatic shielding needed for?

It is used to limit the disturbances created by any existing parasitic currents on the lines, and provides added safety in the event the insulation between the primary and secondary is punctured. The shielding needs to be grounded.

9) Is it normal for the transformer to make a buzzing sound?

Yes, during normal operation the transformer emits a buzzing sound due to the vibration of the plates constituting the core.
If the noise is too high, check:

- Check that the transformer is not working in overexcitation.

a) Using a meter, check the voltage of an untapped winding: the maximum deviation is ± 2.5%.
b) If the voltage is too high, reduce it by reducing the system voltage or by suitably adjusting the tap changer terminals.

- Check that the core is not damaged.

a) Check that the core is compact and that there is no loosening in the joining zones between the columns and yokes. Use the paint as a reference. In case of damage, contact the SEA help service.

- Check that the core is properly anchored.

b) Using the instructions provided in the manual, tighten the magnetic pack to the correct value using the torque wrench.

11) What is tropicalization in the transformer and when is it needed?

Tropicalization is a treatment of the transformer intended to increase the resistance properties of the machine against particularly aggressive climates. There are different types of treatments depending on the intended use of the machine, for example the tropicalization treatment for a warm, humid environment is very different to that for desert environments.

12) How do I dissipate the heat generated by the transformer?
To guarantee best transformer conditions, the installation site must be properly ventilated. For more information regarding natural or forced ventilation, see our use and maintenance manual.

13) Can copper terminals be coupled with aluminium ones?
Copper and aluminium terminals can be coupled, provided a copper-plated aluminium (cupal) plate is inserted between the two terminal joints in order to avoid oxidation/corrosion phenomena. Even tinned copper terminals (for example, cable lugs) can be directly connected to the aluminium terminals.

14) Is it normal for the insulation resistance measurement to be lower than the reference values?
No, if the values are lower than the reference values (...), this may indicate insufficient cleaning of the transformer, or a relatively humid environment, where the high level of moisture reduces the insulation resistance. As a precautionary measure, it is recommended to check the cleanliness of the machine (remove any dust) and repeat the test. If the transformer is humid, simply leave it running for 24/36 hours and repeat the test. In this case the resistance values should be significantly higher due to the drying of the water to heat the core.

Temperature of insulation system (see note 1)	Mean overtemperature limits of winding at rated current (see note 2)
105 (A)	60
120 (E)	75
130 (B)	80
155 (F)	100
180 (H)	125
200	135
220	150
NOTE 1 The letters refer to the classification of the temperatures provided in IEC 60085 NOTE 2 Overtemperature measured as per Article 23	

Table 22: overtemperature in windings IEC 60076-11

19. CONTACT US

For all doubts, clarifications or additional information regarding our products, contact our Sales Department or Technical Service Centre. The contact details are:

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Bowers
Group of Companies

Cast Resin Transformers

Installation, Operation & Maintenance Manual

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