Temps de front: T1 = 1,2 s - 30%
Temps de queue: T2 = 50 s - 20%
Relation entre T1 et T: T1 = 1,67 T
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type
Trihal is a three-phase dry type transformer **cast under vacuum in epoxy resin with an active filler.**
It is this active filler, essentially composed of trihydrated alumina, which is the origin of the Trihal trademark.
Trihal is an indoor type transformer (for outdoor installation, please consult us).

standard
Trihal complies with standards:
- IEC 60076-1 to 5;
- IEC 60076-11 (2004);
- IEC 60905;
- CENELEC (European Committee for Electrotechnical Standardization) harmonization document EN 60076-1, -2, -3, -5, HD 538-2 S1 : 1995, EN 60076-11 concerning dry type transformers.

range
- HV/LV distribution transformers from 160 to 2500 kVA up to 36 kV.
For higher rated power and voltages, please consult us.
Trihal transformers are supplied in many versions:
- **without enclosure (IP00):**
- **with IP31 metal enclosure:** see the different types on pages «options»
Please note! The resin provides insulation for the HV winding but does not provide protection from direct contact. Only the protective enclosure version provides this protection.
- HV/HV power transformers up to 15 MVA and 36 kV.
Please consult us.
**basic equipment**

**version without protective enclosure (IP00)**
- 4 flat multi-direction rollers;
- 4 lifting lugs;
- haulage holes on chassis;
- 2 earthing locations;
- 1 rating plate (HV side);
- 2 “electrical hazard” warning labels (signal C10);
- off circuit tapping links, operational when transformer is de-energised, acting on the highest voltage to adapt the transformer to the true supply voltage;
- HV connection bars with connections from above;
- LV connections from above;
- 1 test certificate and an installation, commissioning and maintenance manual.

**version with IP31 protective metal enclosure.**
- TRIHAL transformer without protective enclosure (IP00) as described above;
- 1 metal IP31 (apart from the base: IP21) protective enclosure:
  - with standard anti-corrosion protection;
  - lifting lugs for handling of transformer with its enclosure;
  - 1 bolted panel on the HV side for access to HV connections and tapping points, fitted with 2 handles, an “electrical hazard” warning label (signal T10), a rating plate and a visible braid for earthing;
  - drilled holes (with covers) on the left of the bolted HV side panel, intended for the mounting of a RONIS type ELP1 or a Profalux type P1 keylock;
  - 2 panels to be drilled to pass the cables through cable glands on the enclosure roof: 1 HV side, 1 LV side (pilot holes and cable glands not supplied);
  - 1 gland plate situated on lower right hand HV side for possible incoming HV cable connection from below.

**technology and construction**

Trihal benefits from two key patented processes:
- a linear voltage gradient from the top to bottom of HV coil, generally used;
- a fireproof casting system.

This technology, patented by France Transfo is implemented in the Ennery plant in France. The companies large production capacity ensures deliveries meet clients particular needs.

**quality system**

The certificate issued by AFAQ (French Association for Quality Assurance) states that Trihal transformers are manufactured in accordance with a quality system in compliance with the international standard ISO 9001.

**environmental protection**

The Trihal manufacturing plant is the first French facility to be certified to ISO 14001 in this sector, and has been so since 1998. Trihal, is designed and produced to be environmentally friendly, providing an ecological response for HV/LV transformers. Environmental protection is integrated in management systems in order to promote the protection of all natural resources and continuously improve conditions for a clean environment.

Product design focuses on minimising environmental impact.
magnetic core

The magnetic core is made from laminations of grain oriented silicone steel insulated with mineral oxide.
The choice and grade of steel and the cutting pattern and method of assembly minimises the loss level and the no-load current with the effect of a very low noise level.
Once assembled, it is corrosion protected using a class F, oven-dried alkyd resin.

low voltage winding

The low voltage winding is made of either aluminium or copper foil (according to manufacturer’s preference) in order to achieve zero axial stresses under short circuit conditions; the foil is insulated by a class F inter-layer film, pre-impregnated with heat-activated, epoxy resin.
The ends of the winding are protected and insulated using a class F insulator.
The whole winding is polymerised by being placed in an autoclave for 2 hours at 130°C which guarantees:
- outstanding resistance to industrial atmosphere aggression,
- excellent dielectric withstand,
- very good resistance to radial stresses under bolted short circuit conditions.
Each LV winding terminates in a tin plated aluminium or copper connection point, enabling connections to be made without using a contact interface (grease, bi-metal strip).
Assembly is carried out according to current practices, including using spring pressure washers under nut and screw heads.

high voltage winding

The high voltage winding is usually wound from insulated aluminium or copper wire, using a method developed and patented by France Transfo: “a linear voltage gradient from the top to the bottom”.
For higher currents, the medium voltage winding may be wound using so-called “strip” technology.
These methods are used to obtain very low stress levels between adjacent conductors.
This winding is cast and moulded under vacuum in a class F loading and fireproofed resin: the Trihal casting system.
These processes combine to give coils of very high dielectric properties with very low partial discharge level (guaranteed ≤ 10 pC)* which is a decisive factor in influencing the transformer’s life span and its lightning impulse withstand(1).
HV tapping points on the copper connection bars enable connections to be made without using a contact interface (grease, bi-metal strip). Assembly is carried out according to current practices, including using spring pressure washers under nut and screw heads.

* The actual level of partial discharge from the transformer alone is, in fact, lower than that measured, as “background noise” in the measuring environment inevitably leads to error.
(1) It is important to note that the level of partial discharge remains the same throughout the transformer’s service life.
high voltage casting system

The system provides a vacuum cast coating of fire resistant filled resin, a technology developed and patented by France Transfo. The class F casting system comprises:

- a bisphenol based epoxy resin with a suitable viscosity to ensure excellent impregnation of the windings;
- an anhydride hardener modified by a flexibilishing additive. This type of hardener assures very good thermal and mechanical properties. The flexibilishing additive gives the casting system the necessary elasticity to prevent cracking during operation;
- an active powdered filler composed of silica and especially of trihydrated alumina thoroughly mixed with the resin and the hardener. Silica reinforces the casting's mechanical strength and improves heat dissipation. The trihydrated alumina guarantees the Trihal transformer's intrinsic fire performance. The trihydrated alumina produces 3 anti-fire effects which occur in case of calcination of the casting system (when the transformer is exposed to flames).
  - 1st anti-fire effect(1): refracting shield of alumina.
  - 2nd anti-fire effect(1): barrier of water vapour.
  - 3rd anti-fire effect(1): temperature held below the fire point.

The result of the combination of the 3 anti-fire effects is immediate self extinguishing of the Trihal transformer(1). In addition to its dielectric qualities, the casting system gives the Trihal transformer excellent self extinguishing fire resistance and excellent environmental protection against aggressive industrial atmospheres.

high voltage coil casting process

The process from proportioning the resin up to polymerization, is fully controlled by microprocessor, preventing any inopportune manual operation. The trihydrated alumina and the silica are vacuum dried and degased to eliminate all traces of humidity and air which could degrade the casting systems dielectric characteristics.

Half is mixed with the resin and half with the hardener under hard vacuum and controlled temperature, to give two homogenous premixes. A new thin film degassing precedes the final mixing. Vacuum casting is then carried out in dried and pre-heated moulds at an optimal impregnation temperature. The polymerization cycle begins with a gelification at 80°C and ends with a long polymerization at 140°C. These temperatures are close to those of a transformer in service, enabling mechanical stresses to be eliminated which could lead to the coating cracking.

HV coil support wedges

The high voltage winding, which is encapsulated in hardened resin, looks like a thick-walled cylinder. This cylinder is centred on the magnetic core and is held in place vertically by an efficient wedging system, during transport, operation and even short-circuits and earthquakes. Thanks to the original design of these wedges, which we developed ourselves, they can be assembled in a variety of ways to suit different levels of HV insulation. Where conditions of extreme stress exist and were clearly specified on the order form (very heavy HV coils, transport by sea or on very rough roads, installation in a wind turbine head, etc.) a reinforced wedging system (comprising two or even three sets of wedges) is used to palliate the situation and adapt the transformer to requirements.

(1) See page 14 : the anti-fire effects are represented on a section of Trihal coil.
The Trihal cast resin transformer can be protected from any damaging temperature rises by monitoring winding temperature using various pieces of optional equipment.

**Z thermal protection**

The standard version for naturally cooled (AN) transformers comprises:

- 2 PTC sensor sets, positive temperature coefficient thermistances mounted in series: the first set for alarm 1, the second set for alarm 2. The main feature of a PTC sensor is the fact that the value of its resistance increases very steeply at a rated and factory-set threshold temperature which is not adjustable (see graph opposite). This abrupt increase is detected by a Z electronic converter. These sensors are installed in the live part of the Trihal transformer with one alarm 1 sensor and one alarm 2 sensor on each phase. They are placed in a tube, which enables them to be replaced as necessary.

![characteristic graph of a PTC sensor](image)

**Z thermal protection connection diagram (normal use) equipment de-energised**
■ 1 terminal block to connect the PTC sensors to the Z electronic converter. The terminal is equipped with a plug-in connector. The PTC sensors are supplied connected to the terminal, attached to the top part of the transformer.

■ 1 Z electronic converter characterised by 3 independent measurement circuits. 2 of these circuits respectively control the variation in resistance in the 2 PTC sensor sets. When the temperature increases too much, alarm 1 (or alarm 2) information is processed respectively by the 2 independent output relays equipped with a changeover contact; the status of these 2 relays is indicated via 2 LED diodes. The third measurement circuit is shunted by a resistance R outside of the terminal block; it can control a third set of PTC sensors as long as this resistance is removed. In this case (“forced air” option available on request), the FAN information is processed by a third independent output relay, equipped with a closing contact and is intended to control fans; the position of this relay is shown by an LED diode marked FAN. In the case of one of these 3 sensor circuits failing (power failure or short circuit), an LED diode marked SENSOR lights up and indication of the incriminated circuit flashes. An LED diode marked ON signals the presence of voltage to the terminal block.

<table>
<thead>
<tr>
<th>Measurement circuits</th>
<th>supply voltage</th>
<th>AC/DC 24 to 240 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>voltage tolerance</td>
<td>± 15 %</td>
<td></td>
</tr>
<tr>
<td>frequency</td>
<td>0 ; 40 à 70 Hz</td>
<td></td>
</tr>
<tr>
<td>input power</td>
<td>&lt; 5 VA</td>
<td></td>
</tr>
<tr>
<td>Cumulated resistance of a PTC sensor circuit for non-activation of the converter</td>
<td>≤ 1500 W</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alarm output and switching contact</th>
<th>maximum switching voltage</th>
<th>AC 415 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>maximum switching current</td>
<td>6 A</td>
<td></td>
</tr>
<tr>
<td>switching capacity</td>
<td>AC 2000 VA (ohmic load), 120 W at 24 V DC</td>
<td></td>
</tr>
<tr>
<td>rated operating current</td>
<td>2 A</td>
<td></td>
</tr>
<tr>
<td>recommended upstream fuse</td>
<td>4 A time delay</td>
<td></td>
</tr>
<tr>
<td>life expectancy mechanical electrical</td>
<td>3 x 10⁷ switching</td>
<td></td>
</tr>
<tr>
<td>at maximum power</td>
<td>10⁷ switching</td>
<td></td>
</tr>
<tr>
<td>load reduction coefficient</td>
<td>0.50 with power factor $\phi = 0.30$</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Z electronic converter</th>
<th>permissible ambient temperature range</th>
<th>- 20° C to + 60°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>overall dimensions (H x W x D)</td>
<td>90 x 70 x 58 mm</td>
<td></td>
</tr>
<tr>
<td>weight</td>
<td>250 g</td>
<td></td>
</tr>
<tr>
<td>protection index</td>
<td>terminal block</td>
<td>IP 20</td>
</tr>
<tr>
<td></td>
<td>casing</td>
<td>IP 30</td>
</tr>
<tr>
<td>maximum connection capacity to one terminal</td>
<td>1 x 2.5 mm² rigid</td>
<td></td>
</tr>
<tr>
<td>fixing method</td>
<td>either on 35 mm rail according to EN 607/15 or with M4 screw</td>
<td></td>
</tr>
</tbody>
</table>

The forced ventilation option for AF transformers is detailed page 11.
This thermal protection device gives a digital display of winding temperatures and includes:

- PT100 sensors.

The main feature of a PT100 sensor is that it gives the real time temperature on a scale of 0°C to 200°C, see graph opposite (accuracy ± 0.5 % of the measurement scale ± 1 deg).

Temperature control and display functions are performed via a digital thermometer. The 3 sensors, each comprising 1 white wire and 2 red wires, are installed in the live part of the Trihal transformer with 1 located on each phase. They are placed in a tube, which allows them to be replaced if necessary.

- 1 terminal block to connect the PT100 sensors to the T digital thermometer. The terminal block is equipped with a plug-in connector. PT100 sensors are supplied connected to the terminal block fixed to the top part of the transformer.

- 1 T digital thermometer characterised by 3 independent circuits.

  2 of the circuits monitor the temperature captured by the PT100 sensors, one for alarm 1, the other for alarm 2. When the temperature reaches 140°C (or 150°C) the alarm 1 information (or alarm 2) is processed by 2 independent output relays equipped with changeover contacts.

  The position of these relays is indicated by 2 diodes (LED).

  The third circuit monitors sensor or electrical supply failure.

  The corresponding relay (FAULT), which is independent and equipped with changeover contacts, is instantly switched as soon as the device is supplied power. Its position is also indicated by a diode (LED).

A FAN output is intended to control the start up of tangential fans in the case of forced ventilation of the transformer (AF) : this option is shown on page 11.

An additional input (CH4) can be connected to a sensor outside of the transformer (not supplied), intended to measure ambient temperature in the HV/LV substation.

### Measurement Circuits

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage (1)</td>
<td>24 V to 220 V AC/DC</td>
</tr>
<tr>
<td>Frequency</td>
<td>50-60 Hz AC/DC</td>
</tr>
<tr>
<td>Input Power</td>
<td>10 VA AC/DC</td>
</tr>
<tr>
<td>Maximum Switching Voltage</td>
<td>250 V AC</td>
</tr>
<tr>
<td>Maximum Switching Current</td>
<td>5 A (resistive circuit)</td>
</tr>
<tr>
<td>Rated Permanent/Opp Current</td>
<td>2 A sous 220 V AC/DC</td>
</tr>
<tr>
<td>Recommended Upstream Fuse</td>
<td>3 A</td>
</tr>
<tr>
<td>Life Expectancy</td>
<td>20 000 000 switching mechanical</td>
</tr>
<tr>
<td></td>
<td>50 000 h/85°C</td>
</tr>
<tr>
<td>Load Reduction Coefficient</td>
<td>0.50 max. power factor ( \phi = 0.30 )</td>
</tr>
</tbody>
</table>

### Operating Conditions

- Permissible ambient temperature range admissibles: – 20° C to + 60° C
- Ambient humidity maxi maxi: 90% RH (non condensable)

### T Digital Thermometer

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Dimensions (H x W x D)</td>
<td>96 x 96 x 130 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>520 g</td>
</tr>
<tr>
<td>Terminal Block Protection Index</td>
<td>IP 54 self extinguishing</td>
</tr>
<tr>
<td>Maximum Connection Capacity on One Terminal</td>
<td>25 mm²</td>
</tr>
<tr>
<td>Fixing Method</td>
<td>92 x 92 mm, flush hole, attached with two rear pressure hooks</td>
</tr>
</tbody>
</table>


A digital output (RS 232 or 485) or a 4-20 mA analogue output is available for connection to a PLC or computer.

A FAN 2 output is available as an option to control the start up of an additional fan.

The T digital thermometer is delivered with an installation manual.

Please note: since the transformer is thermal class F, the user has responsibility for setting the T digital thermometer with a maximum temperature of 140°C for alarm 1 and 150°C for alarm 2.

Non compliance with these maximum temperatures release France Transfo from any liability for damage which may possibly be incurred by the transformer.
In the event of temporary overloading, to avoid overheating of the windings, it is possible to install forced ventilation.

For IP00 as for IP31, for powers equal or greater than 1000 kVA, it is possible to install forced ventilation to achieve a temporary increase in power of 40%, without any special modification.

In all cases, this temporary increase of 40% can be obtained if detailed on ordering.

However, if an increase in power is requested, account must be taken of the impact of this choice on the following points:
- sections of cables and of Prefabricated Busbar Trunking (PBT),
- the rating of the transformer’s protective circuit breaker,
- the size of inlet and outlet openings for air in the transformer room,
- the life span of fans in service, which is considerably shortened compared with that of the transformer (3.5 compared to 30 years).

This option includes the supply of:
- 2 sets of tangential fans, pre-cabled and connected to 1 single power connector per set,
- 1 temperature measurement device, either Z or T type.

For Z type, a third set of PTC sensors is added to the standard thermal protection, in place of the R resistor which originally shunts the third Z converter measurement circuit (see diagram shown on the “Z thermal protection” option).

For T type, the digital converter comprises an output (FAN) intended to start the tangential fans (see diagram shown in the T thermal protection option).

This option includes either of the following, dependant on type of transformer:
- a wiring box, mounted outside of the protective enclosure, to which are connected, sensors and power supplies for the fan sets on a terminal block,
- a control cabinet, delivered separately (transformer IP00) or mounted on the protective enclosure, including:
  - motor protection fuses,
  - start up contactors,
  - thermal protection device.

This unit is connected to the temperature sensors and fan sets if the transformer is delivered with IP31 enclosure. Otherwise, it is the installer who makes the connections.
low voltage connection:

Cable ducting interface
Connection using Prefabricated Busbar Trunking (PBT) provides advantages in terms of safety and also saves time during connection, also enabling an installation to be produced in conformity with NF C 15100. This solution ensures maximum safety for people and property due to its outstanding fire behaviour, in line with that of Trihal. It also ensures the absence of halogenated products, which is not the case for cabling. Moreover, this harmony can also be found in terms of electromagnetic compatibility (EMC): in line with IEC 60076-1, transformers are «considered as passive elements as regards to emissions and immunity to electromagnetic disturbances». For PBT, the concentrating of conductors limits electromagnetic radiation produced by high currents, as opposed to cables.

The option includes the connection interface, together with the junction block, with the whole assembly delivered already mounted on the LV cable connectors. If the protective enclosure is provided for the transformer, a removable aluminium plate is screwed to the roof, vertically relative to the junction block. It will be adapted on site in order to fit the sealing system connecting the PBT and thus enabling the ducting to comply with IP54. If the transformer enclosure is supplied, the sealing system is supplied with the PBT.

Additional cable connectors
In the case of connection using a large number of cables, additional cable connectors can be supplied. It should be noted that the French UTE C15-105 guide dated June 1999 recommends not exceeding 4 cables per LV phase, and recommends the use of PBT beyond this limit.

high voltage connection

Plug-in bushings
HV connections are always made using cables, terminated with cable lugs or square or angled, separable connectors (in this case, cable characteristics must be given). These connectors, fitted to the end of the cable, are then connected to plug-in bushings which are delivered and fitted:
- on a horizontal panel, on the top part of the HV side for transformers without a protective enclosure (IP00),
- on the enclosure roof, HV side, for transformers with a IP31 protective enclosure.

A locking system for connectors can also be supplied and installed in plug-in bushings. This system is delivered without any keylocks, but is prepared ready for a keylock either RONIS type ELP 11 AP – ELP 1 – ELP 2 or PROFALUX type P1 – P2 – V11 and V21.

high voltage surge arresters

If the installation is likely to be subjected to overvoltage of any kind (atmospheric or switching), the transformer must be protected by phase-to-earth surge arresters, installed directly on the transformer’s HV connection terminals (either at the top or the bottom). These arresters consist of class 1, 10 kA insulators (20 kV for HV), which discharge overvoltage from the HV network to the earth, in accordance with standard IEC 994.

It is essential to install these surge arresters:
- where the lightning impact level NK is greater than 25. The risk of direct or induced atmospheric overvoltage is directly proportional to NK;
- during the occasional switching (less than 10 operations a year) of a transformer with a weak load, or during a magnetisation phase.

It is also highly recommended to install them:
- where the substation is supplied by a network including overhead parts, then a cable that is longer than 20 m (case of an overhead-underground network).

Surge arresters can be installed in an IP 31 enclosure, or even on existing equipment, provided that insulation distances are respected.
**protective enclosure**

This comes in various versions, according to the protective index required:

**Indoor type with protective enclosure IP31 and IK7**

This enclosure is particularly well suited to installation in work areas in order to provide protection of people and property.

**Outdoor type, pole-mounted or pad-mounted with protective enclosure IP35 and IK10.**

The IP and IK protective indices refer to the following criteria:

**IP protection indices**

<table>
<thead>
<tr>
<th>IP</th>
<th>protective against solid bodies</th>
<th>protection against liquids</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>&gt; 2,5 mm</td>
<td>protects against vertical splashing by water</td>
</tr>
<tr>
<td>35</td>
<td>&gt; 2,5 mm</td>
<td>protects against water jets from all directions</td>
</tr>
</tbody>
</table>

**IK protection indices**

<table>
<thead>
<tr>
<th>IK</th>
<th>protection against mechanical impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>≤ 2 joules</td>
</tr>
<tr>
<td>10</td>
<td>≤ 20 joules</td>
</tr>
</tbody>
</table>

**bracket for HV cables entering the bottom of the enclosure**

Where required, a high-voltage cable bracket is available as an option to guide and support cables entering the enclosure from the bottom, via a removable, screw-on aluminium plate.

**vibration damping**

**Roller anti vibration pads**

This accessory placed under the rollers, avoids vibrations being transmitted from the transformer to its environment.

**Damper unit**

This device is installed in place of the roller and enables transmission of vibrations to the transformer environment to be attenuated by around 95%.

**high voltage RC filter**

Repetitive HV circuit-breaker switching generates high-frequency voltage oscillations and can cause damaging overvoltage in the core of the transformer. This is especially likely to occur where:

- the circuit-breaker is close to a significantly underloaded transformer (less than 10% of the rated output);
- the load is highly inductive or capacitive (very long cables, capacitors on the secondary side);
- the HV network is of the isolated neutral type or is high impedance earthed.

The solution is to install an RC damping filter between the HV and earth phases, as close as possible to the transformer’s HV connection points.
Immediate self extinguishing.
The IEC 60076-11 standard defines 3 tests on one and the same dry standard transformer.

fire behaviour tests

The fire behaviour test of the Trihal transformer’s casting system is made up of tests on material and a test F1 according to the IEC 60076-11 standard.

- tests on material
  Tests on specimens of the Trihal casting resin were carried out by independent laborato-
  ries.
  - decomposition products:
    The analysis and quantity of gases produced by the material’s pyrolysis are carried out
    according to the clauses of standard NF X 70.100, identical to those of standard
    UTE C 20454.
    Pyrolysis are carried out at 400, 600 and 800°C on specimens weighing approximately
    1 gramme each. This test was carried out by le Laboratoire Central Préfecture de Paris
    (Central Laboratory Prefecture of Paris).
  - test results:
    The table below indicates the average field (in mass of gas/mass of material) obtained from
    the values of the three tests carried out at 400, 600 and 800°C. The NS indication signifies
    the results are close to the limit of sensitivity thus lacking precision and therefore non-
    significant. The 0 indication signifies that the gases are absent or that their contents are
    below the equipments sensitivity.

![Decomposition products: gas content/temperatures](image)

<table>
<thead>
<tr>
<th>Decomposition products</th>
<th>400°C</th>
<th>600°C</th>
<th>800°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon monoxide (CO)</td>
<td>2.5%</td>
<td>3.7%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Carbon dioxide (CO₂)</td>
<td>5.2%</td>
<td>54.0%</td>
<td>48.1%</td>
</tr>
<tr>
<td>Hydrochloric acid (HCl) in the form of Cl⁻</td>
<td>0</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Hydrobromic acid (HBr) in the form of Br⁻</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hydrocyanic acid (HCN) in the form of CN⁻</td>
<td>0</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Hydrofluoric acid (HF) in the form of F⁻</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sulphurous anhydride (SO₂)</td>
<td>0.2%</td>
<td>0.17%</td>
<td>0.19%</td>
</tr>
<tr>
<td>Nitrogen monoxide (NO)</td>
<td>0</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Nitrogen dioxide (NO₂)</td>
<td>0</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

- test F1
  (as per the IEC 60076-11 standard § 28)

![Central Laboratory Prefecture of Paris Test certificate number 1140/86 on December 2nd 1986](image)

- test method
  A complete Trihal transformer column (HV+LV+core) was placed in the chamber described
  in IEC 60332-3-10 (relevant to electric cables).
  The test was started when the alcohol in the tank (initial level 40 mm) was ignited and when
  the 24 kW radiant panel was switched on. Test time was 60 minutes in compliance with
  standard.
- evaluation of results
  The temperature rise was measured throughout the test. In compliance with the standard,
  it remained ≤ 420°C.

\[ \Delta t = 45 \text{ min} : \text{temperature rise was 85°C (≤ 140°C, and in compliance with standard)} \]

\[ \Delta t = 60 \text{ min} : \text{temperature rise was 54°C (≤ 80°C, and in compliance with standard)} \]

No components such as hydrochloric acid (HCl), hydrocyanic acid (HCN), hydrobromic acid (HBr), hydrofluoric acid (HF), sulphur dioxide (SO₂), formic aldehyde (HCOH) were detected.
tests

Trihal is resistant to load variations, overloads and atmospheric disturbances.

climatic tests

- **test C2**
  (as per the IEC 60076-11 standard § 27.4)
  **Thermal shock**

  The Trihal transformer was placed for 12 hours in a climatic room where the ambient temperature was initially lowered down to –25°C (±3°C) in 8 hours (figure 1).

  **evaluation of results**
  The Trihal transformer was subjected to a visual inspection followed by dielectric tests (applied voltage and induced voltage tests at 75% of standard values) and partial discharges measurements. Partial discharges level is critical for cast resin transformer reliability.

  The standard imposes lower than or equal to 10 pC. The result for Trihal transformer was < 2 pC. No flashover or breakdown occurred during the dielectric tests.

  ![figure 1: test C2](image1.png)

environment tests

- **test E2**
  (as per the IEC 60076-11 standard § 26.3.2)
  **Condensation and humidity**

  **1 - condensation tests**
  The Trihal transformer remained for more than 6 hours in a climatic chamber with the temperature control to obtain condensation. Humidity was maintained by continuous water vaporization above 93% (figure 2).

  **evaluation of results**
  Within 5 mn of the end of the vaporization, the Trihal transformer was subjected, in the climatic chamber, to an induced voltage test at 1.1 Um its rated voltage for 15 mn. No flashover or breakdown occurred.

  **2 - humidity tests**
  The transformer remained in a climatic chamber for 144 hours with the temperature held at 50°C (±3°C) and relative humidity at 90% (±5%).

  **evaluation of results**
  At the end of this period, the Trihal transformer was subjected to applied voltage and induced voltage tests at 75% of standard values. No flashover or breakdown occurred.
**electrical tests**

These tests verify contractual electrical characteristics. They include:

- **individual tests (or routine tests).** These tests are systematically carried out on all Trihal transformers at the end of manufacturing and are subject to an official test report (see specimen on the next page).

  They consist of:

  - measurement of characteristics:
    - resistance of windings;
    - transformation ratio and vector group;
    - impedance voltage;
    - load losses;
    - no load losses and no load current.

  - **dielectric tests:**
    - applied voltage tests;
    - induced voltage tests;
    - measurement of partial discharge, acceptance criterion: 10 pC at 1.30 Ur, rated voltage. The acceptance criteria is set at 10 pC by standard IEC 60076-11 § 22.5.

- **type test.**
  They are carried out on request and are at the clients expense.

- **lightning test**
  The impulse test voltage is usually of negative polarity. The test sequence is composed of a calibration impulse between 50 % and 75 % of the full voltage followed by three impulses at full voltage.

  The applied is full standardized lightning impulse, see diagram.

  Trihal’s basic offer proposes a choice of impulse withstand levels as standard, according to list 2 (see table below), i.e. for 36 kV an impulse test voltage of 170 kV with the possibility of taking these values to 200 kV impulse for an insulation level of 38.5 kV.

- **temperature rise test**
  Carried out according to the simulated loading method. Heating measured by two tests:
  - one with only no load losses;
  - the other with only load losses.

  The total temperature rise is calculated in accordance with IEC 60076-11.

---

**Partial discharge level from day 1 \( \leq 10 \text{ pC} \)**

- Insulation 24 kV: impulse tested at 125 kV
- Insulation 36 kV: impulse tested at 170 kV, 200 kV indeed.

---

1) **summary of standard test levels**

<table>
<thead>
<tr>
<th>system highest voltage (kV)</th>
<th>3.6</th>
<th>7.2</th>
<th>12</th>
<th>17.5</th>
<th>24</th>
<th>36</th>
<th>41.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>eff. kV 50 Hz - 1 mm</td>
<td>10</td>
<td>20</td>
<td>28</td>
<td>38</td>
<td>50</td>
<td>70</td>
<td>80</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>impulse kV 1,2/50 μs</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>75</th>
<th>95</th>
<th>145</th>
</tr>
</thead>
<tbody>
<tr>
<td>List 1</td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>75</td>
<td>95</td>
<td>145</td>
</tr>
<tr>
<td>List 2</td>
<td>40</td>
<td>60</td>
<td>75</td>
<td>95</td>
<td>125</td>
<td>170</td>
</tr>
</tbody>
</table>

---

**Tests**

Electrical tests verify contractual electrical characteristics. They include:

- Individual tests (or routine tests).
  These tests are systematically carried out on all Trihal transformers at the end of manufacturing and are subject to an official test report (see specimen on the next page).

  They consist of:

  - Measurement of characteristics:
    - Resistance of windings;
    - Transformation ratio and vector group;
    - Impedance voltage;
    - Load losses;
    - No load losses and no load current.

  - Dielectric tests:
    - Applied voltage tests;
    - Induced voltage tests;
    - Measurement of partial discharge, acceptance criterion: 10 pC at 1.30 Ur, rated voltage. The acceptance criteria is set at 10 pC by standard IEC 60076-11 § 22.5.

- Type test.
  They are carried out on request and are at the clients expense.

- Lightning test
  The impulse test voltage is usually of negative polarity. The test sequence is composed of a calibration impulse between 50% and 75% of the full voltage followed by three impulses at full voltage.

  The applied is full standardized lightning impulse, see diagram.

  Trihal’s basic offer proposes a choice of impulse withstand levels as standard, according to list 2 (see table below), i.e. for 36 kV an impulse test voltage of 170 kV with the possibility of taking these values to 200 kV impulse for an insulation level of 38.5 kV.

- Temperature rise test
  Carried out according to the simulated loading method. Heating measured by two tests:
  - One with only no load losses;
  - The other with only load losses.

  The total temperature rise is calculated in accordance with IEC 60076-11.

---

**Table 1**

<table>
<thead>
<tr>
<th>System highest voltage (kV)</th>
<th>3.6</th>
<th>7.2</th>
<th>12</th>
<th>17.5</th>
<th>24</th>
<th>36</th>
<th>41.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eff. kV 50 Hz - 1 mm</td>
<td>10</td>
<td>20</td>
<td>28</td>
<td>38</td>
<td>50</td>
<td>70</td>
<td>80</td>
</tr>
</tbody>
</table>

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<thead>
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<th>Impulse kV 1.2/50 μs</th>
<th>20</th>
<th>40</th>
<th>60</th>
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<td>145</td>
</tr>
<tr>
<td>List 2</td>
<td>40</td>
<td>60</td>
<td>75</td>
<td>95</td>
<td>125</td>
<td>170</td>
</tr>
</tbody>
</table>
A clear and precise test report, joined to each transformer.

■ special tests. These are carried out on request and at the expense of the customer.

□ short-circuit tests
These tests are carried out on a special test rig according to standard IEC 60076-5. Three tests are carried out on each column lasting 0.5 seconds. Satisfactory tests carried out on a Trihal transformer 800 kVA - 20 kV/410 V dated 29 February 1988 at the EDF Test Centre at Renardières (France).

EDF Renardières Test Centre (France)
Test Report HM 51/20.812 dated 4 March 1988

□ short circuit withstand test of a Trihal transformer equipped with a PBT* feeder. Satisfactory test carried out on a Trihal transformer 2500 kVA – 20 kV/400V dated 18 November 1999 at the EDF Renardières Test Centre (France).

EDF Renardières Test Centre (France)
Test Report HM 21/20-998/1 dated 30 November 1999

□ noise level measurements:
- noise level measurements are part of the special test carried out on request and as an option.
  - the transformer noise is mainly due to magnetostriction of the magnetic circuit.
  - The noise level can be expressed in 2 ways:
    • in terms of acoustic pressure level Lp (A) obtained by calculating the quadratic average of measurements carried out according to standard IEC 60076-10 at a distance of 1 metre on a transformer operating under no load;
    • in terms of acoustic power level Lw (A) calculated from the acoustic pressure level using the following formula:

\[ Lw (A) = Lp (A) + 10 \log S \]

\[ Lw (A) = \text{weighted acoustic power level in dB(A)} \]
\[ Lp (A) = \text{average level of acoustic pressure measured in dB(A)} \]
\[ S = \text{equivalent surface area used for the calculation in m}^2 \]
\[ = 1.25 \times H \times P \]
\[ \text{with } H = \text{height of transformer in metres} \]
\[ \text{and } P = \text{measurement contour perimeter at a distance D.} \]

* Prefabricated Busbard Trunking.
Trihal online...
www.francetransfo.com

All the information you will need to install and operate Trihal

- drawings with dimension tables to prepare the installation and environmental integration of the transformer,
- installation, commissioning and maintenance instructions to make sure that your equipment will last,

Along with:
- general, descriptive specifications for the Trihal cast-resin transformer,
- technical data sheets with electrical and mechanical performance levels per power rating,
- the factory testing procedures for each device we manufacture.

If you require evidence of Trihal’s flexibility, you will find:
- E2-C2-F1 certifications defining Trihal’s ability to adapt to the harshest operating conditions,
- lists of references per country, power rating, voltage, vector group, product range, insulation and geographic area.
Go to “Pro area” and ask for your access code to this exclusive, specialists-only area.

“Pro area” contains:
- **Technical documentation** on the specific features of the transformer and the impact of its environment.
- All our in-factory testing procedures, along with reports on the special and standard tests already performed.
- All you need to know to install, commission and maintain your transformer. Our downloadable **pre-commissioning checklist** (in Excel format) will help you. If you use it correctly, you can get an extended 5-year warranty – free of charge! (see how to use it on page 29).
- **Standard drawings** of Trihal (IP00 or IP31).
- The list of devices available in stock, for those who can’t wait. This list is updated every day!
**general information**

Due to the absence of any liquid dielectric and the excellent fire behaviour of Trihal transformers, no anti-fire precautions are necessary providing the following guidelines are followed:

- the transformer should not be installed in a flood hazard area;
- the altitude should not be above 1000 metres unless a higher altitude is specified at the time of enquiry;
- the ambient temperature for the transformer to be within the following limits:
  - minimum: – 25°C;
  - maximum: + 40°C (unless a higher temperature is designed for based on information provided at the time of enquiry).

Standard transformers are designed in accordance with IEC 60076 for an ambient temperature of:

- maximum: 40°C
- daily average: 30°C
- yearly average: 20°C.

- the local ventilation should allow the dissipation of the transformer total losses, including increased losses during AF operation.
- in highly polluted atmospheres (metal machining oil, conductive dust), the air coming into contact with the device should if possible be cleaned (filtering, inlet of outside air via a ducting).
- the transformer even with IP 31 metal enclosure is designed for an indoor installation (please consult us for an outdoor installation).
- provision should be made for access to connectors and tapping links.
- for mobile installations please consult us.

■ Trihal without enclosure (IP 00) (figure 1).

In this configuration, even with plug-in bushings, the transformer must be protected against direct contact.

In addition:

- care must also be taken to eliminate risks of water drops on the transformer (example: condensation from overhead pipings);
- maintain minimum clearance to the walls according to the following table:

<table>
<thead>
<tr>
<th>Insulation (kV)</th>
<th>dimensions X in mm(1)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>full wall</td>
<td>ventilation grill</td>
<td></td>
</tr>
<tr>
<td>7.2*</td>
<td>90</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>12*</td>
<td>120</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>17.5*</td>
<td>160</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>24*</td>
<td>220</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>36*</td>
<td>320</td>
<td>400</td>
<td></td>
</tr>
</tbody>
</table>

(1) do not take account of access to the variation tapping links.

*according to NF C 13-100 and HD 637 S1.

Please consult us if any of these distances can not be achieved.

■ Trihal with IP 31 metal enclosure (figure 2).

A minimum distance of 200 mm between the exterior of the enclosure and the walls of the building should be maintained to ensure adequate cooling.
**installation**

**substation ventilation**

- determination of the height and area of ventilation grills.

In the general case of natural cooling (AN), the ventilation of the substation or of the enclosure must ensure by natural convection the dissipation of the heat produced by the transformer’s total losses.

In the case of a sufficiently ventilated substation, appropriate ventilation will consist of a fresh air intake opening of S section at the bottom of the substation and an outgoing air opening S’ located above on the opposite wall at height H metres above the intake opening (figures 1 and 2).

To ensure efficient cooling of the transformer and sufficient air circulation, it is essential to maintain a minimum height of 150 mm under the live section, by installing rollers or an equivalent booster.

It must be noted that restricted air circulation reduces the transformer’s continuous and short term overload capacity.

- formula for ventilation (figure 1):

  \[ S' = \frac{0.18 \times P}{\sqrt{H}} \quad \text{and} \quad S' = 1.10 \times S \]

  \[ P = \text{sum of the transformer’s no-load and load losses expressed in kW at 120°C.} \]

  \[ S = \text{area of the lower air intake opening (allow for mesh factor) expressed in m}^2\]

  \[ S' = \text{area of the air outlet opening (allow for mesh factor) expressed in m}^2\]

  \[ H = \text{height difference between the two openings expressed in metres.} \]

  This formula is valid for an average ambient temperature of 20°C and an altitude of 1000 m.

  **Example**:

  - one single Trihal transformer 1000 kVA,
  - \( P_o = 2300 \) W, \( P_{cc} \) at 120°C = 11000 W,
    i.e. \( P = 13.3 \) kW.

  If the distance between the grills = 2 m, then \( S = 1.7 \) m\(^2\) of net surface area necessary.

  If we imagine a grill obstructing the air inlet by 30%; the air inlet grill surface area should then be \( 1.5 \text{ m} \times 1.5 \text{ m} \), and that of the air outlet should be \( 1.5 \text{ m} \times 1.6 \text{ m} \).

- substation forced ventilation (figure 2):

  Forced ventilation of the substation is necessary for ambient temperatures above 20°C, or small or badly ventilated rooms for applications with frequent overloads.

  The fan can be thermostat controlled and operate as an extractor in the top part of the room.

  **Advised flow** (m\(^3\)/second) at 20°C = \( 0.1 \times P \).

  \[ P = \text{sum of the transformer’s no-load and load losses expressed in kW at 120°C.} \]
The incoming HV and LV connections can be made from the top or the bottom.

connections

HV side connections are made by cables. LV side connections are made conventionally by cables, but can also be made using the «very safe» alternative using Prefabricated Busbard Trunking (PBT).

In all cases shown the cables or busbars must be supported to avoid mechanical stress on the HV or LV terminals or HV plug in connectors.

The HV connections should be made to the top part of the delta connection bars. The LV connections are made at the top of the transformer.

Warning:
- The distance between HV cables or busbars and the surface of the winding should be at least 120 mm except on the flat face of the HV side where the minimum clearance will be set by the HV terminal.
- The clearance to the outer HV delta bar should also be a minimum of 120 mm.
- The resin coating, or the use of plug in connectors does not give protection against direct contact and the transformer must not be touched when it is energised.
- The overvoltage limiter (type CARDEW.C) can not be installed on the transformer LV busbars: the working temperature can not exceed 40°C (unless specifically designed for higher temperatures).

Trihal without metal enclosure (IP 00).
- standard HV and LV connections.
- The outgoing (or incoming) LV conductors can be made from above or below (figures 1 and 2).
- The outgoing (or incoming) HV conductors can be made from above or below (figures 1 and 2).

In the case of an outgoing (or incoming) conductor from below it is necessary to put a spacer (spacer will not be supplied by France Transfo).

- HV connections with plug in connectors (figure 3).
- LV connections using prefabricated electrical trunking (PBT)(figure 4).

On site installation is simplified as far as possible, with very easy fitting, assembly and dismantling:
- the transformer is delivered pre-equipped with the PBT connection interface,
- the possibility of adjusting on site by ± 15 mm in all 3 directions,
- connection and disconnection is achieved within an hour at most providing optimum continuity of service.

As an example, the French guide C 15-005 recommends not exceeding 4 cables per LV phase, a limit which does not exist for PBT, which should therefore be used beyond this. PBT/Trihal interface connection, tested in the factory, guarantees conformity of the installation to NF C 15-100.
Trihal with IP 31 metal enclosure.

- Standard HV and LV connections (figures 1 and 2).
- The outgoing (or incoming) LV conductors must go upwards from the terminals under the enclosure cover. The LV conductors should never pass between the HV coils and the enclosure.
- The outgoing (or incoming) HV conductors can pass above (figure 1) or below (figure 2).
- HV connection from below.
- The outgoing (or incoming) HV conductors can come from below directly to the connection terminal (figure 2). In this case incoming conductors are passed through the removable flaps door located at the bottom right of the HV side.
- The HV cables must be fastened inside the enclosure on the HV side panel. A cable bracket can be ordered as an option, for this purpose. It is advisable to verify the feasibility of this type of connection in relation to the section and the bending radius of cables and the space available in the enclosure.
- HV connection by plug in connector (figure 3).
- LV connections using prefabricated electrical trunking (PBT) (figure 4).

Warning:
It is necessary to verify conformity with the IP31 protection index after having drilled the insulation gland plate for HV, LV and other.
general information

The transformers are designed to operate at rated power at ambient temperature defined by IEC 60076:
- maximum: 40°C;
- daily average: 30°C;
- yearly average: 20°C.

Without particular specification, the reference temperature is the annual average of 20°C.

Overloads are allowed without reducing the transformer’s service life if they are compensated by a normal load below the rated power (description in IEC 60905 standard).

\[ K = \frac{\text{load}}{\text{rated power}} \]

The admissible overloads are also subject to the average mean ambient temperature. The 1st column gives the cyclical daily overloads. The 2nd column indicates the acceptable short time overloads.

The figure below shows the acceptable constant load as a function of the average temperature compatible with normal life duration.

One can operate a transformer designed for operation in yearly average ambient temperature of 20°C at higher temperatures by reducing the rating as shown in the table:

<table>
<thead>
<tr>
<th>Yearly average ambient temperature</th>
<th>Admissible load</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°C</td>
<td>P</td>
</tr>
<tr>
<td>25°C</td>
<td>0.97 x P</td>
</tr>
<tr>
<td>30°C</td>
<td>0.94 x P</td>
</tr>
<tr>
<td>35°C</td>
<td>0.90 x P</td>
</tr>
</tbody>
</table>
**handling**

The transformers are equipped with provisions for safe handling.

- **lifting with slings (figure 1).**
  Lifting is carried out using the 4 lifting holes for a transformer without an enclosure and by 2 lifting lugs in the case of a transformer with an enclosure. The slings should not form an inside angle greater than 60°.

- **lifting with a fork lift truck (figure 2).**
  The lifting capacity of the fork lift truck should first be checked. If suitable, the forks should be inserted inside the base channels after removing the rollers.

- **towing.**
  Towing the transformer with or without enclosure should be done from the underbase. For this purpose hole of 27 mm. diameter are provided on every side of the underbase. owing can be done in two directions : in the axis of the underbase and perpendicular to that axis.

- **fitting the rollers.**
  - either by lifting with slings (figure 1);
  - or by lifting with a fork lift truck (figures 1 and 2).
  In this case position the lifting forks in the underbase channels.
  Place timbers of greater height than the rollers under the channels and lower the transformer on to them.
  Position jacks and remove the planks.
  Attach the rollers in the desired position (bi-directional rollers).
  Lower and remove allowing the Trihal to rest on its rollers.

**storage**

The Trihal transformer should be protected in storage from water drops and dust generating work (masonry, sanding, etc.). If the Trihal transformer is delivered with a plastic cover which should be kept over the equipment whilst it is in storage.

The Trihal transformer can be stored at a temperature down to -25°C.
commissioning

- Installation local (see page 20 and 21).
  The location should be dry, clean, finished and free from risk of water entry. The Trihal transformer should not be installed in an area liable to be flooded. The location should have sufficient ventilation to ensure the transformers total heat losses can be dissipated.

- checking the condition after storage.
  If the Trihal transformer is found accidentally to be very dusty, clean it by vacuum cleaner or by blowing with compressed air or nitrogen and thoroughly clean the insulators using paper towels.

- Trihal transformers supplied with a plastic cover.
  To avoid contamination by foreign bodies (screws, nuts, washers, etc.), the cover should remain in place during the whole connecting operation : to gain access to HV and LV connections tear the cover.

- Trihal transformer supplied with metal enclosure.
  The enclosure should in no place support loads other than the supply cables for the transformer.
  The installation inside the enclosure of unauthorised equipment or accessory not supplied by France Transfo except the connection cables correctly installed as shown in the relevant section, is not permitted and invalidates the guarantee.
  For any modifications, attachments and mounting of accessories, please consult us.

- HV and LV connections cables (see page 12).
  In no case should fixing points be made on the transformer core and windings.
  The distance between the HV cables, the LV cables, or the LV bars and the surface of the HV winding should be at the least 120 mm. except on the high voltage side where the minimum distance is to be considered from the most protruding delta connection.

  Particular care should be taken concerning the earthing of HV cable shields.
  The distance of 120 mm should be complied with between earthing cables and the surface of the HV winding.

- connection of HV connectors.
  Connection tightening torque on the HV terminal and tapping links with flat + contact washers (brass screws):

<table>
<thead>
<tr>
<th>tightening torque for bus bars bolts</th>
<th>M8</th>
<th>M10</th>
<th>M12</th>
<th>M14</th>
</tr>
</thead>
<tbody>
<tr>
<td>tightening torque N.m</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>50</td>
</tr>
</tbody>
</table>

- connection of LV connectors.
  Connection tightening torque for the LV bars :

<table>
<thead>
<tr>
<th>tightening torque for bus bars bolts</th>
<th>M8</th>
<th>M10</th>
<th>M12</th>
<th>M14</th>
<th>M16</th>
</tr>
</thead>
<tbody>
<tr>
<td>tightening torque N.m</td>
<td>12.5</td>
<td>25</td>
<td>45</td>
<td>70</td>
<td>100</td>
</tr>
</tbody>
</table>

- case of reactive energy compensation: i.e. an installation combining transformers, capacitor banks and LV switchboards.
  Power factor correction equipment, which is to be connected close to the transformer busbars, should have inrush current limitation to prevent the generation of transient over-voltages. This can be achieved by switching individual capacitors using a contactor incorporating a pre-insertion device (e.g. LC1-D.K. Schneider contactor with preinsertion resistance).

The pre-commissioning checklist that comes with every Trihal transformer (see page 30 of this brochure) will help you make sure that you have completed the commissioning procedure correctly!
auxiliary wiring.
Auxiliary wiring from the transformer (connection to the plug-in connectors) should be attached on rigid supports (without any ties) and have sufficient clearance from live parts. The minimum clearance to respect is determined by the insulation voltage indicated on the rating plate. See the opposite table.
Do not fix accessories etc… to the core and windings of the transformer.

parallel operation.
Verify the identity of the HV and LV voltages and the compatibility of characteristics and especially the vector groups and the impedance voltage.
Make sure that the same tapping is selected for transformers to be coupled in parallel according to the IEC 60076-1 standard.

checks before commissioning:
☐ remove the protective cover and check all the connections (arrangements, distances, tightening torques);
☐ check cable and bus bars entries after connection to ensure IP rating has been maintained;
☐ verify the position identity of tapping links on the three phases are in accordance with the diagram on the rating plate;
☐ verify the transformers general state of cleanliness and carry out an insulation test verifying HV and LV earth and HV and LV insulations using a 2500 V insulation tester (meeger).

The approximate values of resistances are:

<table>
<thead>
<tr>
<th>Insulation voltage (kV)</th>
<th>Minimum clearance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2</td>
<td>270</td>
</tr>
<tr>
<td>12</td>
<td>450</td>
</tr>
<tr>
<td>17.5</td>
<td>450</td>
</tr>
<tr>
<td>24</td>
<td>450</td>
</tr>
</tbody>
</table>

If the values measured are significantly below, verify the transformer is not moist. If it is, dry it with a rag and repeat the verification.

In the contrary please contact your usual correspondent.

maintenance

In normal use and environment at conditions inspect the transformer each year and vacuum clean or blow with dry compressed air to remove excessive dust.
The frequency of cleaning will be a function of service conditions.
During such maintenance the connection bolts should be checked for tightness using a torque wrench.
In the case of greasy dust deposits, only use a cold degreasing product to clean the resin surfaces.

after sales services

For any information or replacement parts it is essential to quote the main characteristics on the rating plate and especially the transformers serial number.
getting your transformer energised

Commissioning assistance
Our after sales technicians make sure your France Transfo equipment is correctly commissioned.

Telephone or online assistance
If you have a question or a problem, just pick up the phone. We are at your disposal from Monday to Friday, 8.30 am to 5.30 pm (French time).

France Transfo on call service
In the event of an emergency outside of these times, you can reach France Transfo’s on-call service at the same number, 24/7.

on-site

Repair
France Transfo’s TRIHAL transformer technology means that full on site repairs are possible, even under difficult access conditions.

Training
Training suited to each type of equipment is given throughout the world.

Expertise

Replacement part emergency supply
The after sales service has a large stock of replacement parts, as befits a major transformer manufacturer, thus enabling us to supply standard parts with very quick delivery times. Moreover France Transfo’s engineering office and ten year archives mean that you benefit from a solution that is perfectly suited to your application.

Assembly or supervised assembly
All Trihal* transformers ordered after 1st July 2006 may be guaranteed for 5 years, provided that:

1. The installation, commissioning and maintenance instructions delivered with the transformer are followed to the letter; the main part of these instructions can be found in the “10 commissioning precautions” on the back of the electrical test report.

2. The pre-commissioning checklist provided with the transformer is completed correctly, giving:
   - the transformer’s serial number, which can be found on the rating plate,
   - an answer to each point (either “yes” or “NA” if not applicable),
   - the insulation resistance measurement results, which must be equal to or greater than the limits specified in the installation, commissioning and maintenance instructions,
   - the date on which the 27-point inspection was carried out,
   - the signatures of the inspector and his manager,
   - the effective commissioning date, which must be no more than 7 days after the inspection date,
   - the final transformer installation site,
   - your full details.

3. Please return the checklist to the address below, within 15 days of the effective commissioning date.

France Transfo will examine and approve your checklist as soon as it arrives, and will send you a letter confirming your 5-year guarantee.

Important: Each point on the checklist will be reviewed during maintenance operations, prior to recommissioning and throughout the transformer’s service life.

* new equipment, never having been repaired.
LIST OF ITEMS TO BE CHECKED
PRIOR TO TRANSFORMER COMMISSIONING

Carefully read the installation instructions provided, and install the transformer accordingly, before fully completing this checklist!

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The information on the rating plate has been checked and meets requirements</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>The tapping links have been adjusted to the voltage network, and are identical on the 3 windings</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Note the 3 insulation resistance measurements in these 3 boxes - see instructions, page 6. MV and LV cables will be disconnected during this measurement.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HV / Ground</td>
<td>MΩ</td>
<td>LV / Ground</td>
</tr>
<tr>
<td>4</td>
<td>The MV connection bars and the off circuit tapping links must remain tightened to 20 N.m</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>The distances required for transformer cooling have been respected on all sides: see instructions, page 3</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>The transformer room is clean and not liable to flooding</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>The room is properly ventilated, with a clean air inlet at the bottom of the wall and an outlet at the top, in accordance with classic engineering practice: see instructions, page 2</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>The plastic cover remained in place up to commissioning day</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>There is no condensation or foreign bodies on the transformer (dust, greasy substances, conducting particles...)</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Energised parts are at the minimum required distance from surrounding exposed conductive parts: see instructions, page 3</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>The MV and LV cables are supported, and are at the correct distance from the MV windings: see instructions, page 3</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>The transformer is grounded via the points marked:</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>The connection to the transformer’s LV bars includes flexible leads, which are not subjected to mechanical stress, in case of junction on busbars: see instructions, page 3</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>14</td>
<td>The ground continuity of the MV surge arresters has been checked</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>15</td>
<td>There are no breaks or short circuits in the heat sensor circuit</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>16</td>
<td>The temperature sensors are correctly connected to the thermal relays</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>17</td>
<td>The thermal relay is correctly connected to the control panels, tripping sequences are set and checked</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>18</td>
<td>The fans and their related relay circuitry are working properly</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>19</td>
<td>The overload protection devices on the HV or LV side have been set</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>20</td>
<td>The I_max protection device has been adjusted to the transformer’s inrush current and time constant: see your Schneider representative for adjustment values</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>21</td>
<td>The H2 (harmonic) check of the electronic protection relay (e.g. Schneider’s SEPAM) is active (Max Io divided by sum of 3 CT)</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>22</td>
<td>The transformer’s upstream and downstream protections have been checked, and confirmed by test</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>23</td>
<td>The protection index (IP..) is respected, particularly when cables go through the housing</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>24</td>
<td>If the transformer is enclosed, the bonding braids have not been moved</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>25</td>
<td>The LV capacitor bank contacts are fitted with pre-insertion resistors</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>26</td>
<td>In the case of parallel operation, the points listed on page 6 of the instructions have been checked</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>27</td>
<td>Locking mechanisms (mobile enclosure panel + plug-in bushings) have been checked</td>
<td>Yes</td>
<td>NA</td>
</tr>
</tbody>
</table>

NA: not applicable

Date:  
Technician name:  
Signature:  

Date:  
Manager name:  
Signature:  

Effective commissioning date:  

france transfo
10 Précautions avant mise en service

Commissioning Precautions

S'assurer que la tension d'alimentation n'est pas supérieure à celle indiquée sur la plaque signalétique.

Éviter les coupures et ré-encelchcements répétés.

Check that the voltage indicated on the rating plate is correct for the system voltage.

Avoid repetitive tripping and re-lamping.

Garantir une distance minimale, entre parties sous tension et mase ou tout corps voisin, en fonction de la tension d'isolement du transformateur, sauf validation particulière du constructeur.

Make sure there is a minimum distance between the live parts and the ground or any neighbouring object in relation to the transformer's insulation voltage, unless otherwise stipulated by the manufacturer.

Isolation Insulation 
Value m

<table>
<thead>
<tr>
<th>Value m</th>
<th>Distance mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2</td>
<td>90</td>
</tr>
<tr>
<td>12</td>
<td>120</td>
</tr>
<tr>
<td>17.5</td>
<td>160</td>
</tr>
<tr>
<td>24</td>
<td>220</td>
</tr>
<tr>
<td>36</td>
<td>320</td>
</tr>
</tbody>
</table>

Éviter les contraintes mécaniques sur les points de raccordement au transformateur.

Avoid mechanical stress on the connection points of the transformer.

Assurer le maintien des câbles HT et BT (effet de fouettage sur courant de défaut ou d'encelchement).

Make sure the HV and LV cables are held in place (whip effect on the fault or inrush current).


Make sure the premises are correctly ventilated and have a clean air inlet in the lower half and an outlet in the upper half.

Vérifier l'absence sur le transformateur de tout corps étranger.

Check the transformer does not have any foreign matter on it.

Dry the equipment if it is wet.

Régler les protections en fonction du courant d'encelchement et de la constante de temps du transformateur.

Set the protections according to the transformer's inrush current and time constant.

Contoller la continuité des masses.

Connect the operating device thermal protection circuits correctly.

Check earthing continuity.

Éviter la position incorrecte de la batterie de réglage, sur les 3 phases (voir plaque signalétique) et respecter le couple de serrage des connections et barrettes HT (2 daN.m).

Check the tapping links are correctly and identically positioned on the 3 phases (see rating plate) and check the tightening torque (2 daN.m) for HV tapping links and connections.

Assurer le transformateur avec habillage, une garde au sol sous l'habillage d'au moins 150mm pour permettre le refroidissement.

Raccorder l'habillage à la terre.

Keep a minimum clearance of 150 mm between the transformer with its enclosure and the ground in order to ensure cooling.

Connect the enclosure to the earth.

Assurer le nettoyage du transformateur avant la mise sous tension (en particulier corps gras ou particules conductrices).

Clean the transformer before commissioning it (check especially for greasy matter or conductive parts).

Limiter obligatoirement le courant d'encelchement des batteries de condensateurs côté HT, en utilisant les résistances de pré-insertion.

It is compulsory to limit the inrush current of the LV side capacitor banks using the pre-insertion resistors.

Pour tout complément d'information, contacter le : +33 (0)3 87 70 57 72

For further information please contact +33 (0)3 87 70 57 72
the advantages
for the development of customer and partner relations with:

- Better involvement of personnel;
- Increased responsibility for management teams;
- A contribution to reducing the consumption of power, water and raw materials;
- A privileged qualification of Schneider Electric as supplier;
- Specific sales assistance for our customers and partners: sales argument, export sales dynamic.

the guarantees
for a lasting development with:

An environmentally-friendly product development using news techniques to better conserve natural resources.

Thanks to current methods, the choice of the configuration and components of products makes allowance for their environmental impact.

A continuously improvement of the environment protection at all the sites by generalising the implementation of a common environmental management system.

The organisation will be based on an international standard: the ISO 14001.