TECHNICAL DOCUMENTATION - MANUAL

10T4-094511A

Valid from 28.05.2025

CAST-RESIN TRANSFORMERS

TRIHAL / TRICAST type

Warning: Do not switch the transformer on before reading this manual.

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1. GENERAL INFORMATION

Principles of operation of TRIHAL or TRICAST types, three-phase cast-resin transformers are the subject of this manual. These transformers are designed for operation in indoor substations. They can operate in all sectors of economy, where there are no special requirements referring to their operating conditions. TRIHAL and TRICAST transformers have low level of no-load losses and low level of noise.

Principles of operation and directions given in this documentation should be strictly observed by transformer's users. Non-observation of these principles may result in a transformer damage, create safety hazards for servicing staff and cause losing the guarantee.

2. COMPLIANCE WITH STANDARDS

The transformers are manufactured and tested according to the EN 60076 standard series; it means:

- EN 60076-1:2011 Power transformers – Part1: General
- EN 60076-3:2013 Power transformers – Part3: Insulation levels, dielectric tests and external clearances in air.
- EN 60076-4:2002 Power transformers – Part4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors.
- EN 60076-5:2006 Power transformers – Part5: Ability to withstand short-circuit.
- EN 60076-8:2002 Power transformers – Part8: Application guide.
- EN 60076-10:2016 Power transformers – Part10: Determination of sound levels.
- EN IEC 60076-11:2018 Power transformers – Part11: Dry-type transformers.

At the request of the client the transformers can be designed according to other standards or requirements.

3. CONNECTED DOCUMENTS

Installation, put into service and operation of transformers should be carried out according to regulations of building and operation of electrical equipment currently in force in the country of installation. Staff making transformer setting on site, assembling and starting up must have knowledge and skills to do such works. Safety rules for works with electrical equipment must be followed.

TRIHAL and TRICAST transformers delivered to EU countries fulfil the law requirements covered in the following documents:

- Directive UE 2009/125/EC of the European Parliament.
- Commission Regulation (EU) No 548/2014 of 21 May 2014 on implementing Directive UE 2009/125/EC of the European Parliament and of the Council with regard to small, medium and large power transformers and Commission Regulation (EU) 2019/1783 changing the regulation before
- Standard EN 50588-1:2018 if law requirements are related to these transformers.
- Standards EN 50708-1, EN 50 708-2, EN 50708-3 - if law requirements are related to these transformers.

The purchaser receives the following documents from Mefta Green Transfo Energy Poland Sp. z o. o.:

- transformer's test report together with the guarantee certificate,

- this manual,
- transformer's overall dimension drawing, if the transformer differs from a catalogue type,
- technical documentation for accessories if a manufacture of accessories delivers such documentation,
- other documents agreed in a contract.

4. OPERATING CONDITIONS

TRIHAL (TRICAST) transformers are intended to be setting in closed ventilated rooms, free from substances destroying insulation and from excess dust settling.

These rooms should be characterized by the following parameters:

- the maximum ambient temperature 40°C,
- average annual ambient temperature 20°C,
- relative air humidity up to 90% (for 20°C),
- minimum ambient temperature minus 25°C,
- the setting altitude up to 1000 m above sea level.

When ambient temperature is very low, i.e. close to minus 20°C, there is recommended to keep the temperature of the room where the transformer is installed minimum 10 degrees higher than outside temperature. It protects the transformer against snow and ice creation on the transformer surface.

Others site conditions have to be agreed with Mefta Green Transfo Energy Poland Sp. z o. o and written in a contract.

The TRIHAL (TRICAST) transformers are fulfilling requirements of F1 C4 E4 environmental classification according to EN 60076-11;2018.

5. RATED AND TECHNICAL DATA

TRIHAL (TRICAST) transformers are designed in the power range from 25 kVA up to 5600 kVA with rating HV 6,3 – 31,5 kV (the maximum system voltage Um = 7,2 - 36 kV). The transformers are designed in the IP00 protection class (without enclosure), or they are equipped with the enclosures with IP20, IP21 or IP31 protection class. At the request of the client, the TRIHAL (TRICAST) transformers can be designed with a different protection class.

6. DESIGN

6.1. Core

The transformer's core is made of a cold-rolled ceramic insulated transformer steel. Core yokes are pressed using beams tightened with bolts and nuts.
Stacking system is done using “step-lap” method – it gives lower no-load losses, lower no-load current and lower noise level.

6.2. Windings

The windings of the primary voltage (HV) are wound with round wires or strips. The windings are made of copper or aluminium using unique technology.

The winding design and manufacturing method based “random” and “strip” winding system together with the system of epoxy resin vacuum-pouring ensure the uniform and compact structure of the coils.

HV coils are mechanically strengthened in the coil production process by adding special meshes and fiberglass mats - these additional elements work similarly to steel in reinforced concrete structures - they strengthen the coils and prevent the formation of cracks on the coil surfaces. Meshes and glass mats are sometimes visible on the finished product. This phenomenon, however, does not indicate poor workmanship, as the surface of the coils remains smooth and the internal structure of the coils is reinforced.

The windings of the secondary voltage of the transformers are made of aluminium or copper foil insulated with thermo-hardening material.

On each primary voltage coil there are one or two tap-changers (for some special design it can be more than two) for the regulation of the primary voltage in the range of ± 2 x 2,5%. At the request of the User the transformers can be designed with other regulation of the primary voltage.

Note:
The visibility of nets and mats on the surface of HV coils is a normal phenomenon and does not indicate poor quality.

6.3. Voltage regulation

The voltage regulation can be carried out in the de-energized state only. The regulation is make by changing the transformer voltage ratio by connecting or disconnecting the additional turns in the primary voltage winding. The regulation is carried out by changing of the position of the bars on the tap-changer. The way of connecting is shown on the diagram plate. The change of the bars position must be done equally on all phases of the transformer. The screws of the tap-changer should be fastened with torque 20 Nm.
In the transformers with housing, terminals of a tap-changer are accessible after removing the front covers of the HV side of a housing.

Fig. 1. Tap-changer – an example: tap-changer with 5 steps.

6.4. Terminals and connections

The secondary voltage connection bars are led to the upper part of the transformer. The part of the bar sticking out above the neutral bar, together with the hole (holes) make up the secondary voltage terminal. The picture of the terminal is shown on the overall drawing.

Transformers with aluminium LV windings can have LV connections made of aluminium bars covered by tin. To these bar terminals, external connections – made of aluminium or copper - can be linked up directly. If transformer connections and terminals are made of pure aluminium (not tinted), there is recommended to use „cu-al" plates between to connect with external copper bars or cables. These "cu-al" plates are not a part of standard equipment of a transformer; they could be ordered during transformer ordering phase and then, they are attached to LV terminals and delivered together with a transformer.

Fig. 2. View of a typical LV terminal

6.5. Frame with wheels

Transformers are equipped with frame and adjustable wheels It makes possibility for transformer's moving in two perpendicular directions.

6.6. Lifting equipment

Each transformer without a housing is equipped with four eyes used for lifting the transformer with a crane. In TRIHAL transformers, the eyes are made in the form of holes in upper beams.

Fig 3. Lifting eyes – in upper beams.

Each transformer with standard housing IP20, IP21 or IP31 is equipped with two lifting eyes placed on a housing cover.

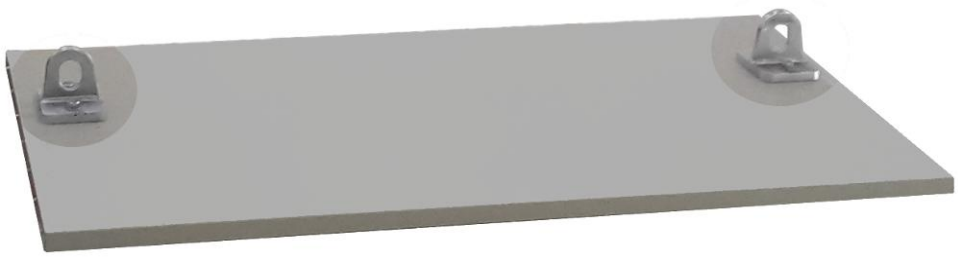

Fig. 4. Lifting eyes – on a housing cover.

Gravity center of the transformer is located relatively high, that's why, the most safety way for lifting is lifting using a crane. Usage of fork-lift tracks for transportation is also possible but it is limited to the transformers without housing, with total mass lower than 5 T and with special marking placed on chassis showing that fork-lift track lifting is allowed. This marking is placed on lower beams. Access of fork-lift track is allowed generally from one side of the transformer only. Then, on the second side of the transformer, there is marking than fork-lift lifting is prohibited.

6.7. Earthing terminals

Each transformer is equipped with minimum 2 earthing terminals placed on lower frame or on side part of lower beams pressing a lower yoke of a core. Earthing terminals are marked.

Fig. 5. Earthing terminal on a frame.

Fig. 6. Marking of earthing terminal

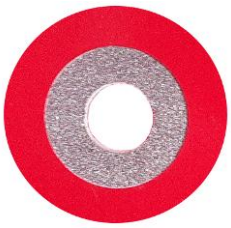

Fig. 7. Earthing terminal on a lower beam.

6.8. Rating plate

Each transformer has got a rating plate containing ratings required by EN 60076-1:2011. If a transformer is delivered to EU country, data placed on a rating plate are also in compliance with EN 50588-1:2018 standard.

6.9. Housing

As a typical execution, TRIHAL (TRICAST) transformers are built and delivered without housing. This kind of execution is marked as IP00. However, these transformers can be equipped with housing with various level of protection class. Description of these housings is placed in the chapter "Optional equipment."

6.10. Non-typical designs

The basic execution of TRIHAL (TRICAST) transformer is distribution, 3-phases, 2-windings transformer where first winding (HV) is supplied by MV network with voltage from 6 kV up to 36 kV and second winding (LV) supplies low voltage network: the most often it is 400 V or 420 V.
TRIHAL (TRICAST) transformers are also built with non-typical design such as:

- 3-winding transformers – with one HV winding and 2 separated LV windings,
- rectifier transformers – 2-winding or 3-winding transformers – intended to supply 6-pulses or 12-pulses rectifiers. During the operation, there are high content of harmonics current flowing through windings and the transformer windings have to be resistant against these harmonics,

- converter transformers - 2-winding transformers – intended to supply converters,
- double-voltage transformers – where HV winding is designed that can be supplied by 2 various voltage values.

7. BASIC EQUIPMENT

7.1. Temperature sensors

TRIHAL (TRICAST) transformers are equipped with 2 sets of PTC temperature sensors. Each sensor is built for specific one threshold temperature, where below this temperature the sensor resistance is close to 60Ω; if temperature is going up and over-crossing the specific threshold temperature then the sensor resistance is going rapidly up reaching a few kΩ. PTC sensors do not measure temperature value but reacting on threshold temperature over-crossing only:

- first set reacting on 140ºC i.e. the alarm temperature, which means, that the rated insulation temperature has been exceeded,
- second set reacting on 150 ºC i.e. the temperature, above which the transformer has to be switch off, since its further operating can damage it.

The sets of sensors described above are delivered with the transformer even if a temperature relay is not delivered with. If the transformer is delivered with a temperature relay, the sets of sensors can be changed or extended by next sensors. More detail information can be found in the next chapter.

The sensors are placed in a cooling ducts in a LV coils; where cooling ducts do not exist, the sensors are placed between LV coils and core legs. The 3 sensors for the same temperature of 3 phases are connected in series and creates one set. The sets are connected to a terminal strip. The diagram of sensor connections is stick nearby to the core clamp. Resistance of the sensor set is in room temperature close to 200Ω and growing rapidly to a few kΩ when threshold temperature is over-crossed for minimum one sensor.

Warning: Placing the temperature sensors in other places than described here is forbidden, specially placing sensors in cooling ducts of HV coils or nearby of HV coils creates risk of transformer damage.

Fig. 8. Sensor properly placed inside LV cooling duct.

Fig. 9. Terminal bar.

Connection of PTC sensors on terminal bar:

- first set reacting on 140ºC is connected to terminals 1, 2, 3, 4
- second set reacting on 150 ºC is connected to terminals 1, 5, 6, 7

8. OPTIONAL EQUIPMENT

8.1. Optional equipment - temperature sensors others than basic equipment

A. Additional sensors PTC for transformers with fans.

Transformers with cooling fans are equipped with 3 sets of temperature sensors:

- first set for 120°C Or for 110°C for ventilation fans steering,
- second set for 140ºC i.e. the alarm temperature, which means, that the rated insulation temperature has been exceeded,
- third set for 150 ºC i.e. the temperature, above which the transformer has to be switch off, since its further operating can damage it.

B. Additional PT100 sensors – sets of 3 or 6 sensors.

Set of 3 PT100 sensors – one sensor per phase – is used for both temperature measurements and for protection against overcrossing of the threshold temperatures. When this solution is applied, the PTC sensors – basic equipment – are not delivered.
Set of 6 PT100 sensors – two sensors per phase – is used in the same way as set of 3 PT100 sensors, where 3 sensors are connected and 3 not - remaining as spare sensors.

C. Additional temperature sensors – others.

Other set of temperature sensors can be agreed in a contract. On client wish, there is possible to install additional PT100 sensor for a core temperature measuring or a thermometer showing temperature of one phase of LV winding.

D. Distinguishing marking of PTC sensors.

PTC temperature sensors can be distinguish by colours od sensor wires. The colours are as follows:

- PTC 100°C – red and red
- PTC 120°C – grey and grey
- PTC 140°C – white and blue
- PTC 150°C – black and black
- PTC 155°C – blue and black
- PTC 160°C – blue and red
- PTC 180°C – white and red

8.2. Optional equipment – the fans

The transformer can be additionally equipped with a set of fans mounted in the bottom part of the transformer. The fans set consists of 6 fans placed on lower core beams on both sides of the transformer. The fans enable the temporary overload of the transformer by 30% or by 40%. It should be taken into account that the fans makes an intensive air flow in transformer cooling ducts only; they do not increase cooling efficiency of a transformer chamber. Ventilation of the transformer chamber has to be checked for increased heat dissipation and a proper ventilation has to be ensured. More detailed information – see chapter 12 of this manual. The transformer overload led also to increased current in supplying system – load of bus bars and switching devices have to check. The set of fans is guided by a temperature relay and the temperature relay is guided by temperature sensors placed in windings. The fans are switched on when transformer is overloaded. It has to be taken into account that fans are prepared for continuous work for circa 3 years when standard transformer working time is 30 years. The supplying system should to be designed in such a way that the fans are working temporary only.

Note: temperature relays (NT935AD, NT935ETH, T154, MSF220VU) are not designed for direct fans steering due to too low value of permissible current. For fan steering, an additional switching device is needed between the temperature relay and the fans. As this additional device, one set of the ZT temperature protection, being in our offer, can be used. The most frequent used additional switching devices are listed in the next chapter.

For transformers with fans, a diagram of steering system is attached to a transformer documentation.

NOTE: decision – equipped the transformer with fan set or not, should be taken on the stage of transformer ordering. Later supplement with fans can occur impossible or very expensive.

8.3. Optional equipment – temperature relay

There are many various temperature relays which can be applied – coming from different manufacturers and with different functionality. Manual of the temperature relay – if delivered with the transformer – should be attached to this manual.

The table below contains a list of the temperature relays more often used. There are also basic description of them and preferred set of sensors.

Temperature relay type.	Basic description	Set of sensors	Notes
NT935AD	Basic relay reacting on over-crossing of 2 or 3 threshold temperatures and showing a temperature of windings. Can manage a fans steering. It is equipped with analog port 4-20 mA and RS-485 port for MODBUS RTU.	PT100 x 3 sensors	Delivered separately; it can be internal part of temperature protection ZT-N935, then it is intended to be installed on a wall of transformer chamber.

NT935ETH	Basic relay reacting on over-crossing of 2 or 3 threshold temperatures and showing a temperature of windings and a core. Can manage a fans steering. It is equipped with Ethernet port for LAN connection.	PT100 x 4 sensors	Delivered separately; it can be internal part of temperature protection ZT-N935ETH, then it is intended to be installed on a wall of transformer chamber.
T154	Basic relay reacting on over-crossing of 2 or 3 threshold temperatures and showing a temperature of windings. Can manage a fans steering.	PT100 x 3 sensors	Delivered separately; it can be internal part of temperature protection ZT-T154, then it is intended to be installed on a wall of transformer chamber.
Typ Z (Ziehl) MSF 220VU	Basic relay reacting on over-crossing of 2 or 3 threshold temperatures. Can manage fans steering.	PTC 2 x 3 sensors or PTC 3 x 3 sensors if transformer is equipped with fans.	Delivered separately; it can be internal part of temperature protection ZT-MSF 220VU, then it is intended to be installed on a wall of transformer chamber.
ZT-NT935	Temperature protection reacting on over-crossing of 3 threshold temperatures and showing a temperature of windings. Intended for fans steering.	PT100 x 3 sensors	For installation on a wall of transformer chamber. NT935AD relay is internal part of this temperature protection.
ZT-NT935ETH	Temperature protection reacting on over-crossing of 3 threshold temperatures and showing a temperature of windings and a core. Intended for fans steering.	PT100 x 3 sensors	For installation on a wall of transformer chamber. NT935ETH relay is internal part of this temperature protection.
ZT-T154	Temperature protection reacting on over-crossing of 3 threshold temperatures and showing a temperature of windings. Intended for fans steering.	PT100 x 3 sensors	For installation on a wall of transformer chamber. T154 relay is internal part of this temperature protection.
ZT-MSF 220VU	Temperature protection reacting on over-crossing of 3 threshold temperatures and showing a temperature of windings. Intended for fans steering.	PTC 3 x 3 sensors	For installation on a wall of transformer chamber. MSF 220VU relay is internal part of this temperature protection.

Basic application diagrams for temperature relay types NT935AD, NT935ETH, T-154 and MSF 220VU are placed below:

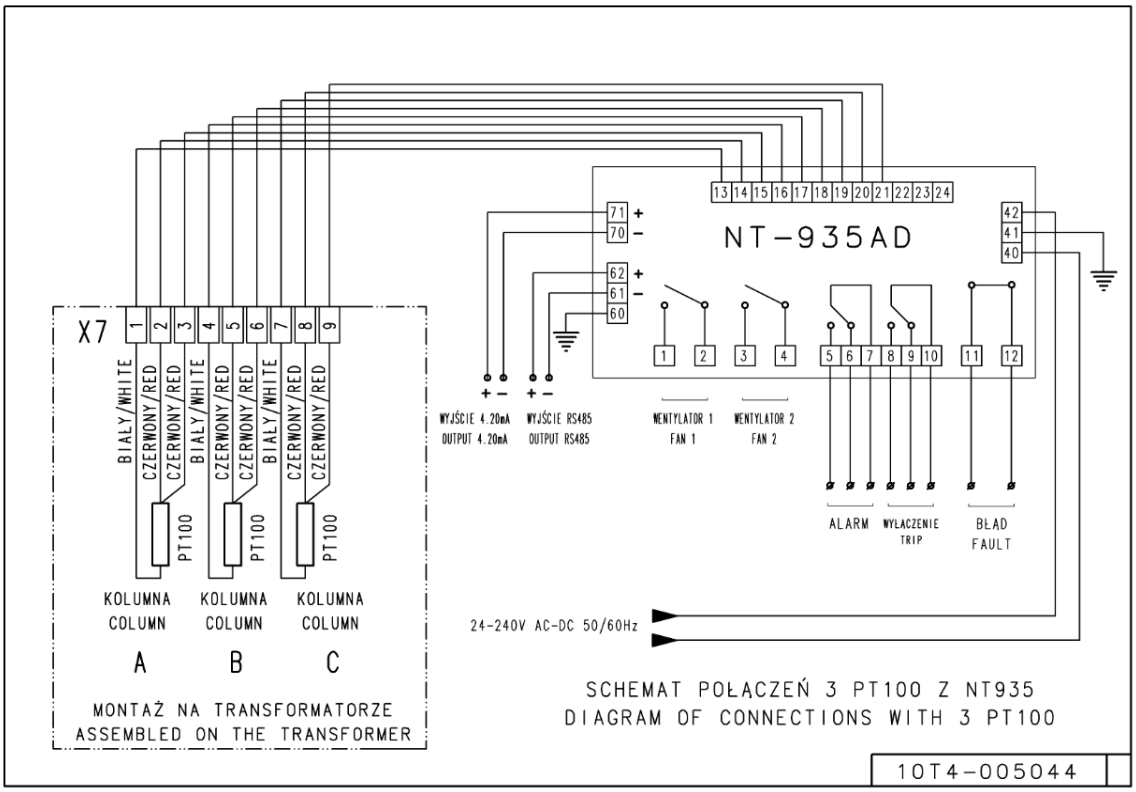

Fig. 10. Application diagram for temperature relay NT935AD

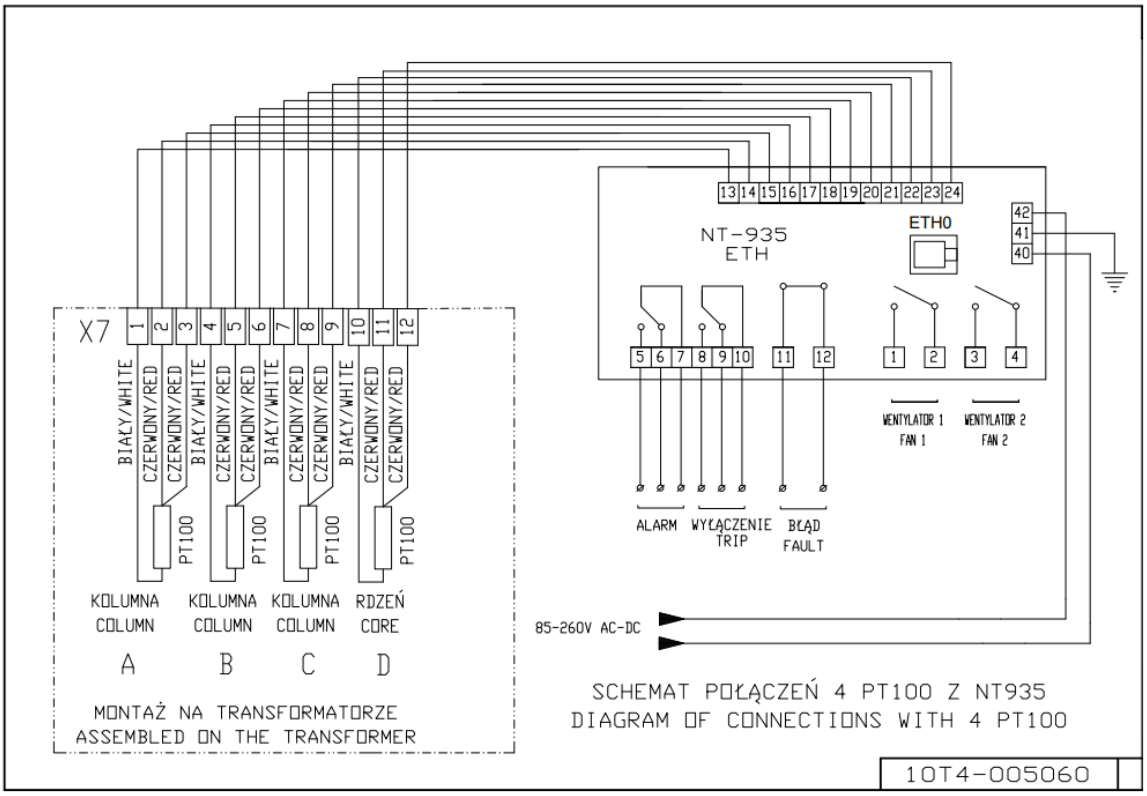

Fig. 11. Application diagram for temperature relay NT935ETH.

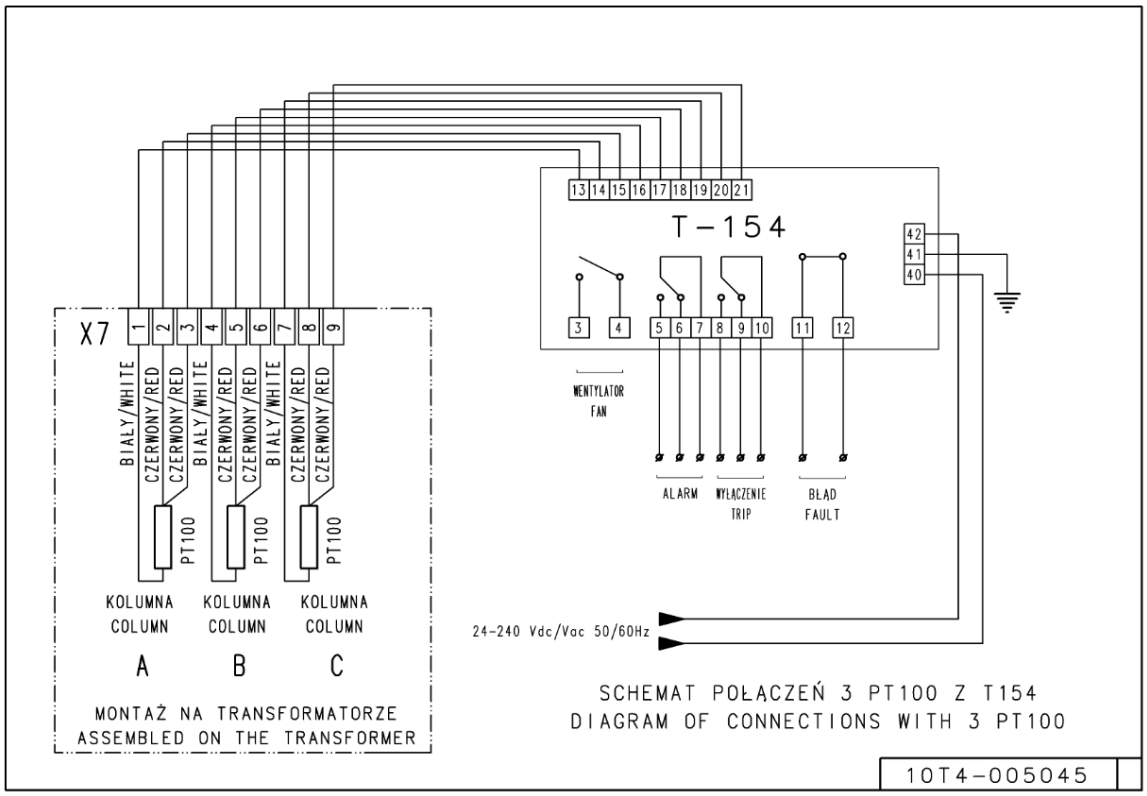

Fig. 12. Application diagram for temperature relay T-154.

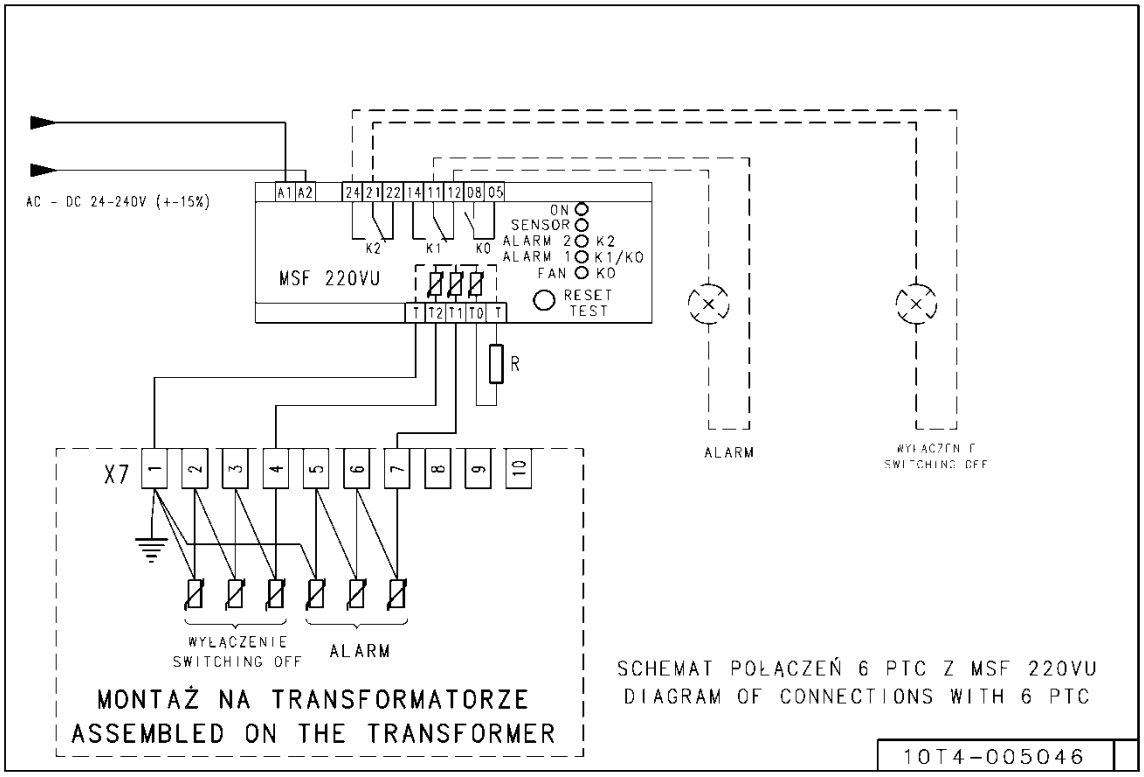

Fig. 13. Application diagram for temperature relay MSF 220VU.

Diagrams of the temperature protections, types ZT-NT935, ZT-NT935ETH, ZT-T154 or ZT-MSF 220VU are placed inside the housings of these protections.

8.4. Additional equipment - typical housing with IP20, IP21 or IP31 protection level.

This housing has got a structure fastened to a transformer. Divided, removable front panels with ergonomic handles make possible quick and easy access to the interior. Ventilation is provided by openings in the bottom and air grids situated in the upper part of side walls. In IP20 housing, ventilation holes are also in a housing cover. Transportation should be done with a transformer inside only. Before transportation, it should be check if the mechanical connections (hangers) between transformer core clamps and cover frame exists or not.

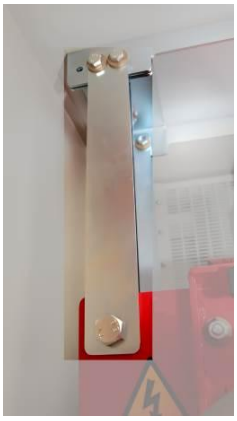

Fig. 14. Hanger

The typical method of connection of a transformer with housing to the supply and distribution networks is connection done by cables. These cables are led by holes in the bottom.

Cables are fastened to special cable stands which are situated inside the housing and individual cable conductors are led to transformer terminals. On the client wish, the transformer may be designed with HV cable inlets or the LV bar connections going through cover or side wall. In these cases the leads and presence or absence of cable stand are precisely described into overall dimension drawing which should to be the contract appendix.

Fig. 15. LV bar connections on a side wall.

All parts of housing are connected by earthing links. Each removable front or back panel is also connected with not removable parts of housing b earthing link. During the taking the front or the back panels off, this earthing connection has to be unscrewed and removed, and during put on has to be screwed again. So, we recommend to do these jobs by two persons.

Fig. 16. Earthing connection of a housing panel.

8.5. Additional equipment – arc protection.

Transformers with housing can be additionally equipped with arc-protection system, type of ZŁ2. The protection consists of ZŁ2 relay and up to 3 optical fibre arc sensors placed inside the housing. The arc protection can switch the transformer supply off in very short time in case of internal short-circuit inside the transformer housing.

Fig. 18. Arc protection

Fig. 19. Arc sensor

9. TRANSPORT

Transformers should be transported completely assembled. The transport should be carried out by covered means of transport protecting transformers against mechanical damage, dirtying, flooding with water, covering with snow. During transport transformers should be protected against moving by means of beams, wedges and fastening belts. The belts can be fastened into the points of the transformer intended for this purpose only i.e. into holes in upper core clamps and into holes in carriage. A proper fastening system is shown in the photo below.

Note: Belts fastening in another way, specially fastening to the transformer windings can lead to transformer damage and to guarantee loose.

During vertical transport - by means of a crane or an overhead crane - all lifting eyes of the transformer should be used. Hooks should be put on eyes in such a way that they would not damage the transformer. The transformer should be lifted and lowered without shocks and jerks.

Fig. 20. The transformer ready for transport on a truck.

Transformers should not be exposed to sudden tilts, jerks, shocks and blows.

Transformer moving on its own wheels should be used only in the place of its setting on, at short distances.

Transformer wheels are adjustable, they can be re-set by 90 degree, which enables to move the transformer in two perpendicular directions - along and crosswise of longer side of the transformer. For transportation time, from the factory to a client site, wheels are screwed to an upper part of carriage beams. Before transformer moving on its own wheels, the wheels have to be screwed in a proper position.

Note: Due to big weight of a transformer, metal wheels can damage floor surface. We recommend to use some kind of surface protection, for instance metal plates on transformer way.

The transformer should to pulled by ropes fastened to the carriage beams, where you can find holes intended for hook setting. There is prohibited to force (pull or push) other transformer parts, specially windings can be destroyed then, which lead to guarantee loose.

10. DELIVERY CONTROL

After transformer delivery, the client should carry out visual inspection of the transformer. The inspection should be done before taking the transformer off from vehicle in presence of a vehicle driver. Special attention should be done for following points:

- possible displacement of transformer during transportation,
- damages of coils, leads, insulators etc. visible from outside,
- accessories are complete and in good state (wheels, temperature relay etc.),
- painted surfaces damages.

Note: All non-conformities and reservations discovered during delivery control has to be documented and written in delivery list (CMR). These notes can be base for possible claim in the future. There is also recommended to make photo documentation. In case of mechanical damages or non-complete deliveries, not confirmed by notes in CMR's, claims can be treated as non-legitimate.

11. STORING

TRIHAL (TRICAST) transformers should be stored completely assembled in closed, dry rooms, protecting the transformer against weather influence, accidental mechanical damages and against access of non-authorized persons. The temperature in the warehouse should not be lower than minus 10°C. Transformers should be protected against dust and dirt by covering with e.g. canvas. Using plastic foils for covering is not recommended and may be a reason of water condensation and corrosion. In period of 2 - 4 months, storing conditions should be inspected.

12. SETTING THE TRANSFORMER ON SITE

12.1. General rules

Transformers should be set in specially assigned and prepared places, complying to current regulations on construction and operation of electrical equipment. Transformers should be installed in such a way that the servicing staff is protected against electric shocks, but all control and measuring indicators can be easily seen by the staff.

If additional accessories are delivered with the transformer, then accessories are packed to a separate delivered box or to cardboard box fastened to lower or upper core clamps. For good cardboard box fastening, special fasteners and plastic foil wrapping are used. Such packing is shown on the right side photo. Special fasteners, if used, have to be disassembled before transformer setting on site.

Fig. 21. Cardboard box with additional equipment

Transformer wheels – for transport time – are screwed in reverse position. If the transformer is planned be set directly on transformer carriage beams, the wheels should be disassembled.

12.2. Room ventilation

The room in which transformer is to be installed should have appropriate ventilation, that the heat created by the transformer would not warm the room up to a temperature exceeding conditions specified in point 4 of this manual. In most cases appropriate ventilation is provided by air grids - intake and exhaust - situated in walls of the transformer chamber. In case of doubt about the efficiency of room's ventilation the forced ventilation should be introduced. It should be taken into account, that 180 m3/h of air exchange is needed per 1 kW of transformer losses to ensure good ventilation of the chamber.

The ventilation openings of the room should usually be located on opposite walls. The inlet opening should be as low as possible and the outlet as high as possible.
The inlet ventilation opening must not be placed in close proximity to the transformer windings, so that the sucked air containing raindrops or snow - during unfavorable weather conditions - does not fall directly on the windings. If the room is of small size and the air inlet must be placed close to the windings, additional air flow guide should be installed at the inlet in such a way that the incoming air mixes with the air in the chamber before it reaches the windings.
The exhaust vent should not be located directly above the transformer to exclude the possibility of water droplets falling on the transformer core or windings.

Ventilation openings - inlet and outlet - should be equipped with grilles preventing rodents from getting inside the room with the transformer.
If the air in the transformer's workplace is heavily polluted, e.g. with coal or cement dust, dust containing conductive or organic particles, filters can be used at the air inlets. Filters should be selected so that the amount of ventilation air is adequate. Filters must be cleaned or replaced periodically.

Ventilation grids, most often, are placed on opposite sides of the chamber. Intake grid should be placed near a bottom of the chamber, and exhaust grid as high as possible. Surfaces of grids may be calculated with following formulas:

$$\mathbf{S1=0.18} \times \frac{P}{\sqrt{H}} \qquad \mathbf{S2=1.1} \times \mathbf{S1}$$

where:

S1 surface of intake grid [m^2]
S2 surface of exhaust grid [m^2]
P total losses of transformer (sum of load losses at 120^{o}C and no-load losses) [kW]
For transformers with fans, total losses P should to be increased to losses during possible overload – load losses are growing according to square of transformer current.

H height difference between axis of grids (intake and exhaust) [m]

It is recommended to use specialists for ventilation for solving ventilation problems.

12.3. Transformer setting

Transformers should be placed at the proper distance from room's walls for good insulation and ventilation and also for proper free space for staff.

For transformers without housing (IP-00) placed in special rooms for electric equipment the minimum distances between coils, leads or other “hot” parts and walls or earthed elements should be as in the table below.

Voltage level [kV]	Solid wall [mm]	Net wall [mm]
7.2	100	300
12.0	150	300
17.5	200	300
24.0	250	300
36.0	350	400

These distances ensure also a proper ventilation. A proper free space for staff access to the transformer has to be also ensured.

If there are two or more transformers placed in one room, a minimum distance between the transformers should be the same as to the solid wall.

Note: Cast-resin coils, , nevertheless its encapsulated and thick insulation, have not to be touched when the transformer is energized. Touching may cause fatale electric shock.

Transformers in housings should be placed at the proper distance from room's walls to ensure free space for staff. For ventilation reason, distances between room wall and housing wall with ventilation grids should be minimum 200 mm.

13. ASSEMBLING AND STARTING UP

13.1. Tests before starting up.

In order to check whether the transformer has not been damaged or has not got damp during transport and storage the following control measurements should be carried out before connecting it to the network:

- insulation resistance measurements,
- windings resistance measurement.

Insulation resistance measurement should be carried out for LV and HV windings, using inductor of voltage up to 2500 V. Insulation resistance measured at temperature 20±5°C should not be lower than:

- 300 MΩ for HV winding insulation,
- 20 MΩ for LV winding insulation.

If the above requirements are not met then the client should contact with producer and further actions should be discussed.

Windings resistance measurement is aimed to control continuity of transformer circuits, especially contacts of taps connections. Measurements should be carried out with an instrument for small resistance measurements and should be done for all transformer tapings.

Measured values of resistance of transformer windings should not differ from the factory routine test by more than 5 %.

13.2. Assembly of the transformer

All the assembly works have to be done in such a way that the transformer should not be damaged during these works, any kind of small particles or dust is not allowed on winding surface or inside cooling ducts of windings. The following rules have to be applied. There is forbidden to walk on the transformer, to lean on windings or connections. If the transformer is high, self-standing ladder or podium should be used; to put traditional ladder on windings or connections is forbidden. LV connections should be well prepared before assembling (all drill works) and the final assembly should be realized by screwing only. There is forbidden to make drilling, grinding and polishing works of LV bars over the transformer body to protect winding surface and cooling ducts against small particles coming from drilling, grinding or polishing. These particles can lead to transformer damage.

After setting the transformer in its installation place, the transformer should be earthed, using for that the earthing terminal situated on the transformer lower beam or frame (the transformer with housing is equipped with earthing terminal placed on the side wall of the housing). The earthing connection should be safe and protected against corrosion and self-unscrewing during normal operation.

Then LV and HV connections should be carried out. These connections should be possibly short and fitted in such a way, that they should not exert any breaking forces on pin insulators. All connection surfaces should be cleaned and polish before.

Note: Transformer LV terminals made of aluminium covered by tin should not be cleaned using sharp tools to not damage tin layer.

LV terminals made of aluminium covered by tin can be directly connected with Cu or AL bus bars. Contact grease between linked surfaces should be used.

If mix of Al and Cu terminals / bars is used, special AL-CU plates (Cupal) should be placed between bars and transformer terminals. For screwing Al or Cu bars the stainless steel screws or hot-dip galvanized screws are recommended. Connections should be strongly tightened and protected against slackening. In TRIHAL transformers with housings, the supplying cables should be fastened to special cable stands placed within the housing.

For terminals - bars screwing the following torque should to be applied:

Size of screw	Torque [Nm]
M8	20
M10	40
M12	70
M14	100

In transformers with housings terminals and cable stands have access after removing front panels of the housing. Transformers should be protected against effects of short-circuits and overloads.

13.3. Switching the transformer on

Before switching the transformer on, the following actions should be carried out:

a) checking whether transformer's assembling has been properly carried out, according to the documentation and according to the requirements of rules and regulations mentioned in this manual, whether accessories into auxiliary circuits have been mounted properly and work good, whether protection relays are set correct and work good,

b) performing post-assembling measurements according to local requirements (if needed). For Polish market the standard PN-E-04700:1998 "Electrical equipment and circuits. Directives on carrying out post-assembling acceptance tests" – is in force,

c) for transformers assigned for parallel operation, checking if they meet conditions of such operation,

d) checking whether transformer's taps are properly set,

e) checking if the surface of winding is clean, dry and undamaged, the screws are properly screwed.

After checking that the above conditions are met the transformer may be connected to the supply network.

14. EXPLOITATION OF THE TRANSFORMER

TRIHAL transformers can work in maintenance-free stations.

14.1 Visual inspections and periodical surveys

During exploitation the transformers require periodical visual inspections, surveys, and tests, whose results should be recorded in the way defined by the Management Board of the Company using the transformer. At least after each six months the visual inspection should be made, and the periodical survey minimum once per each 5 years. Frequency of the visual inspection should to be stated by a user management taking into account possibilities of winding to get dirty (by dust and organic particles) in local conditions.

The visual inspection can be made without switching the transformer off. During the inspection the following should be checked:

- the indications of the measuring instruments,
- the condition of the auxiliary devices,
- the working loudness,
- the temperature of the windings, if the transformer is equipped with a thermometer,
- the condition of the insulators and bar connections,
- evaluate the dirt level on the transformer.

The periodical survey is carried out after switching the transformer off. The survey includes the following:

- thorough inspection of the windings, electric installations and auxiliary devices,
- removing the dust; the windings can be cleaned with a vacuum cleaner or compressed air. It is recommended, when compressed air is used, the pressure of air should not be bigger than 0,2 MPa (2 Bar). The connection elements, taps, clamps, insulators should be cleaned with a brush or wiped with a dry cloth.
- measurements of the resistance of the winding insulation,
- checking the protection devices functioning,
- checking the auxiliary equipment functioning,
- checking the tightness of screws of all terminals and connections.

14.2 Transformer switching ON / OFF during exploitation.

If the transformer was not energized longer than 6 weeks, then before next switching ON a visual inspection and a measurement of winding insulation resistance should be done. Insulation resistance should be higher than as stated in chapter 13.1.

If the brake in energizing of the transformer has been shorter than 6 weeks and relative air humidity inside a transformer chamber has been lower than 90% during whole period of the brake then you can skip the insulation resistance measurements, but make sure that the transformer windings are dry.

15. SAFETY RULES AND FIRE RISC

1. Do not touch the windings if the transformer is in on-voltage state.
2. Dis-assembling of the housing parts is forbidden if the transformer is in on-voltage state.
3. Works related with periodical surveys can be done after transformer switching off and after earthing of HV and LV terminals.
4. In case of fire, the transformer has to be switch off immediately. For fire extinguish, only not conducting current agents can be used.

TRIHAL (TRICAST) transformers are built using majority non-flammable materials. Only 2-3% total mass of the transformer they are materials difficulty flammable and self-extinguishing. In fire conditions the TRIHAL transformers are not dangerous for people and for environment.
In fire caused by external reason, for instance by building on fire, the transformer does not create a toxic gases and after removing it from fire zone a self-extinguishing process starts.

16. COMPLAINTS

WITH THE RISK OF LOOSING PRODUCT WARRANTY, PLEASE FAMILIAR WITH THE FOLLOWING STATEMENTS:

Non following the rules presented in this technical documentation, it means: transformer exploitation in other conditions than transformer is designed i.e. non proper room ventilation, presence of dust on transformer windings, not proper site conditions, to high humidity, presence of chemical substances destroying transformer insulation, presence of small particles on the transformer body (see Chapter 4 and Chapter 12), as well as transformer damage caused by not proper transportation, storage or exploitation, as well as braking seals release manufacturer from any responsibility and warranty.

In case of the transformer failure during the guarantee period the producer should be immediately informed, and the following documents should be submitted:

- the report of the tests and measurements made before switching the transformer on (chapter 13 of this manual),
- the warranty certificate of the transformer,
- the description of the failure,
- the application of the complaint contained at least: type of the transformer, serial number, type of failure,
- post-failure photo documentation of the transformer.

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Until an employee delegated by the producer arrives, or until the User is authorized by the producer to make minor repairs, no repairs should be carried out. Each of the complaint is considered individually

and the action of the service depend on the kind of failure and depend also on the customer needs (accessibility or inaccessibility of the emergency supply).

Depend on the current case, the producer service can realize:

- visual inspection of the transformer,
- minor repairs of the transformer on site,
- transport of the transformer to the manufacturer's factory,
- repair the transformer in the manufacturer's factory,
- decide to repair the transformer by other entity authorized by manufacturer.

If the conditions of the contract not specified in another way, the producer do not organize and do not participate in cost in in-house transport of the transformer through customer plant. Loading of the transformer on the track is also on customer site.

17. UTILIZATION OF TRANSFORMER, DENGEROUS MATERIALS

Transformers produced by Mefta Green Transfo Energy Poland Sp. z o. o. not include dangerous materials in accordance with a directive RoHS 2002/95/WE (lead [Pb], cadmium [Cd], six-valent chromium [Cr], PBB and PBDE). Utilization or storage transformers or transformer's parts after live cycle should be realized in accordance with RoHS and REACH directives.

Resin transformers are made of following materials: steel, copper or aluminium, cellulose insulating materials, artificial materials, rubber.

The best idea is to consign utilization process to specialized company which is licensed and experienced to take this type of operations. Burning of the transformer parts in not adapted installation or in installations not fulfilling special requirements for utilization is categorically prohibited.

After disassembling, transformers metal parts are not contain dangerous materials and can be recovery again as a steel wrap.

It is permissible to recover a copper or aluminium from coils, but insulation materials like epoxy resin or glass-fiber are dangerous discard. This materials must be given back to a company which is specialize in utilizations of this type materials.

18. ADDITIONAL INFORMATION

In case of any doubts, problems, or needs for additional information or assistance, regarding the transformers, you are requested to contact:

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