BEZ TRANSFORMÁTORY
MANUFACTURING TRANSFORMERS SINCE 1902

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

Technical Regulation for Cast – resin Dry Type Transformers

TPR 537 ANG

Number of pages: 37
Edition: 2
Prepared by: Technical Department
Bratislava: May 2024

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

TABLE OF CONTENTS

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

1. GENERAL INFORMATION

Cast - resin dry type transformers are designed for indoor operation. There is no need of any special environmental or fire protection actions during the transformers operation and thus can be used directly in the place of consumption. These types of transformers can be widely used in infrastructure and all industry areas.

This Technical Regulation (TPR) applies to standard designed cast resin transformers manufactured in BEZ TRANSFORMÁTORY, a.s. Technical Regulation contains the most important instructions for transportation, handling, installation, maintenance and safety operation, as well as disposal of cast - resin transformers. Technical Regulation is intended to those electrically skilled or instructed persons having basic knowledge to carry out the activities described in this document. Technical personnel performing activities on the transformer must be familiar with this Technical Regulation and must comply with the safety regulations, procedures and instructions contained therein.

	Technical Regulation must be accessible to the responsible technical personnel at the transformer installation site at all the time. Be sure to pay attention to Chapter **2. SAFETY GUEDLINES** before carrying out any work on the transformer.

	*If you have any questions on the proposed Technical Regulation or other characteristics of the transformer, please contact the manufacturer dealership or directly the manufacturer* ***BEZ TRANSFORMÁTORY, a.s.***

1.1. Technical information

The basic data about the transformer are indicated on the rating plate on the transformer. Make sure that the data on the rating plate correspond with those specified in the order. If not, please contact the manufacturer trade agency or directly the manufacturer. Enter type, rated power, year of the manufacture and serial number of the transformer.

More technical details about delivered transformer – results of routine tests and specific customer tests, wiring diagram, dimensional drawing and thermal protection wiring diagram – are part of technical documentation delivered together with transformer.

If the transformer is damaged or does not work for unclear reasons, is necessary to contact the manufacturer immediately.

	Transformer is made according to customer requirements. It can be put into operation only under conditions of use specified in the order. If these conditions change, or should changes be necessary on the transformer, it is necessary to contact the manufacturer immediately.

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

1.2. Regulations (EU) and reference standards

Cast-resin transformers are manufactured in accordance with Commission Regulation (EU) 2019/1783 of 1 October 2019 amending Regulation (EU) No 548/2014 on implementing Directive 2009/125 / EC of the European Parliament and of the Council with regard to small, medium and large power transformers (setting a framework for ecodesign requirements for energy-related products) and in accordance with international and European technical standards

- EN IEC 60076-11 Power transformers - Part 11: Dry-type transformers
- EN 50588-1 Medium power transformers 50 Hz, with highest voltage for equipment not exceeding 36 kV - Part 1: General requirements
- EN 50708-1-1 Power transformers - Additional European requirements: Part 1 - 1: Common part – General requirements
- EN 50708-2-1 Power transformers - Additional European requirements: Part 2 - 1: Medium power transformers – General requirements
- EN 50708-3-1 Power transformers - Additional European requirements: Part 3 - 1: Large power transformers – General requirements

Following reference standards:

- EN 60076-1 Power transformers. Part 1: General
- EN 60076-3 Power Transformers - Part 3: Insulation levels, dielectric tests, external clearances
- EN 60076-4 Power transformers - Part 4: Guide to the lightning impulse and switching impulse testing – Power transformers ad reactors
- EN 60076-5 Power transformers. Part 5: Ability to withstand short-circuit
- EN 60076-10 Power transformers - Part 10: Determination of sound levels
- IEC 60076-12 Power transformers. Part 12: Loading guide for dry-type power transformers
- EN 60085 Electrical insulation. Thermal evaluation and designation
- EN 60270 High-voltage test techniques. Partial discharge measurements
- EN 60529 Degrees of protection provided by enclosures (IP code)
- EN IEC 61936-1 Power installations for alternating voltages exceeding 1 kV and direct voltages exceeding 1.5 kV. Part 1: Alternating voltage
- EN 50522 Earthing of power installations exceeding 1 kV a.c.

	Special requirements for the operation of the transformer must be the subject of an agreement between the manufacturer and the customer.

Customer must specify all deviations from standard operating conditions described in the reference standards, e.g. energisation in excess of 24 times per year; load voltage wave shape will be heavily distorted; loads involving abnormal harmonic currents; unusual voltage conditions including rapid transient overvoltage, resonance, switching surges, etc.; abnormal vibration, mechanical shocks; expected seismic

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

activity at the installation site; damaging vapours, excessive or abrasive dust, explosive mixtures of dust or gasses, smoke, salt spray, excessive moisture, or dripping water, etc.

2. SAFETY GUIDELINES

Cast-resin dry type transformers are manufactured in accordance with the latest technical knowledge and the high level of safety regulations. Nevertheless, during the use of the transformer, some danger situations can occur for the users and third parties and transformer itself may be damaged same as other equipment. The transformer may be used only to the specified operation and in accordance with safety regulations. All national, resp. regional regulations that take into account the protection of persons, property and the environment (building regulations, guidelines for the installation of electrical equipment, regulations for transformers, environmental protection, etc., as well as EN IEC 61936-1) must be strictly observed.

2.1. Operator qualifications

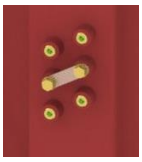
All works on the transformer may be carried out only by persons electrically skilled or instructed following this Technical Regulation and under supervision of professional electrical engineer in accordance with local regulations. Used testing and metering instruments must be calibrated and with valid calibration certificate. Every work must be done according to this Technical Regulation.

2.2. Operator safety precautions

	The operator must use at work personal protective equipment – protective helmet, safety footwear, Hi-Vis clothing and other protective equipment. Safety devices, protective equipment, fire-fighting equipment and insulating gloves must be available and must be regularly inspected and tested. Keep a safe distance.
 	When working on the transformer the following rules must be observed: 1. Switch off the transformer at no-load. 2. Ensure the transformer against the re-switch on. 3. Determine the out-off-voltage transformer mode. 4. Ground, short circuit and discharge the transformer. 5. Disconnect or put out of the operation the adjacent live parts. 6. Faults, which endanger safety, must be removed immediately.
	It is strictly forbidden to use open fire or smoke at the transformer installation site.

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

2.3. Transformer safety precautions

	In order to avoid any personal hazard, the transformer must be positioned so no to be accessible during the operation.
	The protective measures must be taken to allow the access to the transformer only when both sides are disconnected from the mains. If one of the windings is energized, then other windings are also energized.
	The taps-connection setting on each phase of the transformer must be in accordance to the diagram located on the middle phase and the rating plate and tightened. A change in the taps - connection setting is only possible in the de-energized state.

   	Before energizing the transformer, it is necessary to check: • presence of foreign objects (washers, screws, nuts, etc.) on the magnetic circuit, winding or busbars of the transformer • transformer grounding • that no operator performs activities on the transformer The operator must keep a safe distance from the transformer at the time of switching on.

2.4. Residual hazards in the operating and user conditions of the transformer

Prior to putting the transformer into operation, the transformer user is obliged to ensure and check the condition of the devices at the transformer installation site and to take measures to deal with emergencies that may result from improper handling and endanger health, property and the environment.

2.4.1. Mechanical hazards

- Incorrect handling when lifting and pulling the transformer (see Chapter **5. HANDLING**).

2.4.2. Electrical hazards

- Direct contact with hazardous live parts.
- Indirect contact (with exposed-conductive parts which became live under the fault condition).
- Access to live parts being under the high voltage.

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

Protection against the direct contact with live parts must be provided according to national regulations.

- Overvoltage after-effects at atmospheric and switching overvoltage.

If the transformer is exposed to frequent or repeated surges from switches, circuit breakers, atmospheric phenomena, etc., it is recommended to install surge arresters of the appropriate class, as close as possible to the HV or LV terminals.

For protection of higher rated power transformers we recommend electronic protection relays (not only fuses). To ensure the correct function of such protections, it is necessary to measure the currents of the individual phases and / or neutral. The manufacturer will provide more detailed information on the measurement options.

2.4.3. Emission of electromagnetic fields (EMC)

In relation to emission and resistance to electromagnetic interference in accordance with EN 60076-1, the transformer must be considered as a passive element. Electromagnetic energy is emitted on the external side of the transformer - on LV connections or busbars.

Perform an EMC check for busbars and cables. The effect of emission can be reduced by grounding, shielding or by suitable installation procedures and distances.

2.4.4. Thermal hazards

- Transformer overheating due to insufficient ventilation and heat dissipation.
- Burns from contact with transformer parts after loading without the use of protective equipment.

Sufficient ventilation of the transformer must be ensured to keep the ambient temperature below the permissible limit (see Article 7.1.2).

2.4.5. Noise and vibration

- Exposure to noise and vibration.

Transformer noise is generated by magnetostriction of transformer sheets, of which the magnetic circuit is composed. When installing the transformer, the designer must take into account the agreed properties of the transformer. To reduce transmission of the vibration from transformer to the floor (and other parts of building) and to avoid the generation and spread of structural noise, transformers are installed on anti-

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

vibration pads. Transformer manufacturer can provide information for proper selection of anti-vibration pads for each type of transformer.

Increased noise and vibration indicate a fault of the transformer. Please, contact the manufacturer.

2.4.6. Fire hazards

- Prevent the formation and accumulation of gases at the installation transformer site.
- Regularly check the condition of the surface of the winding, outlets and ventilation openings of the enclosure and remove dust by blowing with dry compressed air.

The installation transformer site must comply with national regulations regarding the degree of fire safety of the fire department.

	These safety instructions cannot cover all safety hazard, they are intended to help the operator as much as possible to prevent safety incidents during the operation and maintenance of the transformer. *The manufacturer is not responsible or liable for cases in which direct or indirect damage has occurred due to the transformer not being installed and operated in accordance with this Technical regulation. This also applies to non-compliance with the general safety regulations, even if they are not listed in the submitted Technical Regulation.*

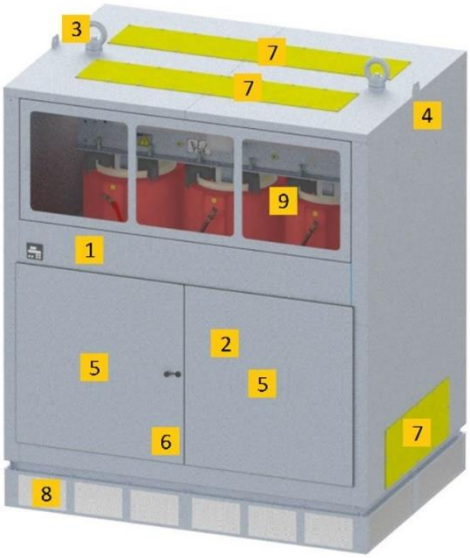
BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

3. TRANSFORMER DESIGN

3.1. Transformer

1 Rating plate
2 Safety sign
3 HV terminals
4 LV terminals
5 HV tapping
6 HV connection rods
7 Earth terminal
8 Clamping
9 Undercarriage
10 Wheels
11 Lifting lugs
12 Towing holes
13 PTC relay
14 Terminal box for temperature sensors

3.2. Enclosure



1 Rating plate
2 Safety sign
3 Lifting eyebolts
4 Enclosure lifting lug
5 Enclosure doors
6 Door switch
7 Removable insulating cover
8 Air inlet
9 Air outlet

(The images are illustrative only.)

Transformer enclosure is made of steel sheets. It is assembled from parts, which in case of space constraints allows the assembly of enclosure directly at the transformer installation site.

Enclosure doors allow access to the transformer terminals and taps. A door switch connected in appropriate circuits can be used to protect against accidental opening of the enclosure door.

To HV outlets, the cables are standardly connect from the bottom of the enclosure. The connection to HV outlets from the top is possible via the opening in

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

the enclosure roof. Parallel opening in the roof allows connection to LV outlets. If LV outlets are oriented to left or right side of the transformer, the connection is secured via opening on the side of the enclosure. The openings for the outlets are closed with removable insulating covers.

3.3. Technical parameters of the transformer

General technical parameters of the transformer are listed on the rating plate which is firmly attached on the transformer (it may vary depending on specific requirements):

- Manufacturer's name: BEZ TRANSFORMÁTORY, a. s.
- CE marking
- Transformer name and number of phases
- Standard
- Type - aTSE (Al winding), TSE (Cu winding)
- Manufacturer's serial number
- Year of production
- Rated power (kVA)
- Maximum voltage of the equipment (kV)
- Insulation levels (kV)
- Rated HV (V)
- HV tapping range (%)
- Tapping positions and interconnection diagram
- HV at individual taps
- Rated current HV (A)
- Rated LV (V)
- Rated current LV (A)
- Steady short-circuit HV winding (kA/2s)
- Frequency (Hz)
- Impedance voltage (%)
- Vector group
- No-load losses (W)
- Load losses (W)
- Sound pressure level L_{pA} (dB(A))
- Sound power level L_{WA} (dB(A))
- Cooling (AN; AN/AF)
- Thermal class 155°C (F);
- Degree of protection (IP 00, IP 21, IP 23, IP 31, IP 33)
- Climatic class (C)
- Environmental class (E)
- Fire behaviour class (F)
- Weight of winding (kg)
- Weight of magnetic circuit (kg)
- Total weight of transformer (kg)

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

3.4. Forced cooling of the transformer

The rated power of the transformer can be increased by up to 40 % for a short time in the mode of operation of the transformer with forced cooling (AN/AF) by fans.

(The image is illustrative only.)

The requirement to increase the power by forced cooling must be stated in the transformer order. Increased short-circuit losses must be taken into account when dimensioning the ventilation of the forced-cooling transformer. The service life of the fans is approximately 20 000 hours (approx. 2.3 years of operation). After this period, the fans must be refurbished or replaced.

3.5. Thermal protection

The transformer is equipped with thermal protection - a system for monitoring the winding temperature, which protects the transformer from an abnormal temperature rise of the winding. Thermal protection consists of temperature sensors – posistors (PTC thermistors) or PT100 sensors (RTD - resistance temperature detectors), or their combinations, and relays. The sensors are located in the LV coils so that they measure the temperature of the hottest point of the coil (hot-spot).

The posistor thermal protection consists of 6 posistors (2 posistors in each LV coil), which are connected in 2 circuits. In the first circuit, 3 posistors at a temperature of 140°C are connected in series (signalling the approach to the non – permissible winding temperature), in the second circuit, 3 posistors at a temperature of 150°C are connected in series (warning - load reduction or transformer shutdown is required). Both circuits are connected to the PTC resistance relay or to the terminal block, to which the customer connects the PTC relay himself. Usually PTC resistance relays MSF220V, MSF220VU and MSF220K are used.

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

The functions Alarm1 (warning) and Alarm2 (trip) are connected to the protection system. When the temperature reaches 150°C, measures must be taken to reduce the load on the transformer or switch it off.

When using PT100 sensors, one PT100 sensor is located in each LV coil. For PT100 sensors, the control unit T154 - a digital dry type transformer temperature monitor - is usually used. The control unit T154 has 4 PT100 inputs and 4 outputs: Alarm – the alarm circuit is set to 140°C, Trip - the warning circuit is set to 150°C, Fault (PT100 control, power supply control) and Fan - start of the ventilation system.

Instructions for use of the MSF relay and the T154 control unit are supplied together with the relay and the control unit and are also available on the websites of their manufacturers or sales representatives.

	The thermal protection can be supplemented with a sensor that monitors the temperature of the magnetic circuit. The wiring diagram of the thermal protection applied to the supplied transformer is shown in the drawing, which is part of the technical documentation of the transformer.

Examples of thermal protection wiring diagrams are given in Articles 3.5.1 - 3.5.2 of the Technical Regulation.

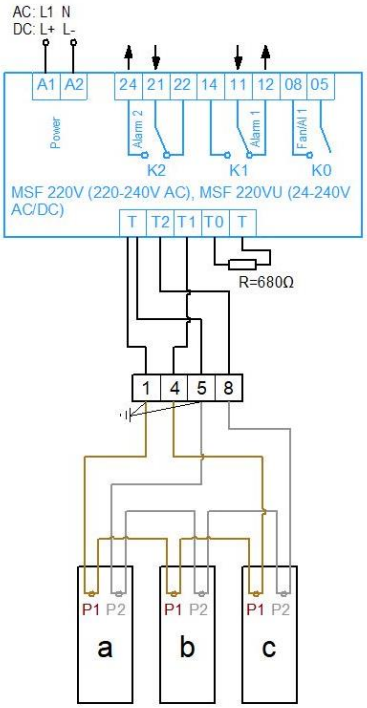
3.5.1. Thermal protection wiring diagram – PTC relay MSF220V/ MSF220VU

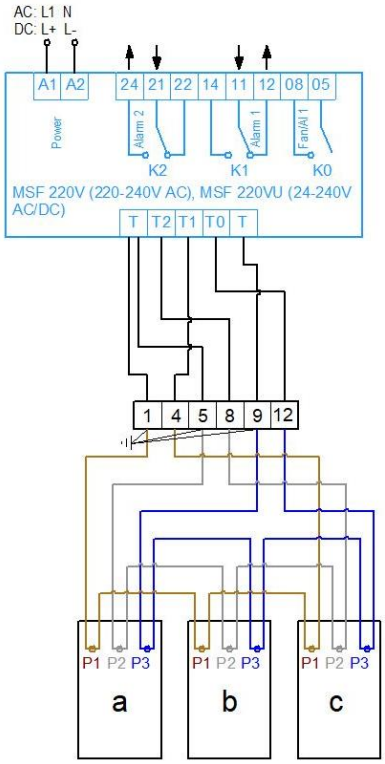
To the terminals of relay K1 (Alarm1) - reacting at a temperature of 140°C (posistors P1 entering T/T1) - it is possible to connect, for example, an orange signal light, which lights up when the specified temperature is reached. A red signal light and an acoustic signal can be connected to the terminals of relay K2 (Alarm2) - reacting at a temperature of 150°C (posistors P2 entering T/T2). Simultaneously with the light and acoustic signal, a time relay can be switched on, which, if the operator does not register a critical condition after the set time (approx. 3 min.), sends a signal to switch off the partial load.

A fans circuit is connected to the relay terminals K0 (Fan) - reacting at a temperature of 130°C (posistors P3 entering T/T0) - which is activated when the specified temperature is reached.

The supply voltage of the MSF220V relay is 220.-.240 V AC (50/60 Hz) and the supply voltage of the MSF220VU relay is 24 - 240 V AC/DC (connection to terminals A1, A2).

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

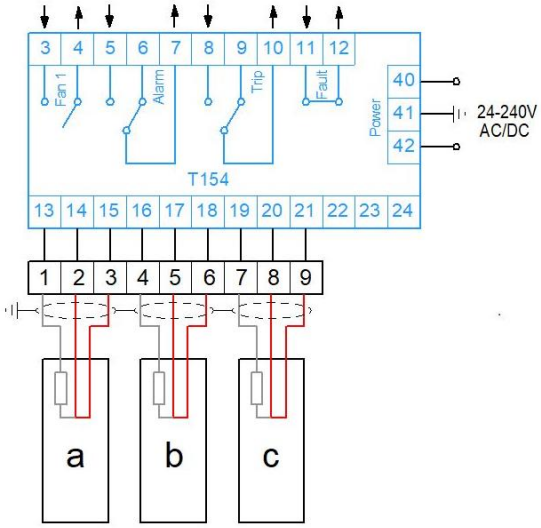


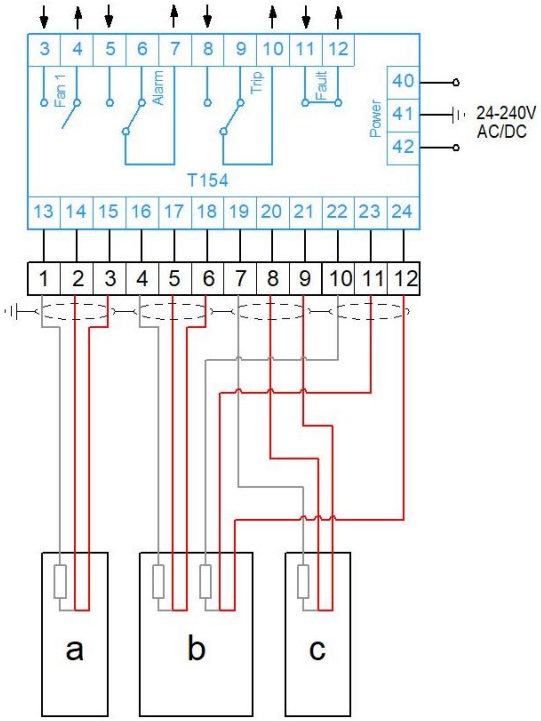


Posistors P1 - terminals 1/4 -	T/T1 - K1 (Alarm1 - 1/12)	warning	140°C
Posistors P2 - terminals 5/8 -	T/T2 - K2 (Alarm2 - 21/24)	trip	150°C
Posistors P3 - terminals 9/12 -	T/T0 - K0 (Fan/Alarm1- 05/08)	fans	130°C

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

3.5.2. Thermal protection wiring diagram – control unit T154



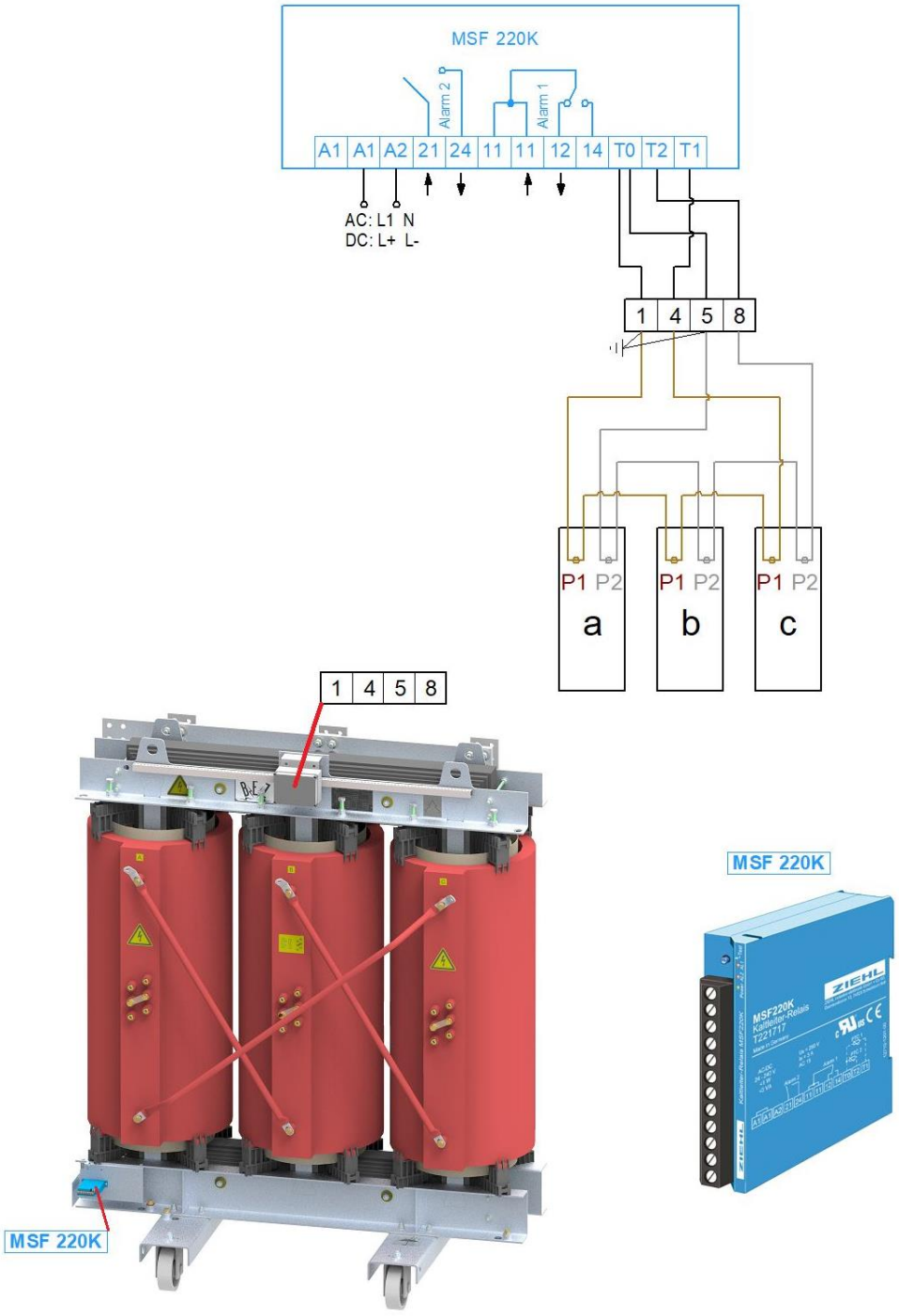


PT100 (phase A) - terminals 1 ÷ 3 - 13 ÷ 15
PT100 (phase B) - terminals 4 ÷ 6 - 16 ÷ 18
PT100 (phase B) - magnetic circuit or ambient temp. - terminals 10 ÷ 12 - 22 ÷ 24
PT100 (phase C) - terminals 7 ÷ 9 - 19 ÷ 21

Alarm - terminals	5 - 7	warning	140°C
Trip - terminals	8 - 10	trip	150°C
Fan - terminals	3 - 4	fans	130°C
Fault - terminals	11 – 12	check	(fault)

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

3.5.3. Thermal protection wiring diagram – PTC relay MSF220K



Posistors P1 - terminals 1/4 - T0/T1 - K1 (Alarm1 - 11/12)	warning	140°C
Posistors P2 - terminals 5/8 - T0/T2 - K2 (Alarm2 - 21/24)	trip	150°C

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

	PTC resistance relays MSF220V, MSF220VU and temperature control unit T 154 are supplied as accessories. The MSF220K PTC resistance relay can be mounted on the lower clamping of the transformer. Signalling components are not included in the delivery of the transformer.
	When supplying the relay or the control unit directly from the LV busbar of the transformer, the line must be equipped with a safety switch.

4. PACKING AND TRANSPORTATION

During transport, the transformer is covered with a protective foil that protects it from rain, dust and foreign objects. At the place of the lifting lugs, the protective foil is removed and then glued with adhesive tape to tightly wrap the transformer and thus prevent the penetration of water, dust and foreign objects to the transformer.

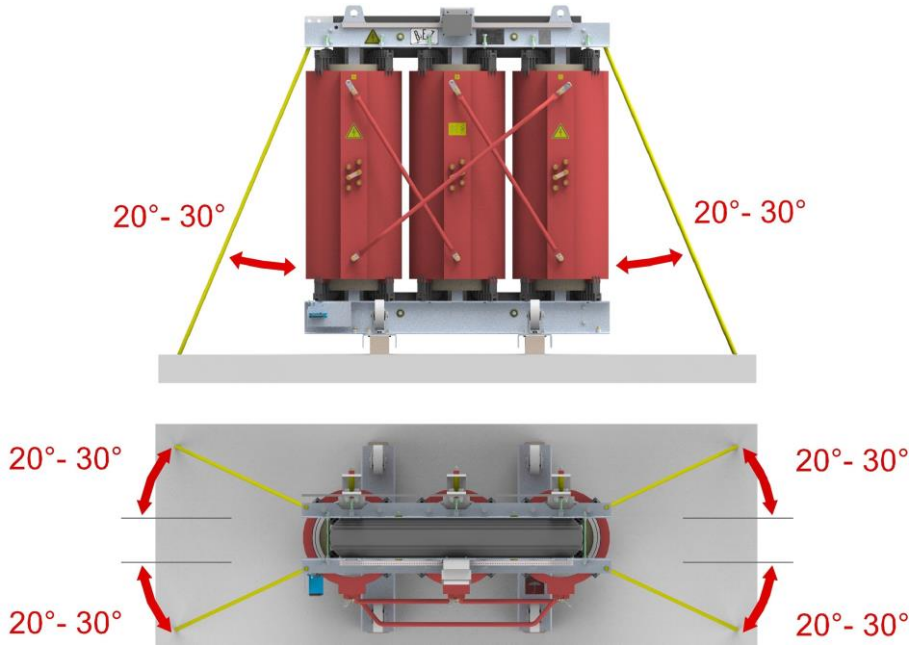
For overseas or longer inland transports, transformers are placed in wooden boxes or containers. In case of excessive humidity, it is necessary to transport transformers with dehumidifiers (silica gel). Road transport is only permitted on vehicles with air suspension.

Instructions, directives and guidelines for securing cargo during transport and the transport itself in accordance with the relevant ENs, in particular EN 12195-1-4, are provided in the European Guide to Best Practice for Securing Freight for Road Transport.

The transformer is transported together with the accessories. The weight of the transformer is stated on the transformer rating plate and in the shipping documents. The transformer wheels are removed during transport. The transformer is transported on wooden prisms, which are firmly connected to the undercarriage beams and secured against slipping on the surface of the vehicle. During the transport of the transformer in the enclosure, the lower ventilation covers of the enclosure are also removed.

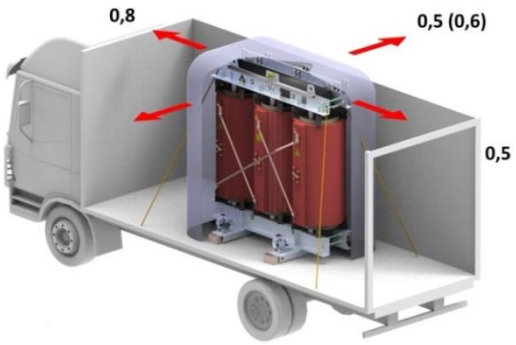
The transformer is mounted on the vehicle so that its longitudinal axis is oriented in the direction of travel of the vehicle. It is anchored to the vehicle through four fastening holes on the upper clamping by means of ropes or straps so as to prevent any movement of the transformer during transport. Anchor ropes or straps must not touch the coils, LV and HV terminals or the pressure elements of the winding. Loads subject to transport forces must be prevented from slipping and tipping over in all directions. Transformer attachment angles of 20° - 30° are recommended on the vehicle chassis.

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com



Even if there is no risk of the load slipping or overturning, it is recommended to take measures to prevent the unlocked load from moving freely due to vibration. The security measure must at least secure of withstand:

- 0,8 G load in the forward direction
- 0,5 G load in the lateral and rearward directions
- 0,6 G load to the sides if there is a risk of the load tipping over



During transport, the transformer must not be exposed to strong shocks or rapid changes in movement. The transformer must withstand, without damage, an acceleration of at least 10 m/s^2 in each direction in addition to the gravitational acceleration. It is recommended to use impact and shock recorders to record and evaluate acceleration during transport. Normal accelerations during road transport were recorded in the range of 0.5 to 1g with a frequency of 3 - 350 Hz. The limits applicable to the storage of transformers apply to the temperature and humidity

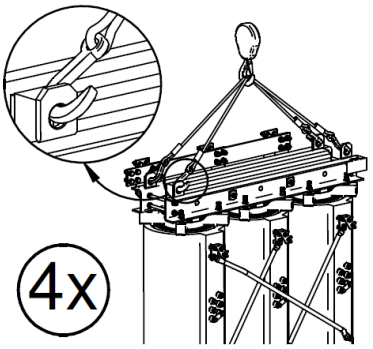
BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

during transport - the temperature should be in the range from - 25°C to 50°C, the air humidity must not exceed 90 % (see Chapter **6 STORAGE**).

	After transporting the transformer to the place of unloading, it is necessary to carefully check whether the transformer has been damaged during transport. Special attention must be paid to LV and HV outlets, the presence of cracks and fissures on the HV coils, dirt, foreign bodies, moisture and water, and the completeness of the enclosure (if supplied). The shipped transformer can be equipped with accessories that are part of the transformer or are supplied separately. It is necessary to verify whether the ordered accessories have been delivered (wheels, temperature sensors, thermometer, relay, etc.). In case of damage, it is necessary to find out its cause and extent. The extent of the damage as well as any missing accessories shall be notified to the supplier in the form of a report and a report shall be submitted to the carrier at the same time.

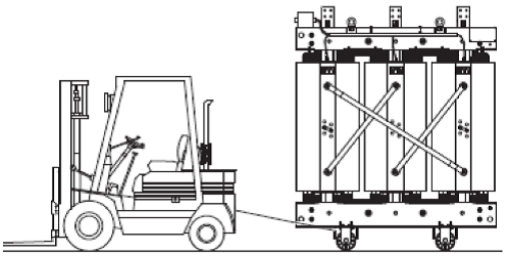
5. HANDLING

The transformer may be lifted and carried by a lifting device (crane), the transformer must be attached to all four lifting lugs and the angle between the ropes may not exceed 60°.

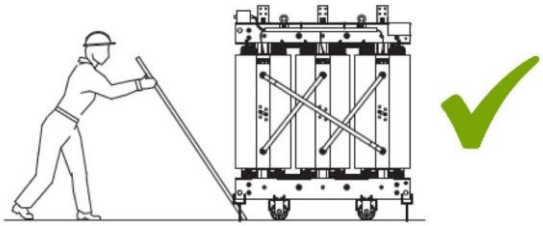


The lifting ropes are tensioned slowly and the lifting must be smooth and stable to avoid sudden shocks and impacts of the transformer. The transformer should not be left in the hanging position for unnecessarily long time. After lifting the transformer and dismounting the wooden transport prisms, the undercarriage wheels are mounted, which allow the transformer to be transported over a short distance (up to 10 m). The wheels of the undercarriage are adjustable in two positions and allow the transport of the transformer in the longitudinal and transverse direction. The transformer can be transported on the undercarriage wheels by pulling the four towing holes on the undercarriage beams.

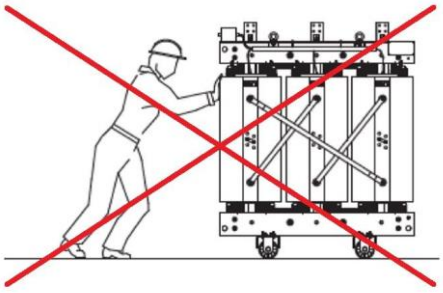
BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com



If it is not possible to move the transformer by pulling the towing holes, it is also possible to move the transformer at very short distances with a lever. The lever should be made of a sufficiently durable material (e.g. U - profile made of hard steel). A sufficiently strong floor (or hardboard underlay) is also assumed. Solid wood is attached to the lower clamping piece of the transformer (on the narrower side of the transformer) and the lever push on the wood so that it is pushed as far as possible in the place of the perpendicular wall of the clamping piece. The lever is applied successively or simultaneously to both lower clamping pieces.

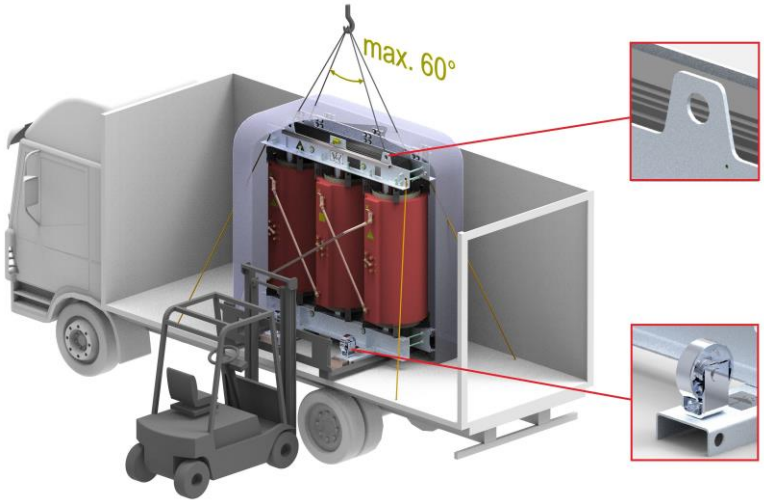


	It is forbidden to push or pull the transformer by the HV coils or HV phases connection rods. Collisions with the magnetic circuit and other components such as fans, thermal protection components, earth terminals must be avoided.



If a crane is not available when unloading the transformer from the vehicle, it is possible to unload the transformer with a forklift. The forks of the forklift truck, equipped with anti-slip guards, are inserted from the outside of the undercarriage beams. Special care must be taken not to damage the HV or LV outlets during this manipulation.

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

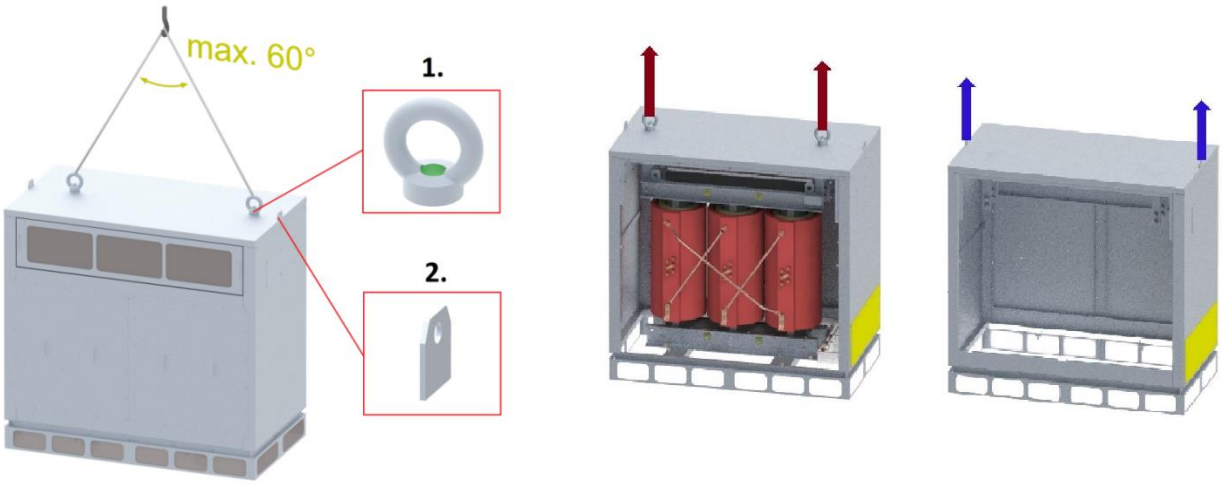


If the transformer is going to be transported by a forklift truck, it is recommended, after dismounting wooden prism, to place the transformer on these wooden prisms and then insert the forks into the undercarriage beams. If the transformer will continue to be transported on wheels, the wheels will be mounted on the undercarriage, after dismounting the wooden transport prisms.

When handling the transformer with a forklift, special attention must be paid to increasing the height in order to prevent the transformer from tipping over or falling due to an unstable centre of gravity. Lifting and folding the transformer from the forklift truck must be smooth, avoid a strong impact of the transformer on the ground.

	The transformer located in the enclosure may be lifted only by crane!

The ropes must be attached to all lifting eyebolts (1.) and the angle between the ropes must not exceed 60°.



BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

	The two lifting eyebolts (2.), which are located on the narrower edges of the enclosure roof, serve only to lift the enclosure itself without a transformer!

When handling with a transformer, all relevant regulation and directives related to work with lifting devices, forklifts and others must be observed. These operations may be performed by qualified personnel only with experience in tying and handling loads and must be equipped with appropriate protective devices.

	When lifting the transformer vertically, it is strictly forbidden to stand under the transformer and enter the working area of the crane.

6. STORAGE

	Cast – resin dry type transformers must be stored on a suitably firm, horizontal surface, inside a clean and ventilated room at a temperature in the range - 25°C to 50°C, the air humidity must not exceed 90 %.

After placing the transformer at the storage location, it is necessary to remove the foil that protected the transformer during transport and cover the transformer with opaque cover so that during storage it is protected from pollution by dust, direct sunlight, foreign bodies and small animals. Ventilation of the transformer cover must be provided to prevent moisture condensation and condensation on the transformer. It is recommended to treat the current terminals and contact surfaces with contact Vaseline. Transformers must not be stored together with active chemicals and corrosives.

7. TRANSFORMER INSTALLATION

Unless otherwise agreed, the normal operating conditions for dry type cast-resin transformers are as follows:

- Altitude does not exceed 1 000 m;
- Ambient temperature (cooling air) is in the range from - 25°C to maximum 40°C while not exceeding an average daily temperature of 30°C and an average annual temperature of 20°C.

7.1. Transformer installation site

The transformer must be placed in a vertical position on the installation site; the floor of the installation site must be horizontal and dimensioned for the total weight of the transformer. The transformer must be mounted on wheels or on a stand at least the

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

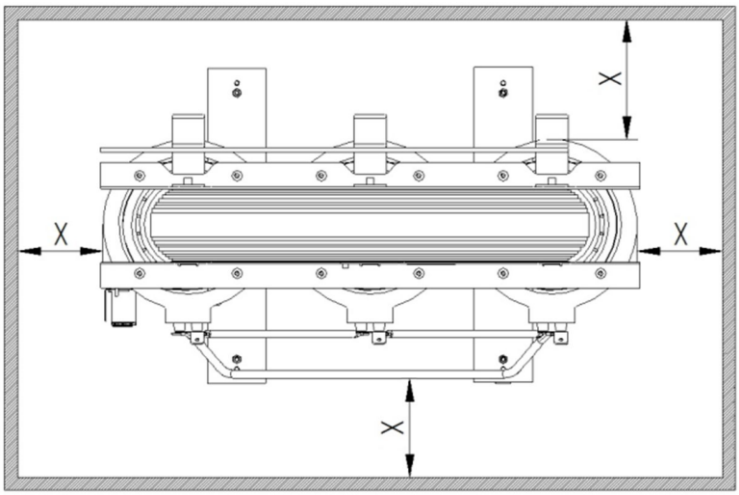
height of the undercarriage to ensure sufficient cooling of the transformer and must be secured against movement.

Sufficient space must be available for the transformer operator to have access for installation and maintenance. If the transformer is in the enclosure, the distance on the side of the enclosure door must be such that the operator can access the transformer after opening the door, and on the other sides there is access for the installation and maintenance of cables or busbars.

	The enclosure lifting eyebolts are removed on the installation site of transformer. After removing the lifting eyebolts, the connecting bolts must be screwed towards inside of the stirrup to avoid their contact with enclosure. **Caution - the thread is anticlockwise!** The holes for the connecting screws on the roof of the enclosure must be covered with the caps and seals included in the transformer supply!

7.1.1. Electrical safety clearance

	Transformer without enclosure (degree of protection IP 00) is not protected against direct contact. The outer surface of the coils is considered to be a living part and cannot be touched, even if the transformer is equipped with plug - in connectors.



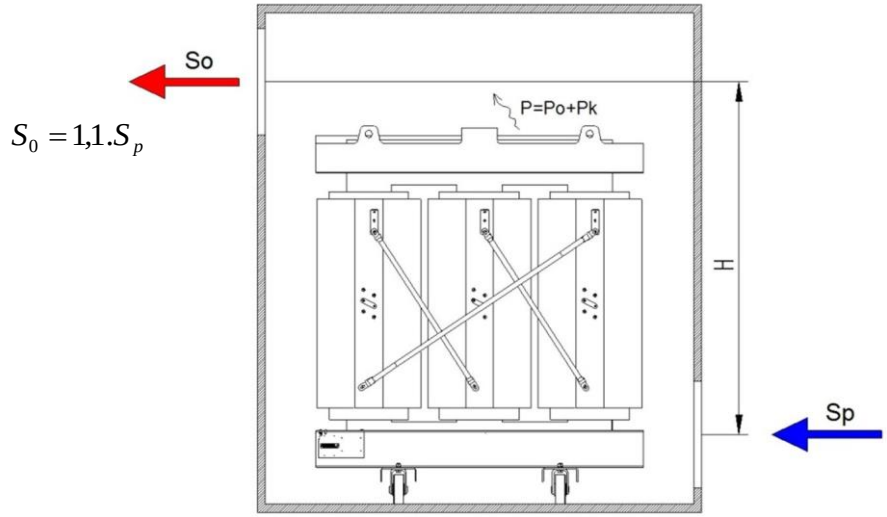
Maximum voltage of the equipment	Minimum distance value X from the wall
7,2 kV	90 mm
12 kV	120 mm
17 kV	160 mm
24 kV	220 mm
36 kV	320 mm

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

7.1.2. Transformer natural cooling

To ensure sufficient cooling of the transformer, it is necessary that the room in which the transformer is operated has ventilation openings for the supply and exhaust of cooling air. Restricted air circulation would result in a reduction in the rated power of the transformer.

Calculation of the size of ventilation openings for cooling the transformer by natural air circulation AN:



$$S_0 = 1{,}1.S_p$$

$$S_p = \frac{0{,}18.P}{k.\sqrt{H}}$$

P_0 – No-load losses (kW)
P_k – Load losses - for insulation class 155°C (F) at temperature 120°C (kW)
P – Total losses at rated power $P = P_0 + P_k$ (kW)
S_p – Cross section of inlet air (m^2)
S_0 – Cross section of outlet air vent (m^2)
H – Distance in height between inlet and outlet air vents (m)
k – Coefficient related to type of air vent (e.g. k = 0,44 - jalousie for degree of protection IP 23, k = 1 - without jalousie)

This formula applies to an average annual ambient temperature of 20°C and an altitude of up to 1000 m.

If the transformer is operated in a small or poorly ventilated room with an average annual temperature higher than 20°C, or in case of frequent overloading of the transformer, it is necessary to ensure forced cooling of the room. A suction fan is mounted into the air outlet vent, to direct the flow of warm air out of the room. Transformer thermal protection (alarm circuit) can be used to control the fan.

The recommended volume of exhausted air is given as 3.5 ÷ 4.5 m^3 / minute per 1 kW of total transformer losses.

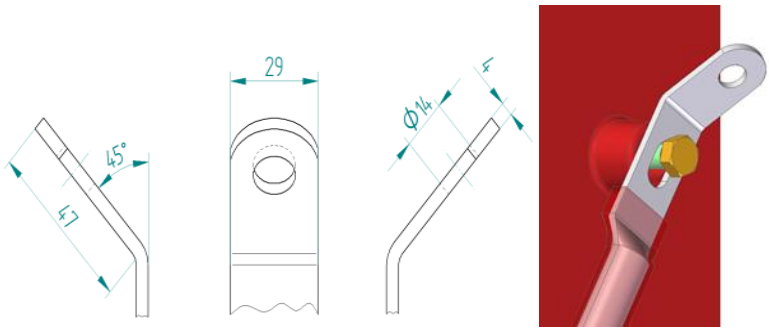
The minimum distance between the walls of the room and the transformer enclosure to ensure sufficient air flow through the ventilation openings of the enclosure is 500 mm.

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

7.1.3. Connection system

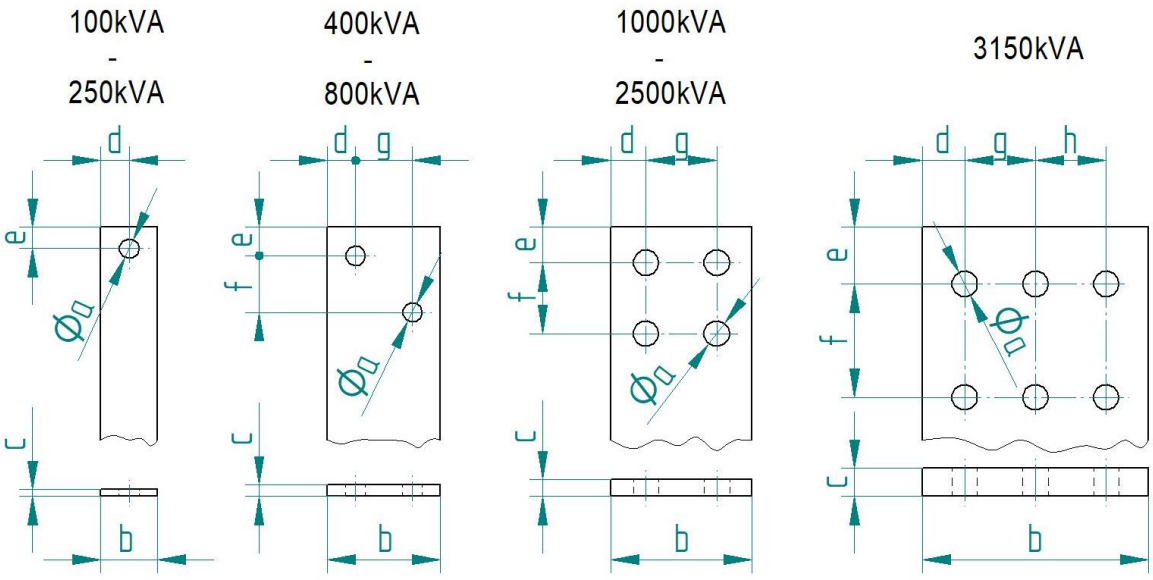
The HV terminals of the transformer are connected on the terminal bolts, the HV cable is connected to the end of the phase connections rods. In standard design the HV terminals are at top, the terminals at the bottom are optional.

The termination of the HV terminals of the transformer is as follows:



,

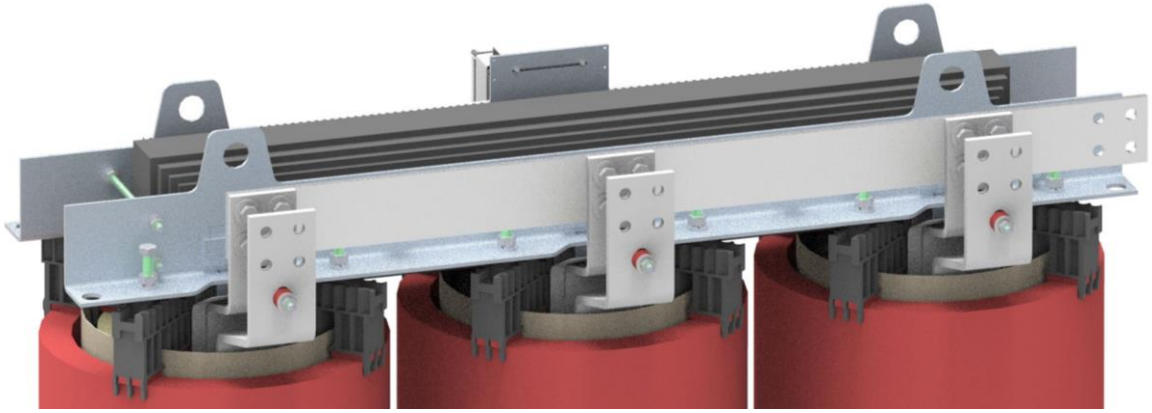
The termination of the LV terminals of the transformer is as follows:



BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

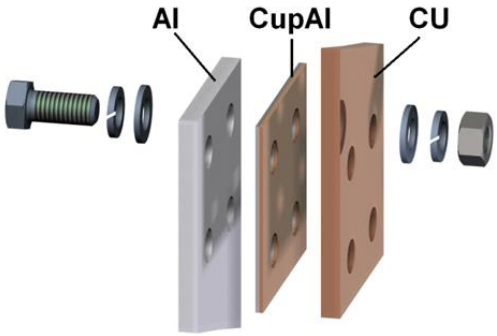
[kVA]	100	160	250	400	630	800	1000	1250	1600	2000	2500	3150
a	14	14	14	14	18	18	18	18	18	18	18	18
b	40	40	60	80	100	100	100	120	120	120	125	160
c	5	5	5	8	10	10	12	12	15	16	20	20
d	20	20	30	20	30	30	25	30	30	30	32,5	30
e	15	15	20	20	30	30	25	30	30	30	32,5	40
f	-	-	-	40	40	40	50	60	60	60	60	80
g	-	-	-	40	40	40	50	60	60	60	60	50
h	-	-	-	-	-	-	-	-	-	-	-	50

The LV terminals of the transformer in standard design are oriented at top, in the same way as the HV terminals:



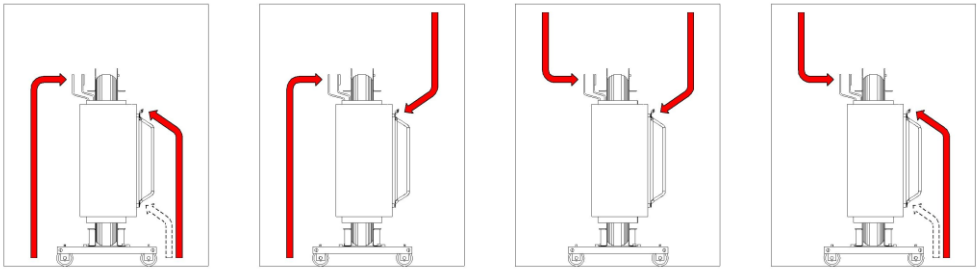
The marking of the LV phases is made by stamping the appropriate letter to end the outlet.

If copper cables or busbars are connected to aluminium outlets, it is necessary to insert aluminium - copper composite foils - CupAl washers between them:



BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

The connection of HV cables to the transformer outlets is possible from the channel trough from below (A, D) or from above (B, C) and connection to LV outlets from below (A, B) or from above (C, D):



Depending on the customer's requirements, side LV terminals on the right or left side of the transformer can also be made.

	Connection to LV outlets can be realized by cables or busbars. If busbars are used, it is recommended to use flexible couplings to avoid mechanical effects on the low-voltage windings and to limit the level of structural noise emission. Prior to connection, the oxide layer on the contact surface must be removed and the contact surface polished. The transformer operator usually arranges the cable entry holes in the removable insulation covers of the enclosure.

	Reliable support for cables and busbars must be ensured. The coils outlets must not be mechanically loaded with cables or busbars.

Bolts shall be secured with a torque wrench to ensure uniform clamping force. The following torque values are recommended for busbars and taps connection:

Bolt	Torque (Nm)
M 6	10
M 8	20
M 10	30
M 12	40
M 16	80

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

8. COMMISSIONING

This procedure applies to all newly installed transformers, transformers put into operation after revision or repair, and transformers that have been out of operation for a long time. The user must be familiar with these instructions before putting the transformer into operation.

8.1. Transformer inspection

Before the transformer is put into operation, it is necessary to make sure that the transformer has not been damaged during transport or storage or that its electrical properties have not deteriorated significantly during long-term storage.

- Remove the plastic sheeting. Check that the transformer is not dirty, including the ventilation openings of the enclosure. The ventilation openings of the enclosure must be permanently clean. If necessary, wipe the dirt with a dry cloth or blow out the transformer with air.

- If there are the foreign objects in the transformer, they must be removed.

- The tightening status of the winding is checked. (The inspection procedure is set out is in Article 10.1 Regular revisions).

- Check the distance between the live parts of the transformer and its surroundings to ensure that requirements for the minimum safe electrical distances at the transformer installation site are met. All connecting and control lines as well as fastening and auxiliary parts must be routed at a sufficient distance from the HV winding.

- Connect and test the grounding of the transformer (the grounding resistance must comply with the applicable regional regulations and the guidelines of the electricity supplier). The minimum cross-section of the grounding cable is 50 mm^2.

- The insulation resistance of the winding must be measured. The insulation resistance is measured with a 2.5 kV measuring instrument. At an ambient temperature of 20°C ± 5°C, the insulation resistance values must be at least:

HV - LV	500 MΩ
HV - ground	500 MΩ
LV - ground	200 MΩ

- Check the tightness of all electrical screw connections.

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

- The tap-connection settings must be in accordance with the transformer rating plate and the same in all phases of the transformer. The tightening of the connecting bridges is checked.

- In case of parallel operation of the transformer, the suitability of the vector group is checked.

- The correct function of the protections is tested. If fans are applied, their control and direction of rotation must be checked.

- The mechanical load on the coil outlets that can be caused by cables and busbars is checked.

8.2. Connecting the transformer to the mains

If no defects are found during the inspection or the detected deficiencies have been resolved, the transformer is connected to the rated voltage according to the wiring diagram supplied with the transformer.

- In severe climatic conditions, the ambient temperature during connection of the transformer to the voltage should be at least 10°C. If the ambient temperature of the installation site is less than 10°C or if the transformer has been present for at least 24 hours before connecting in an environment with an ambient temperature lower than 10°C, it is necessary to increase the ambient temperature to at least 10°C for 24 hours before connecting the transformer.

- All connection points are cleaned and protected with anti-corrosion protection (Vaseline, etc.).

- The phase arrangement is checked.

- The transformer must be connected to the mains at no-load.

- The HV side is connected first, then the LV side.

	When transformer is switched on (at no-load) the peak value of the inrush current can reach 6 - 8 times of rated current. The setting value of the fast current protection of the transformer shall be higher than the peak value of the inrush current and the time limit shell be ≤ 0.5 s.

- Before the transformer is loaded, it is recommended to operate the transformer at no-load for 10 - 12 hours. Then the load on the transformer gradually increases.

- When the transformers operate in parallel, check that there is no voltage difference between the corresponding terminals of the transformers on the output side.

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

9. OPERATION

9.1. Transformer operation checks

Routine checks during transformer operation are performed only if the competent measuring or control instruments are installed.

	***Keep a safe distance!***

Check:

- Low voltage and current if possible in all phases (check that the transformer is not overloaded)
- Ambient temperature
- Transformer noise
- Temperature control system response (according to the manual from the monitoring temperature unit or relay manufacturer).

9.2. Load capacity of the transformer

The transformers are designed for continuous loading with rated power at an average annual ambient temperature of 20°C. The permissible permanent load of the transformer changes as the ambient temperature changes. As the ambient temperature decreases, the load capacity of the transformer increases; as the ambient temperature increases, the load capacity decreases as follows:

Average annual ambient temperature	Permissible permanent load of the transformer
- 20°C	124 %
- 10°C	118 %
0°C	112 %
10°C	106 %
20°C	100 %
30°C	93 %

Transformers can be overloaded for a short time according to the conditions specified in IEC 60076-12. Overload curves must be calculated for specific conditions.

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

9.3. Voltage regulation

On the HV coils, taps in the range of ± 2 x 2,5 % of the nominal HV are standard. The voltage regulation is carried out by changing the position of the connecting bridges in equally on all phases of the transformer. The transformer must be disconnected from the mains on both sides (DETC). The taps on each phase of the transformer must be connected according to the diagram located on the middle phase and the transformer rating plate and tightened.

9.4. Instructions for troubleshooting transformer operation

Problem	Possible reasons	Troubleshooting
1) Low insulation resistance	Moisture on the windings surface	Ventilate the installation room, wipe the surface of the windings with a dry cloth and alcohol
	Contamination of the windings surface	Clean with dry compressed air
2) Automatic disconnection	Inrush current	Set the switch-off delay
	The primary voltage does not match the connection	Check connection
	Fuse tripping	Replace fuse
	Protection	Check the protection time and current settings
3) Load side output voltage is high or low	Primary voltage - absence of primary voltage	Contact the energy supplier
	Incorrect connection of the tap-changer	Check the tap changer
	Winding interruption	Contact the manufacturer
4) Unbalanced output voltage	Incorrect connection of one phase	Check connection
	Single phase fuse tripping	Fuse replacement
	Winding interruption	Contact the manufacturer
	Unbalanced load of secondary winding	Check LV installation
	Absence of voltage on one phase	Contact the energy supplier

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

5) Overcurrent relay or HV fuse response	Short circuit on the secondary side Breakdown of insulation	Eliminate the fault Contact the manufacturer
6) Differential relay response	Transformer fault Current transformer fault	Contact the manufacturer Check current transformers
7) Noise is abnormal	HV is higher than nominal voltage Loose clamping Reflections from walls and other equipment Low frequency	Check the connection of the taps and set so that the output no-load voltage is equal to or lower than the voltage on the rating plate Tighten the screw connections Use damping elements Contact the energy supplier
8) Mechanical resonance	Rigid outlets connection	Insert flexible connection between transformer and busbars Use anti-vibration pads
9) High temperature of magnetic core	HV is higher than nominal Increased eddy currents in magnetic core Damaged sheets of magnetic core	See 7a) Check and replace the insulation of the magnetic core tightening bolts Contact the manufacturer
10) High winding temperature	Higher ambient temperature Transformer is overloaded Local terminal overheating	Check, loosen / clean ventilation openings, ensure air flow; install fans Reduce the load on the transformer Clean contact surfaces and tighten bolts

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

11) Thermal protection malfunction	Loose connection in thermal protection circuit Faulty PT100 or PTC sensor Incorrect temperature setting PTC relay or monitoring unit fault	Check, clean and tighten all contacts Check PT100 or PTC sensor Check setting Replace PTC relay or monitoring unit
12) Winding surface discharge	Fleck on winding, dust	Clean the winding surface
13) Smoke formation	Breakdown of insulation	Contact the manufacturer

10. MAITENANCE

Cast-resin dry type transformers usually require only a minimum of maintenance. During normal operation of the transformer, it is recommended to carry out an inspection during which the transformer is switched off, periodically once a year. During the inspection, the winding, screw connections, warning devices, enclosure vents (if applied) are checked and cleaned. In the case of a transformer with AN/AF forced cooling, all fan functions are also checked

10.1. Regular inspections

As part of the inspection, after disconnecting the transformer from all terminals, the following actions are performed:

The contamination condition of the winding surface, transformer terminals and enclosure vents (if supplied) is checked. The transformer is blown out with dry compressed air with a maximum pressure of 6 bars. A vacuum cleaner can also be used instead of compressed air. The surface of the HV coils is wiped with a dry cloth.

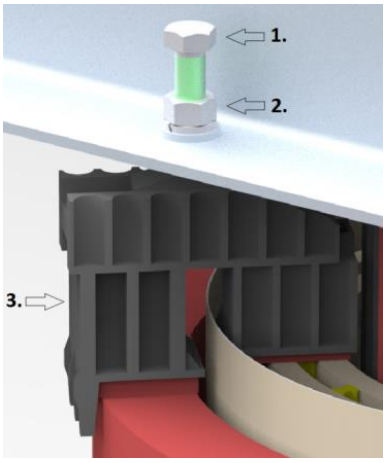
- Check the condition of the current terminals and contact surfaces. Tighten the screws for the power and signal cables.
- Check the setting of the tap-changer and tightening of the tap-changer screws.
- Check the grounding of the transformer.

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

- Check the correct function of the protections (thermal protection, door switch if applied) is checked.

- Check the winding compression. The torque wrench must set the torque of all coils pressure screws on the upper pressure pieces (3) to 5 - 10 Nm as follows:

- loosen all locking nuts (**2.**)
- tighten the clamping screws to the specified torque (**1**.)
- tighten the locking nuts (**2**.), check.



If the transformer is operated in a dusty environment or close to a source of pollution, it is recommended to shorten the cleaning interval to six months.

It is recommended to shorten the inspection interval also in case of transformer is installed in very dirty place or in case of frequent transformer overloading.

	The transformer must be switched off and all terminals must be short-circuited and earthed before starting inspection work.

11. WARRANTY CONDITIONS

Guarantees and liability for defects in the goods are governed by the General Terms and Conditions of joint – stock company BEZ TRANSFORMÁTORY or purchase contract.

The warranty period of the goods is 24 months from the date of putting into operation, but not more than 30 months from the date of delivery of the goods to the buyer.

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

The replaced or repaired parts of the goods are covered by the 24-month warranty period and the conditions of the warranty as for the originally delivered goods. For other parts of the goods, the warranty period is extended only by the time during which these parts of the goods had to be out of service due to the elimination of the fault.

The warranties do not cover faults of the goods caused by unprofessional intervention of the buyer or a third party and faults of the goods caused by natural wear, incorrect maintenance, non-compliance with Technical Regulation, chemical and electrolytic influences, construction and assembly work of persons other than the seller and all other causes without fault of the seller or damage caused by force majeure (lightning, flood, fire, earthquake and other natural disasters).
The buyer is obliged to complain in writing to the seller about obvious errors and incompleteness of the delivery when taking over the goods, he is obliged to notify the seller of other errors in writing without undue delay after they could be discovered while maintaining professional care. The buyer's rights shall be expire if the errors have not been duly and on time notified to the seller in writing or if the buyer does not comply with the conditions specified in this Technical Regulation for the transformer, respectively in the product commissioning, operating and maintenance instructions, or if the buyer handles the goods improperly. The seller is not liable for damage related to errors in the goods indirectly, nor for consequential damages or nor for lost profits.

If you find a fault, contact the manufacturer and provide him the maximum available fault information to help confirm the condition and cause of the fault:

- type and serial number of the transformer
- delivery date
- date of putting the transformer into operation
- a record of the commissioning of the transformer and subsequent periodic inspections
- date and time of failure
- information about the site of installation of the transformer
- environmental data - temperature, humidity, transformer pollution
- Weather conditions at the time of the fault (storm, rain…)
- description of non-compliance, resp. the course of the failure
- records of the course of the load, voltage and current conditions, protection reactions
- photographs of the extent of damage and, where appropriate, visible traces of arcs on the windings and terminals
- other relevant observations

Based on this information, the manufacturer will assess the severity of the failure. If a repair is necessary, they will ensure the presence of their technicians at the repair site or it will be agreed to transport the transformer to the production plant.

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

12. TRANSFORMERS DISPOSAL

Cast - resin dry type transformers, manufactured in BEZ TRANFORMÁTORY, are environmentally friendly and do not harm human health.

Disposal of the transformer at the end of service life must be in accordance with the relevant EU directives and waste legislation. The disposal of the transformer can be entrusted to an authorized company providing collection, recycling and disposal of waste within the environmental service.

Dry-type transformers contain only solid components. The main components of a dry-type transformer are the magnetic core, the winding and the protective enclosure (if applied).

Transformer sheets of magnetic circuit - silicon steel and structural steel (clamping, undercarriage and enclosure) - are metals of the ordinary waste category, recyclable as scrap iron.

Transformer winding components - coils, high - voltage connecting rods, terminals, tapings - are made of aluminium or copper and insulating materials. Aluminium or copper components, without insulating parts, are recyclable as non-ferrous metals. Transformer thermal protection components (sensors, PTC relays or monitoring units) are recycled as electronic waste. Insulation and other constructional materials (insulation, plastics and rubber) are evaluated by an authorized person.

Components classified as hazardous waste must be disposed of by an authorized company.

Combustion of waste outside an authorized combustion plants is prohibited.

BEZ TRANSFORMÁTORY, a.s.
Rybničná 40, 835 54 Bratislava, Slovakia
Tel.: +421 918 791 820
e-mail: bez.or@bez.sk | bez-transformers.com

13. NOTES - Transformer serial number