



COMPACT KIOSK-TYPE TRANSFORMER STATION GRÄPER HKP

Basic technical specifications:

- HV nominal voltage: 3 AC 22 kV 50 Hz
- LV nominal voltage: 3/PEN AC 420/242 V 50 Hz / TN-C,
- Frequency: 50 Hz
- Transformer nominal power: to 400 kVA (630 kVA)
- HV bus-bars nominal current: according to HV switchgear type to 630 A
- LV bus-bars nominal current: to 1 000 A
- HV / LV distributor nominal insulation voltage: 24 kV / 1 000 V
- HV distributor short-time / dynamic current: 16 kA / 40 kA
- LV distributor short-time / dynamic current: to 25 kA / to 60 kA
- LV distributor cover: IP 20
- Whole station cover: IP 23D
- Temperature coefficient (cover class): K 20
- External dimensions (LxWxH): 3 000x1 500x2 570 mm
- Empty skeleton weight with door: cca 6 800 kg
- Environment: 3.1.1. basic (within the kiosk-type TS rooms),
4.1.1. external, ordinary (outside the TS rooms)
- Exp. class: for internal components: XC1; for external components: XC4, XF1, XA1.
- Operating conditions: ambient temperature $-40^{\circ}\text{C} \leq t \leq +40^{\circ}\text{C}$
altitude up to 1 000 m asl.

Note: If the transformer substation is used in different climate and operating conditions, the TS supplier must be consulted.

Electrical current injury prevention:

(STN EN 33 3201, STN EN33 2000-4-41)

- in normal operation mode (of the live parts): in HV system by: 4.1.1 – out of reach placement

4.1.1 – live parts insulation

4.1.1 – barrier, cover

in LV system by: 3.7.1. live parts insulation

3.7.2. barriers or covers

3.8.5. out of reach placement (position)

- in case of failure (of dead parts): in HV system by: 4.2.5. automatic feed disconnection with quick IT networks disconnections to be off (with low imped. neutral TR grounding)

4.2.9. bonding – uniform potential installation

in LV system by: 3.2. automatic feed disconnection

3.6.1. additional protection by residual current device (TS install.)

3.6.2. additional protection – additional protecting bonding





Station construction:

Externally controlled compact kiosk-type transformer substation is partially flush mounted, suitable for placement in sloped terrain, with external dimensions of 3 000x1 500 mm, total height of 2 570 mm, clear height of 2 310 mm, ground sinking depth of 700 mm, over ground height of 1 870 mm (with flat roof). Self-supporting construction of the TS is by default made of reinforced concrete Gräper LC 30/37, with 8/12 granularity. Steel reinforcement frame is composed of steel bars and mats, it is bilaterally welded and conductively connected together and takes part in bonding, grounding, or even lightning protection system. The installation of the station skeleton does not require any foundations, but only a well flushed and rammed out cut. The transformer substation is type-approved, conforming to the STN EN 62271-202 norm and meets the resistance tests against internal arcing fault of the German PEHLA directive.

Station construction is formed by a compact unit consisting of two monolithic parts: basement tank with sidewalls and flat roof.

Basement tank with sidewalls: made of waterproof and oil proof concrete (crack width up to 0,2 mm guaranteed) as an oil catch tank. The construction resistance against strong chemical action of liquids, soils and vapours conforms to the DIN directive. The tank serves as the foundation for the non-freezing part of the TS and for lifting the whole station by means of 4 anchor points (sealed chasing nuts) RD 36, placed in the longer sides of the TS (as viewed on „A”, “C”). In order to join the external grounding two M12 points of HV/LV switchgear are led from the sidewalls of the station. The bell casting method was used to construct the tank and cable exchange label bodies, thus creating a monolithic unit which meets requirements for the impermeability of water and oil substances. All surfaces of the transformer substation touching the ground and cable feeder entry and exit seals may be painted by two layers of black penetrating insulation paint, if required by the customer.

HV and LV cable entry holes are made on production in the lower part of the body (HV or LV distributor's side). After cable installation, the entry holes are sealed by Hauff press fittings (HSI 150, HSI 90). The basement tank is fully divided by a separation wall to catch possible transformer's oil leakage in order to protect the space under the HV and LV distributors from the leaking oil.

Internal walls are treated with washable paint by default. The surface finish of the external walls is available in the following selection:

- concrete with bare filler (exposed aggregate concrete) with 8/12 granularity,
- raw concrete in final finish colour according to the RAL colour palette
- from plastered concrete with material (scraped finish), or Rollputz material (plaster applied by roller), in final finish colour from the RAL colour palette
- stone facing (for example Dupa-Stone), facade bricks, wood of other material as required by customer.

Floor: sealed from reinforced concrete LC25, 120 mm thickness in the HV and LV distribution plant compartment. There is a feed opening into cable cellar (floor space) and with pressure balancing lid.

Roof: connected to the walls from inside at 4 points by screws and overlapping the wall contour by 9 cm. The roof can be lifted by 4 anchor points (sealed chasing nuts) RD 16, standardly corniced by 9 cm all around, thus providing additional protection of the joints between vertical walls and the roof. If the TS is built next to already existing construction or next to another building, the roof gutter can be partially or





totally eliminated, or if required, the width of the roof gutter can be bigger than 9 cm. Drainage is ensured by means of inbuilt rain drains from plastic material, being placed under the attic (in stations with gutter) or on attic's side (stations without gutter) connected with downpipes outside the station body. In order to increase the protection of the concrete surface against humidity, the upper roof is covered with additional hydrophobic coating, which fills capillary pores and acts against the hygroscopic properties of the concrete.

Surface treatment of the roof can be made of exposed aggregate concrete, or fair-face concrete with rough surface and paint according to the RAL colour palette. The shape of the roof (terraced, saddle, cradle,) is optional as well.

Door: All metal parts including doors, frames, and ventilating parts are made by default of hot-dip galvanized 1,5 mm thick sheet steel, basic paint and two layers of the finish paint in RAL 7032 colour palette. The door is equipped with armour including external knob and internal handle with plastic lock cover and a pawl for fixing the door in open position at a 95° angle. For arrestment – the locking, bob weights and point-to-point bars are used within each door wing frame (four-point locking system Gräper). The lock is adapted for standard lock inserts. The outer side of the door is covered by warning plates in terms of the valid EN.

Optionally, the door and ventilating parts can be made of anodized aluminium and 2 lock inserts can be used for double lockout.

The access to the HV and LV switchgear of the substation is provided by a common single wing door with full ventilation (blinds Gräper of DIN40 050 V2A safety class) and with internal dimensions WxH of 855x1 380 mm, on the HV/LV transformer's side with a standard 2 wing door with partial ventilation and internal dimensions WxH of 2 840x1 440 mm. Door is equipped with an arresting pawl for fixing in open position and door wings facility to arrest the open position and door wings are connected with the frame through a copper conductor with cross-section of 16 mm².

Transformer air exchange calculation: Gräper HKP

1. Oil transformer 22 kV, 400 kVA Typ : BEZ TOHn 358/22, „BA“

- Transformer strain in summer time: 50 % - 60% of the nominal power
- Outside air temperature: +35 °C
- no-load losses: $P_o = 0,93$ kW
- load losses: $P_{kn} = 6,00$ kW
- Air vent altitude difference: $h = 1,6$ m

2. Calculation :

no-load losses: $P_o = 0,93 + 0,093(10\%) = 1,023$ kW

load losses: $P_k = 6,0 + 0,60(10\%) = 6,60$ kW



$$N = 200 (50\% \text{ of the nominal power})/400(100\% \text{ of the nominal power}) = 0,5$$

$$\text{Total losses: } P_z = P_o + P_{kn} \times N^2 = 1,023 + 6,6 \times 0,25 = 2,673 \text{ kW}$$

$$\text{Heat losses for air exchange calculation: } P_{ch} = 0,6 \times P_z = 0,6 \times 2,673 = 1,6038 \text{ kW}$$

Air vent section in m^2 :

- Air inlet: $S_p = 0,1942 \times (P_{ch}/\sqrt{h}) = 0,1942 \times (1,6038/\sqrt{1,6}) = \mathbf{0,25147 \text{ m}^2}$
- Air outlet: $S_o = 0,2007 \times (P_{ch}/\sqrt{h}) = 0,2007 \times (1,6038/\sqrt{1,6}) = \mathbf{0,3,3655 \text{ m}^2}$

Air vents in the HKP transformer station:

Air inlet: $80 \times 1440 \text{ mm}^2 = \mathbf{1,15 \text{ m}^2}$ - TS door

Air outlet: $1440 \times 1680 \text{ mm}^2 = \mathbf{2,4 \text{ m}^2}$ - transformer space

Air exchange: Air vents for the transformer space are placed in the TR door and in the double door to on the LV distributor side. Size of the air vents is designed to provide for a sufficient air exchange and transformer cooling. Air vents are equipped with grid (lamellas - blinds Gräper) and net against foreign bodies.

Grounding:

Internal ground of the TS is made of:

- **bonding bar (BB)** Cu 30x4 mm with clips M12, located on the spreader insulator 1 kV, which is directly connected with all the technological components of the TS (vessel of the TR, HV and LV distributor boxes metal shield of the HV cables, branch bar PEN) and with individually mounted components (construction components – tank and roof reinforcement, frames, door, grate, conducting „U“- beam of the transformer, bearing structures of the distributors...) by a Cu conductor with $S_{min} 30 \text{ mm}^2$. Each conductor of the grounding connected to BB is labelled.

- **earth artery** is made of an Fe strip conductor with $S_{min} 125 \text{ mm}^2$, it is a part of the TS reinforcement and it is sealed directly in the external walls and kiosk's beam, serving for the connection of the common points of the grounding. Flexible parts are connected to the frame with Cu frame copper strip or grounding Cu cable with min. cross-section of 16 mm^2 .

- **2 nodes of the grounding feeder** by Hauff HDE-M12/X to connect the external grounding (in general line FeZn 30x4 mm) to the bonding bar (form internal part of the node through connecting screw M12-St 37 Zn, form external part of the node through **test clips** of the **SZ1, SZ2** grounding with screw M12). distributor.

Transformer substation in the standard finish does not have any external lightning protection system, as it is a ground object mostly located close to other higher objects. All the metal reinforcement built-in to the corresponding parts of the TS (roof, walls, false ceiling, basement tank) are welded into a single unit using conductive joints (e.g. Cu lines 35 mm^2), thus forming Faraday's cage and after roof mounting they are





fully connected to the grounding. If customer wishes otherwise, it is possible to equip the transformer substation with external lightning rod with one collector and two wires connected to the common TS grounding via test clips in terms of the valid STN.

For each transformer station a common grounding system for HV and LV facilities must be constructed and its design needs to take into account the operating conditions – fault current value of the distribution network in the given region, power transformer node operation mode and local soil conditions (STN EN 33 3201, STN EN 33 2000-5-54,)

Installation:

The internal installation of the station includes interior lighting of the TS, consists of oval incandescent 60 W lamps fitted with gate switch lighting in the distributor's space of high and low voltage of the transformers and in the cable cellar, and a one-phase socket of 230 V. Circuits to feed the lighting and socket installation are led out from the main LV distributor via installation breakers, or combined with residual current circuit breaker.

Further equipment – as specified by customer.

Internal space of the TS is horizontally divided by concrete floor into two compartments: transformer space and HV and LV space; over ground part of the TS is made by two vertically divided rooms – HV/LV switchgear space and transformers' space.

Transformer:

Oil, hermetic or dry-type transformers up to the power of 400 kVA, optionally up to 630kV with reduced dimension, located on shock absorbers of the Gräper company. In case of oil leakage the seat of the transformer is designed as an impermeable oil catch tank. If the transformer is equipped with bolster, it is fixed against side movement. Transformer insertion and removal can be performed through an entrance door or by crane if roof is removed. Max. dimensions TR (LxWxH) are: cca 1 150x800x1 700 mm.

Transformer cooling is atmospheric. Air renewal is provided by air vents at the bottom of the door of the transformer substation (on the transformer's side) and in transformer chamber's walls. Transformer's protection against over current, or overcurrent is provided:

- a) on HV side – by plugs or by switch with safety relay
- b) on LV side – by air breaker.





High voltage distributor:

All types of the commonly produced covered HV gas insulated distributors SF6 can be used in the transformer substation (e.g. GA, GA-C by Moeller, 8DJ10, 8DJ20 by Siemens, RM6 by Merlin Gerin,...), or type-approved vacuum distributors up to the width of 4 fields. Nominal current of the distributors according to type may be up to 630 A, shorting resistance (nominal short-time withstand current 1 s) to 20 kA, optionally up to 25 kA. The HV distributor can be either provided by the customer, or by Gräper company including the facility for decreasing pressure in arcing fault in the HV distributor conforming to STN EN 62271-200 (to PEHLA standards). Max. dimensions of the HV distributor (WxHxL) are: cca 1 450x1 400x900 mm.

Low voltage distributor:

The panel version of the LV distributor is covered with IP 20 panel. The feeder is equipped with air breaker depending on the transformer's power. Outlets are equipped with breakage bar switches (8-10 outlets with switches to 400 A and construction width of 100 mm for one TR, or adequate number of outlets with switches to 160 A and construction width of 50 mm), or breakers allowing the attachment of cables with max. cross-section of 300 mm². Nominal current of the distributor is standardly to 630A, shorting resistance (short-time nominal withstand current 1 s) 20 up to 25 kA. Besides this, the distributor can include electric energy consumption monitor, circuits for station lightning and a service socket. The clips can be grounded on the main breaker's feeder („ball pivots“) Ø 25 mm, which allow to protect the work place during the maintenance of the LV distributor via grounding system (shorting set). Max. dimensions of the LV distributor (WxLxH) are ca: 1 300x1 300x350 mm.

The distributors meet STN EN 60439-1 norm and also DIN VDE 0660, part 500, VDE 0100, VDE 0414, UVV standard requirements.

Cable connections:

They include HV distributor connection with transformer 24 kV by single-core cables 24-N2XSY 3x1x35 mm² and LV distributor connection with transformer 1 kV by cables 1-NYY-O 1x150 mm², resp. 1x240 mm².

Cable connections for high voltage are checked in each production phase. Filed tests of the TE fractional discharges in Gräper company's own test-room can be carried out, following VDE 0434, VDE 0472 technical norms. According to the regulations the maximum allowed value for TE is ≤ 20pC. The real achieved value is ≤ 5 pC.

Transformer station construction specifications:

The station is constructed according to the norms and rules of STN EN, DIN, UVV etc., directly following the bellow given normative standards:

Cellular concrete	- DIN 4219
Reinforced concrete	- DIN 1045
VDE Directives	- DIN 0141, 0101, 0100
Directive on the protection of ground waters	- GwSchV
Federal directive on waste disposal	- BimSchV
Electromagnetic radiation compliance	- BimSchV č.26





Individual structural components of the transformer substation are made of unflammable materials, fire resistance of the station constructen meets STN 73 0821 (fire resistance class required is F90, class documented is F120).

Delivery, assembly, ground cut for station placement:

The kiosk-type transformer station is delivered assembled and prepared for HV, LV cable connection and grounding. It is installed by crane into a prepared pit with compressed and flat surface according to the design project of the transformer substation's producer – Gräper company (dimensions of the ground cut: 360x210 cm, cutting depth: 90 cm, compressed layer width: min. 20 cm).

