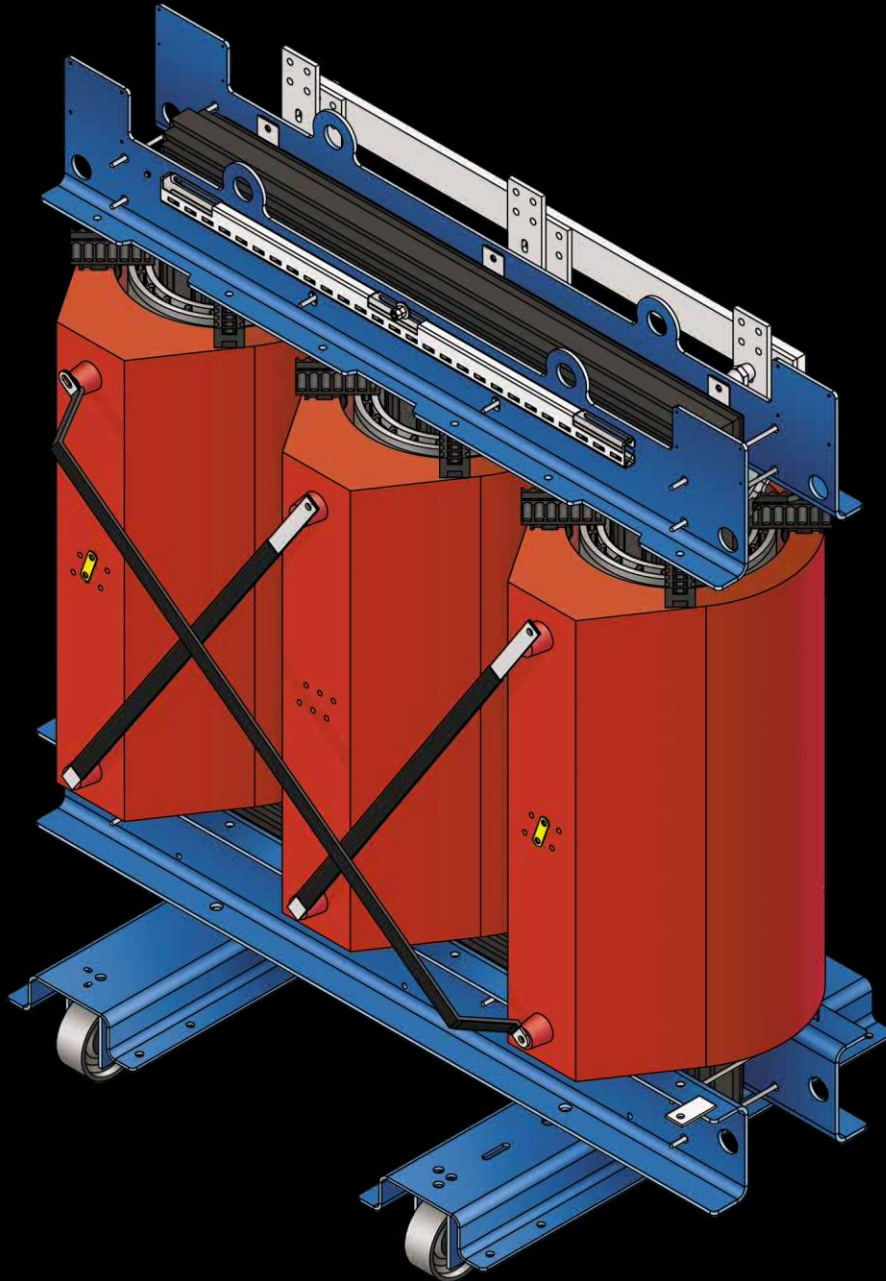




**KLM**  
engineering



**Transformers KLM**  
6-35KV; 110-220KV  
16-25000kVA

# 1. TSL

## Dry-type cast coil transformers



### 1.1. Advantages

- installation at built-in substations;
- fire safety: flame-retardant self-extinguishing resin is used as dielectric material;
- environmentally friendly: no emission of harmful substances during fire, no oil discharge; □ low noise;
- resistance to dust, moisture, and fungi; □ minimum operating costs.

### 1.2. Design features

**Magnetic core** is made of double-coated cold-rolled grain-oriented sheet steel. A state-of-the-art technology of metal cutting and component assembly Step-Lap ensures low no-load losses and results in lower noise.

**LV windings** are made of aluminum/copper wire (up to 160 kVA) or aluminum/copper strip (up to 250 kVA) The windings are impregnated with resin polymerized during heat treatment in the oven, contributing to a higher resistance to short-circuit currents due to increase in the structure rigidity and protecting the winding against dust, moisture, and weather.

**HV windings** consist of several series-connected sections. Each winding section is made of insulated wire (up to 400 kVA) or aluminum/copper strip (up to 630 kVA). Inner and outer surfaces of the windings are covered with glass-fiber mesh to reinforce epoxy resin with fillers.

The **fillers** used ensure the required thermal and mechanical strength (thermal-expansion coefficient, hardness, flexibility) and fire-protection properties (fire resistance, self-quenching ability).

### 1.3. Operating conditions

Transformers TSL are installed in dry unheated premises. Transformers TSL of the standard version (U3 climatic category) are designed for operation at an ambient temperature of -25 to +40°C, while that of the frostproof version (UKhL3 climatic category) – at an ambient temperature of -60 to +40°C. The premises shall be provided with natural or forced ventilation for efficient removal of the heat generated during the transformer operation. To ensure the transformer cooling, it shall be mounted on wheels or raised at the height equal to that of wheels.

The recommended distance between the transformer windings and walls or other grounded structures is 300 mm. Leading-in cables and buses shall be fixed in order to prevent mechanical stresses on HV and LV terminals.

## 1.4. Operation requirements

Transformers by "Transformer" are suitable for long-term operation at voltages 10% higher than the rated value if the load does not exceed the rated one.

We recommend you to perform the following preventive operations once a year:

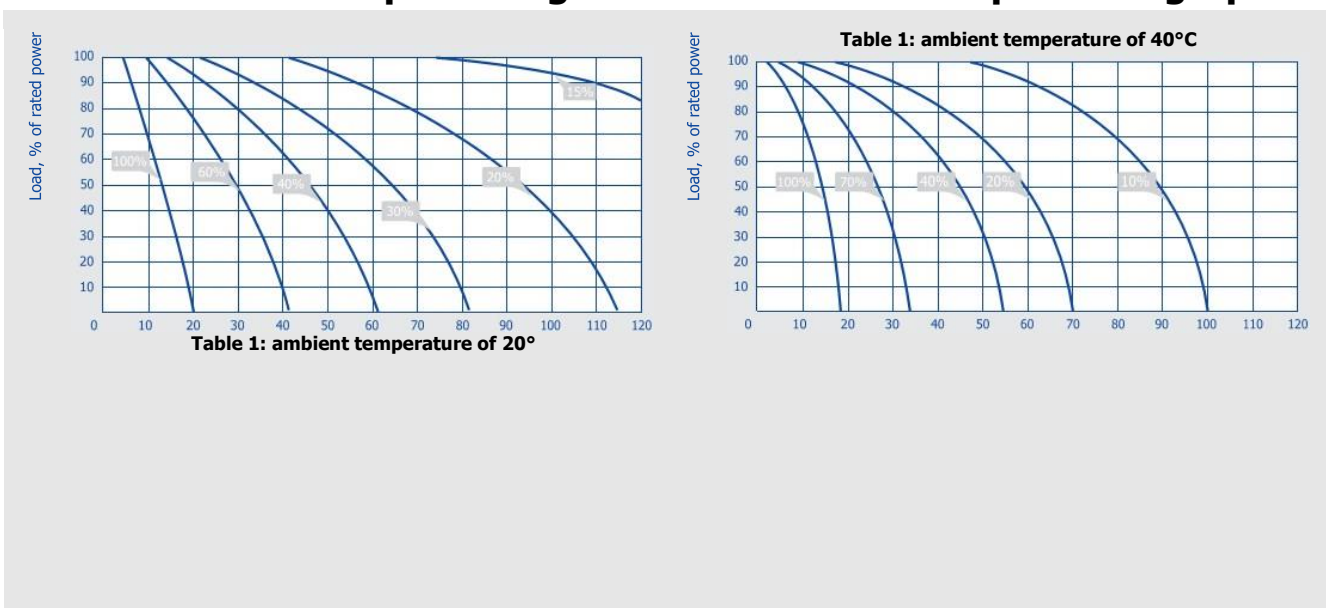
1. Reliability check of bolted connections with a torque wrench. The force to be applied to each thread size is specified in the Operation Manual and in a table affixed to the upper transformer beam.
2. Removal of dust, dirt, and foreign objects from the magnetic core, windings, and cooling ducts of the transformer by means of a vacuum cleaner or compressed air.
3. Cleaning of HV winding surfaces with a sponge wetted with alcohol solution (solvent). The scope and frequency of preventive maintenance depend on operating conditions (dust content, humidity, etc.). The transformers shall be operated in compliance with the Operation Manual of the manufacturing plant and the regulatory documents: Electrical Installation Code, "Guidelines for Electric Equipment Tests", and "Rules for Operation of Power Stations and Networks in the Russian Federation". The transformers shall be visually examined on a periodic basis in accordance with regulations of the operating organization.

## 1.5. Transformer overload protection

The transformer is designed for operation at the rated power and at an ambient temperature no higher than 40°C. The transformer may be operated at a higher temperature provided that the power is reduced according to the table to the right. Transformers TSL are suitable for short-term overload operation without service-life reduction. However,

the overload value shall be limited by the heat-resistance where P is rated load class of windings. For insulation class F, the value is 155°C.

## Overload time vs. preceding load and ambient temperature graphs



## 1.6. Thermal protection

Thermal protection of "Transformer"-brand transformer windings is ensured by linear PT100-type transducers. In standard version, the transducers are mounted at each low-voltage winding. The transformer is completed with a programmable microprocessor protection unit T-154 by Tecsystem (Italy) with the Installation and Programming Manual in Russian. The linear PT100 transducers and the microprocessor protection unit T-154 allow flexible selection of pre-fault temperatures as well as of fan start and shutdown temperatures.

Winding temperatures recommended by the manufacturer are as follows:

- overheat alarm – 140°C;
- transformer shutdown – 150°C; □ start of forced ventilation – 100°C;
- shutdown of forced ventilation – 90°C. Set values (setpoints) can be adjusted at the front panel of the T-154 relay with the transformer running.

## 1.7. Complete set

The mandatory complete set of all "Transformer"-brand transformers TSL must include three PT100 temperature transducers, one microprocessor protection unit T-154 by Tecsystem (Italy), and a set of wheels. Optional accessories may include a set of fans, thermal protection cabinet, thermal protection and ventilation control cabinet, or vibration dampers. The complete set is to be agreed upon order placement.

## 1.8. Packaging and transportation

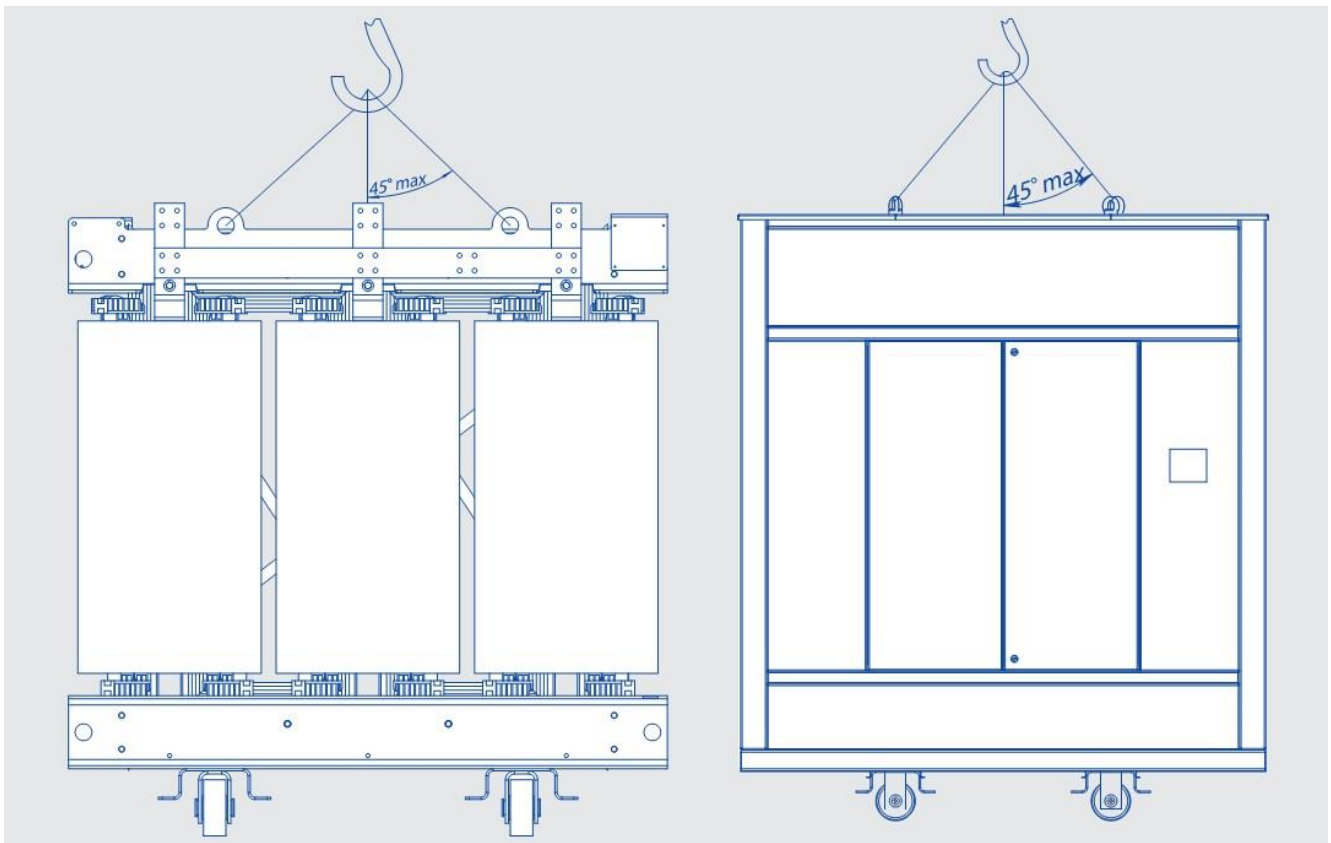
The transformer shall be packaged in a protective PE film or a wooden box to protect it against moisture and mechanical damages. The packaging method shall be agreed with the customer.

The transformer is transported in the completely assembled and packaged condition. Upon agreement with the customer, the transformer enclosure may be supplied in the disassembled condition, fully or in part, with the busbar bridges dismantled in a separate package. The transformer can be delivered by any mode of transport.

During transportation, the transformer shall be fixed to prevent its turnover and damage. This can be ensured by means of soft vehicle belts (at least two per unit), steel braces, and bars. The transformers shall be placed with their long side in the direction of travel.

The manufacturing plant recommends you to use motor-vehicle transportation by trucks with wooden floors, which is best suited for mounting of spacing blocks and stop bars. The motor-vehicle speed shall be no more than 60 km/h in case of bituminous roads and 40 km/h in case of soil roads.

## TSL and TSZL transformer slinging diagram



## 1.9. Warranty

Manufacturer's warranty is **5 years**. The service life is **30 years**.

Experts of "KLM" Production assist in issues of the product transportation to the installation site. Transportation services as well as transformer diagnostics, installation, and repair services are to be agreed by the parties on an individual basis.

## Basic technical characteristics

Transformer type	TSL, TSZL
Power	25 to 16,000 kVA
Vector group	D/Yn-11, Y/Yn-0, others upon the customer's request
HV and LV winding material	aluminum, copper
Rated high voltage	(3, 6, 10, 20, 35 kV)±2x2.5%
Rated low voltage	230, 400, 690 V; 6, 10 kV
Partial discharge level	<10 pC
Heat-resistance class	F (155°C)
Fire safety class	F1
Environmental safety class	E2
Rated value of climatic factors	U3, UKhL3 as per GOST 15150-69
Cooling	AN (natural)
	AF (forced)
Protection rating	without protective enclosure – IP00
	in metal enclosure – IP10 to IP33
Operation, transportation, and storage temperature	-25° to +40°C in case of U3; -60° to +40°C in case of UKhL3
Service life	30 years
Warranty period	5 years
Standard	GOST R 52719, GOST 11677-85

## Corrected sound power levels of TS(Z)L transformers

Transformer power, kVA	Corrected sound power level, no more than, Lpa, dBA	
	with normal noise level	with reduced noise level
25 to 100	75	66
160	76	67
250	77	68
400	78	69
630	79	73

1,000	80	74
1,250	80	76
1,600	80	76
2,000	81	77
2,500	82	77
3,200 (3,150)	83	78

## 1.10. Normal-loss transformers TSL 6 (10) kV

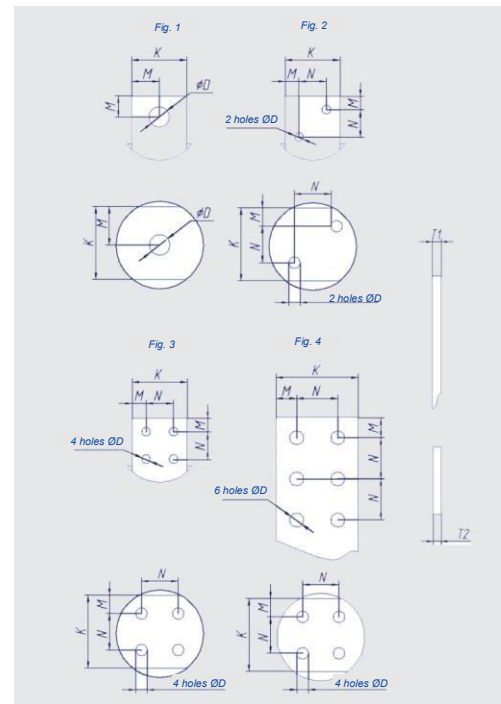
### Technical characteristics

Power, kVA	Voltage		Winding circuit and vector group	U <sub>k</sub> , %	I <sub>xx</sub> , %	Losses, W		Weight, kg
	HV, kV	LV, V				no-load, W	short circuit, kW*	
25	6 10	0.4	D/Yn-11 Y/Yn-0	4	4	195	450	280
40				4	3	230	780	350
63				4	3	300	1,350	450
100				6	1.5	420	2,100	550
160				6	1.5	600	2,700	770
250				6		750	3,700	930
400				6		1,150	5,900	1,300
630				6	0.8	1,300	7,100	1,750
630				8	0.8	1,000	7,600	1,750
800				6	0.8	1,800	7,600	1,750
1,000				6	0.8	2,000	8,900	2,500
1,000				8	0.8	1,500	9,000	2,500
1,250				6	0.8	2,600	11,400	2,850
1,250				6	0.8	2,200	12,000	2,950
1,600				6	0.6	3,300	11,500	3,800
2,000				6	0.6	3,300	15,000	4,050
2,500				6	0.6	4,100	19,500	4,900
3,150				6	0.6	4,600	24,000	5,600
4,000	6, 10, 35	6.3	Y/D 11	8	0.3	6,500	36,000	10,600
8,000	10	6	Y/D 11	9	0.37	11,000	44,000	19,100
8,000	35	10	Y/D 11	10	0.37	12,000	46,000	23,200
10,000	6, 10, 35	6.3	Y/D 11	9	0.3	12,000	50,000	19,000
10,000	10	6	Y/D 11	9	0.35	12,500	50,000	21,900
10,000	35	10	Y/D 11	10	0.35	14,000	56,000	24,300
16,000	10	6	Y/D 11	10	0.3	20,000	64,000	28,600
16,000	35	10	Y/D 11	12	0.3	22,000	68,000	33,400

\*Short-circuit losses are reduced to the temperature of 115°C.

## Coupling dimensions

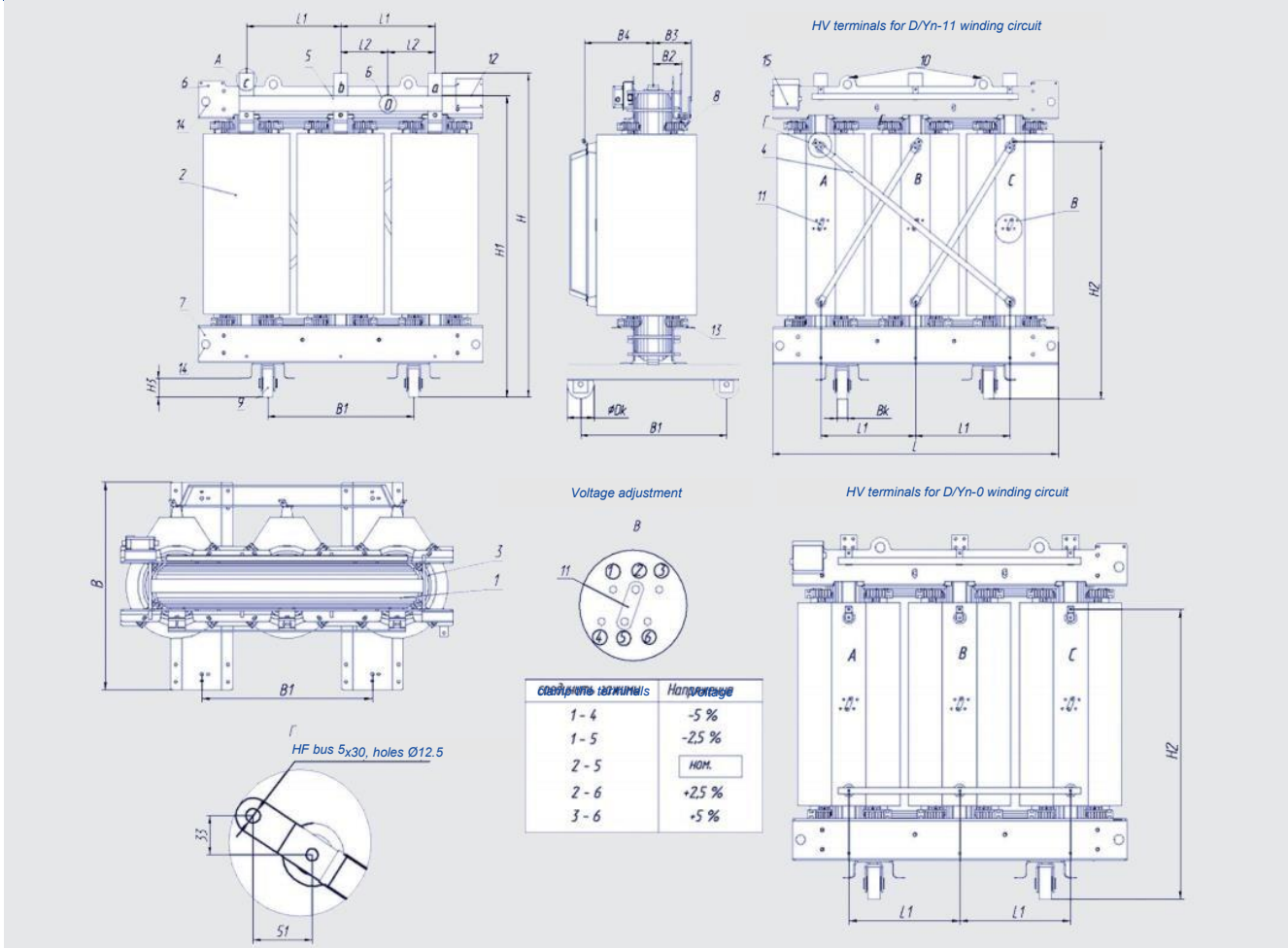
Power, kVA	Coupling dimensions of LV bus							Wheel size	
	Fig.	K, mm	M, mm	N, mm	T1, mm	T2, mm	D, mm	Dk, mm	Bk, mm
25	1	30	15	-	5	5	12.5	125	40
40	1	30	15	-	5	5	10.5	125	40
63	2	50	13	24	5	5	10.5	125	40
100	1	30	15	-	5	5	10.5	125	40
160	2	50	13	24	5	5	10.5	125	40
250	3	50	13	25	5	5	10.5	125	40
400	3	60	15	30	6	6	10.5	125	40
630	3	80	20	40	6	6	10.5	125	40
1,000	3	80	20	40	10	10	12.5	150	60
1,250	3	100	25	50	10	10	12.5	150	60
	3	100	25	50	10	20	12.5	150	60
1,600	4	120	30	60	10	10	16.5	150	60
2,000	4	120	30	60	15	30	16.5	200	84
2,500	4	120	30	60	15	15	16.5	200	84
3,200 (3,150)	5	150	25	50	20	40	16.5	200	84



## Overall dimensions

Power, kVA	Overall dimensions											
	height, mm				width, mm			depth, mm				
	H	H1	H2	H3	L	L1	L2	B	B1	B2	B3	B4
25	897	812	618	80	860	285	142	650	500	86	126	255
40	1,025	916	756	80	880	290	145	650	500	92	137	236
63	1,175	1,125	820	80	920	310	155	650	500	100	145	250
100	1,060	960	787	80	1,070	360	180	650	500	105	145	267
160	1,127	1,145	860	80	1,160	380	190	750	600	110	155	285
250	1,221	1,155	915	80	1,220	400	200	750	600	125	175	325
400	1,280	1,195	955	80	1,390	460	230	750	600	140	195	350
630	1,515	1,435	1,180	80	1,435	475	238	750	600	140	195	350
1,000	1,725	1,630	1,330	107	1,600	530	265	970	820	175	245	390
1,250	1,710	1,595	1,330	107	1,690	560	280	970	820	185	250	390
1,250	1,743	1,628	1,358	107	1,730	580	260	970	820	187	268	425
1,600	1,865	1,680	1,370	107	1,885	625	313	970	820	200	295	425
2,000	2,205	2,020	1,715	130	1,720	570	285	1,270	1,070	190	300	435
2,500	2,285	2,100	1,785	130	1,885	625	313	1,270	1,070	205	310	425

3,200 (3,150)	2,365	2,235	1,849	130	2,020	675	373	1,270	1,070	251	387	485
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- 1. Magnetic core
- 2. HV windings
- 3. LV windings
- 4. HV buses
- 5. LV buses
- 6. Upper pressing blocks
- 7. Lower pressing blocks
- 8. Pressing screws and insulators
- 9. Wheel
- 10. Slings holes
- 11. HV bridge
- 12. Nameplate
- 13. Earthing
- 14. Hoisting holes
- 15. Junction box for temperature transducers

## 1.11. Normal-loss transformers TSL 20 kV and 35 kV

### Technical characteristics of transformers TSL 20 kV

Power, kVA	Voltage		Winding circuit and vector group	U <sub>k</sub> , %	I <sub>xx</sub> , %	Losses, W		Weight, kg
	HV, kV	LV, V				no-load, W	short circuit, kW*	
630	20	230 400	D/Yn-11 Y/Yn-0	6	0.8	1,700	7,500	2,300
1,000				6	0.6	2,300	11,000	3,300
1,000				8	0.6	2,300	11,000	2,500
1,250				6	0.6	2,800	13,100	3,700
1,600				6	0.6	3,100	16,800	4,200
2,000				6	0.6	4,000	20,000	4,700
2,500				6	0.6	5,200	23,000	5,300



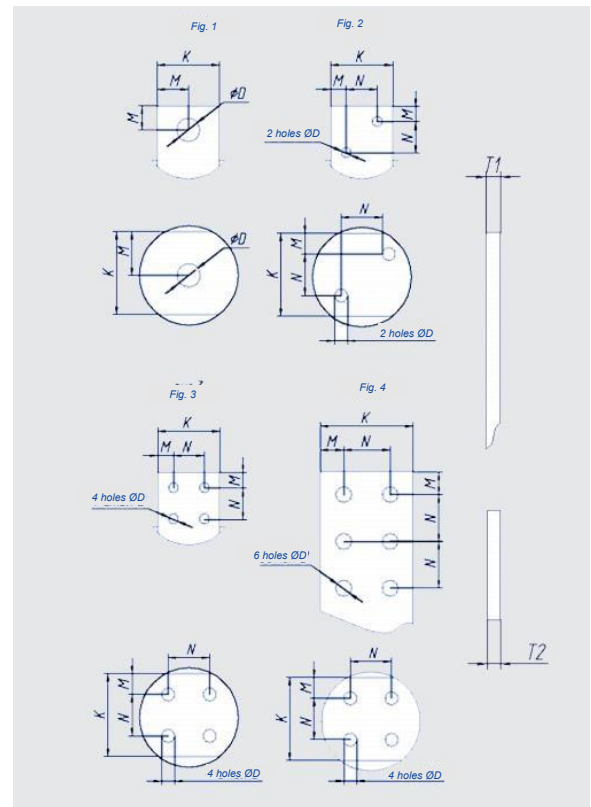
## Technical characteristics of transformers TSL 35 kV

Power, kVA	Voltage		Winding circuit and vector group	Uk, %	Ixx, %	Losses, W		Weight, kg
	HV, kV	LV, V				no-load, W	short circuit, kW*	
100	35 kV	6 kV 10 kV	D/Yn-11 Y/Yn-0	6	2	850	1,800	950

\*Short-circuit losses are reduced to the temperature of 115°C.

## Coupling dimensions

Power, kVA	Coupling dimensions of LV bus							Wheel size	
	Fig.	K, mm	M, mm	N, mm	T1, mm	T2, mm	D, mm	Dk, mm	Bk, mm
<b>Normal-loss transformers TSL 20 kV</b>									
630	3	80	20	40	6	6	10.5	125	40
1,000	3	80	20	40	10	10	12.5	150	60
1,250	3	100	25	50	10	20	12.5	150	60
1,600	4	120	30	60	10	10	16.5	150	60
2,000	4	120	30	60	15	30	16.5	200	84
2,500	4	120	30	60	15	15	16.5	200	84
<b>Transformers TSL 35 kV</b>									
100	2	50	15	20	5	5	10.5	125	40



## Overall dimensions

Power, kVA	Overall dimensions											
	height, mm				width, mm			depth, mm				
	H	H1	H2	H3	L	L1	L2	B	B1	B2	B3	B4
<b>Normal-loss transformers TSL 20 kV</b>												
630	1,805	1,723	1,452	107	1,600	535	268	970	820	171.2	238	367

1,000	2,005	1,893	1,625	107	1,670	555	278	970	820	187	268	417
	1,978	1,883	1,614	107	1,710	575	288	970	820	180	261	421
1,250	2,055	1,933	1,643	107	1,760	585	243	970	820	194.4	275	421
1,600	2,295	2,124	1,805	130	1,850	615	308	1,270	1,070	205	311	501
2,000	2,350	-	-	130	1,950	-	-	1,270	1,070	-	-	-
2,500	2,360	-	-	130	2,080	-	-	1,270	1,070	-	-	-
<b>Transformers TSL 35 kV</b>												
100	1,571	1,520	1,180	80	1,530	525	262	750	600	123	168	374

## 1.12. Copper-winding transformers TSL 6 (10) kV

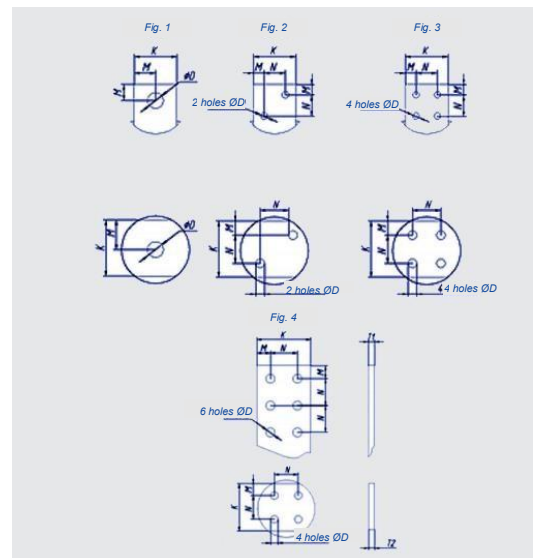
### Technical characteristics

Power, kVA	Voltage		Winding circuit and vector group	U <sub>k</sub> , %	I <sub>xx</sub> , %	Losses, W		Weight, kg
	HV, kV	LV, V				no-load, W	short circuit, kW*	
400	6 10	230 400	D/Yn-11 Y/Yn-0	6	0.8	1,000	4,800	1,600
630				6	0.8	1,400	6,000	2,200
1,000				6	0.8	2,000	8,800	2,700
1,000				8	0.8	2,000	8,800	2,700
1,600				6	0.6	2,800	10,500	4,300
2,500				6	0.6	4,300	18,000	5,200

\*Short-circuit losses are reduced to the temperature of 115°C.

### Coupling dimensions

Power, kVA	Coupling dimensions of LV bus							Wheel size	
	Fig.	K, mm	M, mm	N, mm	T1, mm	T2, mm	D, mm	Dk, mm	Bk, mm
400	3	60	15	30	5	5	10.5	125	40
630	3	80	20	40	8	8	10.5	125	40
1,000	3	80	20	40	6	12	12.5	150	60
1,600	4	100	25	50	8	10	16.5	150	60
2,500	4	120	20	60	10	20	16.5	200	84



## Overall dimensions

Power, kVA	Overall dimensions											
	height, mm				width, mm			depth, mm				
	H	H1	H2	H3	L	L1	L2	B	B1	B2	B3	B4
400	1,310	1,185	1,000	80	1,360	450	225	750	600	145	205	350
630	1,440	1,336	1,126	80	1,360	450	225	750	600	155	222	327
1,000	1,415	1,307	1,042	107	1,630	540	270	970	820	193	262	403
			1,035		1,690	560	280			190	260	419
1,600	1,850	1,691	1,435	107	1,750	580	290	970	820	199	293	418
2,500	2,195	2,015	1,679	130	1,750	580	290	1,270	1,070	190	286	401

## 1.13. Low-noise transformers TSL 10 kV

### Technical characteristics

Power, kVA	Voltage		Winding circuit and vector group	Uk, %	Ixx, %	Losses, W		Weight, kg
	HV, kV	LV, V				no-load, W	short circuit, kW*	
400	10	230 400	D/Yn-11 Y/Yn-0	6	0.4	800	5,600	1,400
1,000				6	0.3	1,500	8,900	2,650
1,250				6	0.3	2,100/2,200	11,400/12,000	2,850
1,600				6	0.3	2,800	11,000	3,800
2,000				6	0.3	2,400	15,600	4,350
2,500				6	0.3	3,000	19,500	5,150

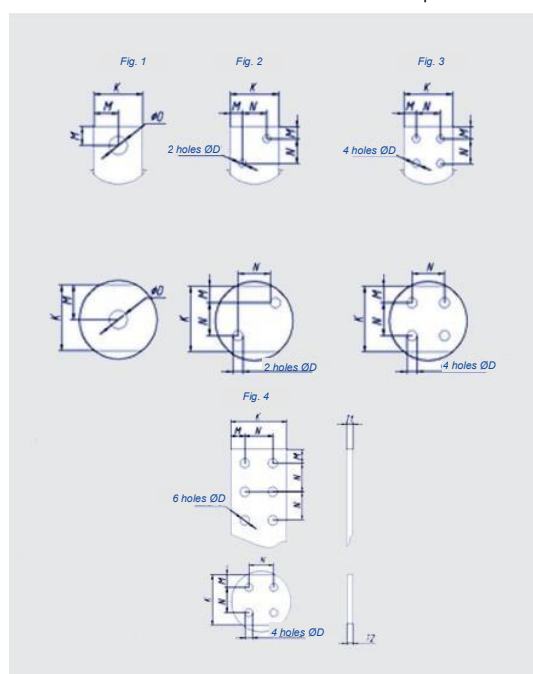
### Coupling dimensions

Power, kVA	Coupling dimensions of LV bus							Wheel size	
	Fig.	K, mm	M, mm	N, mm	T1, mm	T2, mm	D, mm	Dk, mm	Bk, mm
400	3	60	15	30	6	6	10.5	125	40
1,000	3	80	20	40	10	10	12.5	150	60
2,000	4	120	30	60	15	30	16.5	200	84
2,500	4	120	30	60	15	15	16.5	200	84

\*Short-circuit losses are reduced to the temperature of 115°C.

### Corrected sound power levels

Transformer power, kVA	Corrected sound power level, no more than, Lpa, dBA	
	with normal noise level	with reduced noise level
25 to 100	82	77
160	76	67
250	83	78
400	78	69
630	79	73
1,000	80	74
1,250	80	76
1,600	80	76
2,000	81	77
2,500	82	77
3,150	83	78



### Overall dimensions

Overall dimensions	

Power, kVA	height, mm				width, mm			depth, mm				
	H	H1	H2	H3	L	L1	L2	B	B1	B2	B3	B4
400	1,280	1,195	955	80	1,390	460	230	750	600	140	193	350
1,000	1,725	1,630	1,330	107	1,600	530	265	970	820	175	245	390
1,250	1,730	-	-	-	1,690	-	-	970	-	-	-	-
1,600	1,875	-	-	-	1,885	-	-	970	-	-	-	-
2,000	2,205	2,020	1,743	130	1,720	590	295	1,270	1,070	212	332	421
2,500	2,285	2,100	1,785	130	1,885	625	313	1,270	1,070	205	310	425

## 1.14. Isolating transformers TSL 6 (10) kV

### Technical characteristics

Power, kVA	Voltage		Winding circuit and vector group	U <sub>k</sub> , %	I <sub>xx</sub> , %	Losses, W		Weight, kg
	HV, kV	LV, V				no-load, W	short circuit, kW*	
1,250	6 10	230 400	D/Yn-11	6	0.8	2,800	11,000	3,450
1,600			Y/Yn-0					

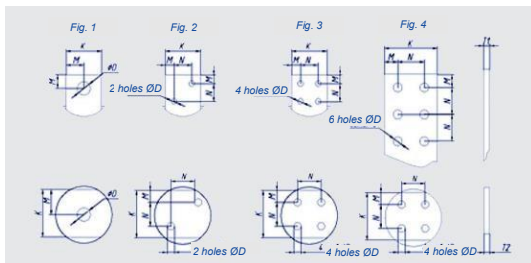
\*Short-circuit losses are reduced to the temperature of 115°C.

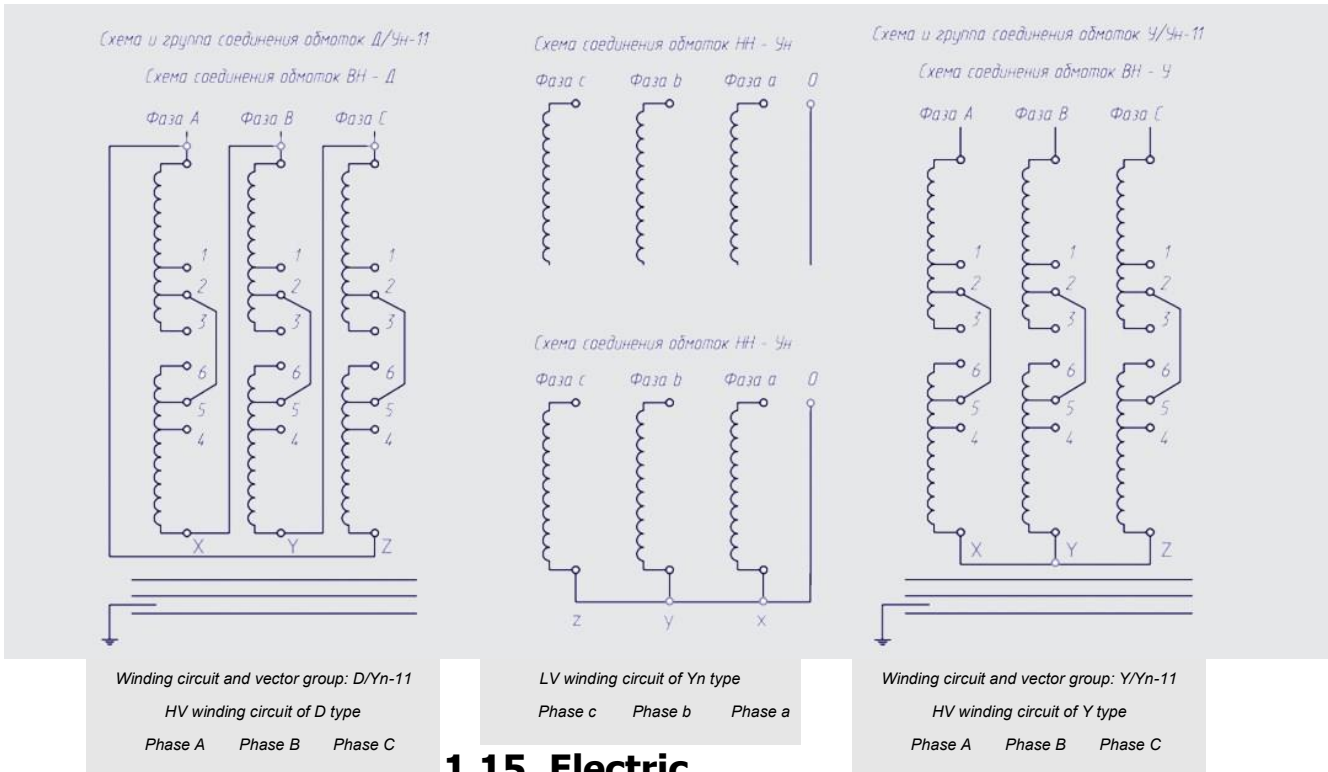
### Overall dimensions

Power, kVA	Overall dimensions											
	height, mm				width, mm			depth, mm				
	H	H1	H2	H3	L	L1	L2	B	B1	B2	B3	B4
1,250	2,074	-	1,659	107	1,720	570	-	970	820	251	-	426
1,600	2,134	-	1,684	107	1,850	605	-	970	820	273	-	450

### Coupling dimensions

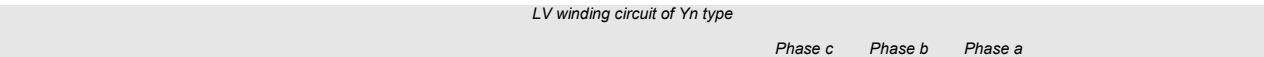
Power, kVA	Coupling dimensions of LV bus							Wheel size	
	Fig.	K, mm	M, mm	N, mm	T1, mm	T2, mm	D, mm	Dk, mm	Bk, mm
1,250	5	30	15	-	5	30	12.5	150	60
1,600	5	30	15	-	5	30	12.5	150	60





### 1.15. Electric

## schematic diagram of transformer winding connections



### 1.16. Winding circuits

Upon the customer's request, "Transformer" offers various winding circuits and vector groups of the transformer.

**Winding circuit D/Yn-11** (delta/star-neutral) is the most efficient circuit in terms of power supply quality (shape of voltage curve), operation under unbalanced loads, and construction of discriminative relay protection. It can be used in almost all types of networks, for power supply of residential buildings in urban and rural settlements.

The **winding circuit Y/Yn-0** (star/star-neutral) is used, as a rule, for low-power transformers. It is used in networks with three-phase balance loads.

## 1.17. Microprocessor protection unit

The programmed microprocessor protection unit is designed for temperature control of the operating transformer. It consists of three PT100 temperature transducers and a T-154 thermal protection relay by Tecsystem. With a temperature rise, the active resistance of the temperature transducers increases, and once the set value (setpoint) is reached the relay trips.



T-154 thermal protection relay Terminal box Fans by Tecsystem with the Installation and Programming Manual in Russian.

## 1.18. Fans

Depending on the power of the power transformer, a set of fans includes 6 to 12 units. The fans are installed on a common plate, 3 or 6 units on each of two sides of the transformer. They are started upon a signal sent by the microprocessor protection unit and transmitted to the fan start/shutdown circuit. They allow the loading capacity of the transformer to be increased by 15 to 20 % under linear load.

## 1.19. Thermal protection cabinet (TPC)

The cabinet is designed for control of operating temperature conditions of the power transformer and for its protection. It receives information from PT100 temperature transducers and sends it to the T-154 microprocessor unit that, in case of the transformer overheating, transmits the shutdown signal. Upon the customer's request, the signal may be displayed at the operational control panel.

The rated voltage of the cabinet is 220 V; the frequency is 50 Hz; and the loading capacity of output relays is 1 A. Overall dimensions (height, width, depth) are 400x300x200 mm; the weight is 15 kg.

The cabinet is designed for control of operating temperature conditions of the power transformer, its protection and ventilation control. As opposed to TPC, it provides an additional feature of fan start upon a signal transmitted by the thermal relay. It provides an opportunity to create optimal conditions for the transformer operation in any load and climatic conditions.

The rated voltage is 220 V; the frequency is 50 Hz; the loading capacity of the output relay is 0.25 A; that of the incoming switch s263 C16 is 16 A; that of the electric contactor is 10 A; that of the control circuit breaker s261 C6 is 6 A.

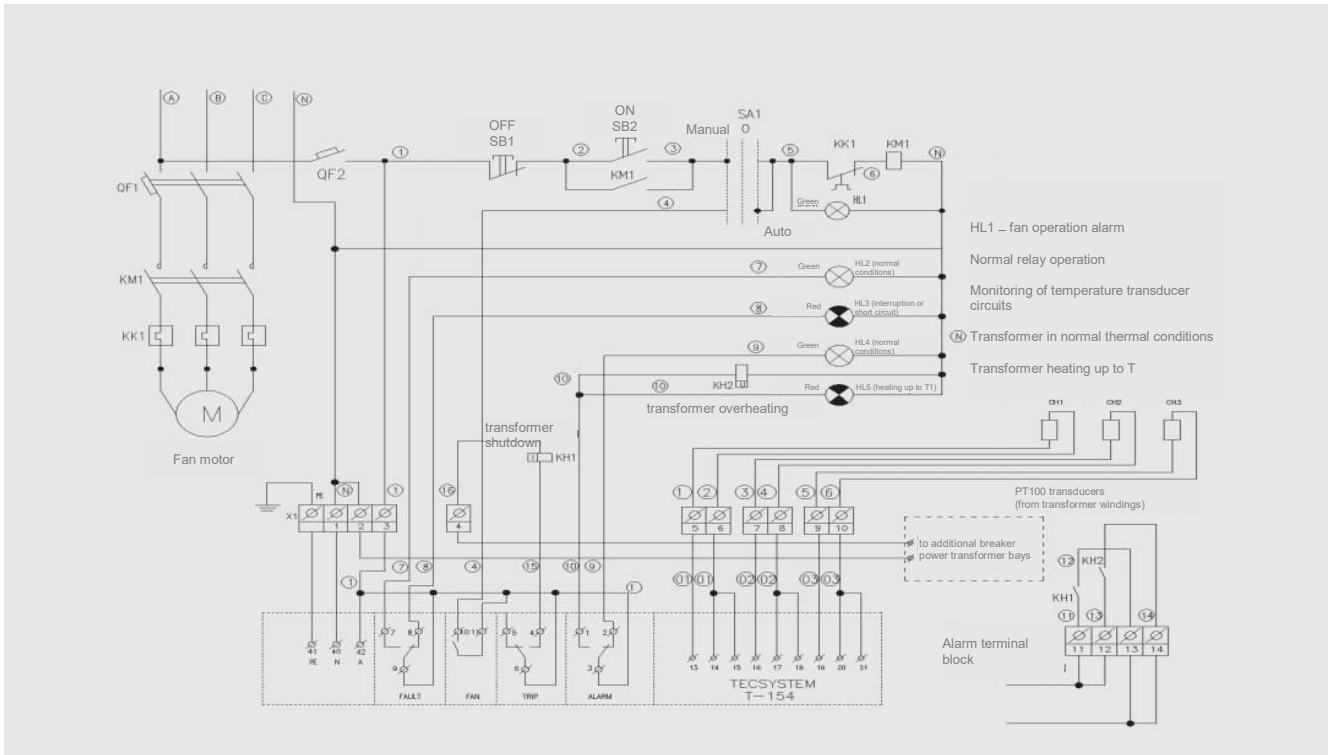
Overall dimensions (height, width, depth) of the cabinet are 400x400x200 mm; the weight is 15 kg.

When the thermal protection and ventilation control cabinet is ordered, the T-154 microprocessor protection unit is installed inside the cabinet.



## 1.20. Electric schematic diagram of the thermal protection and

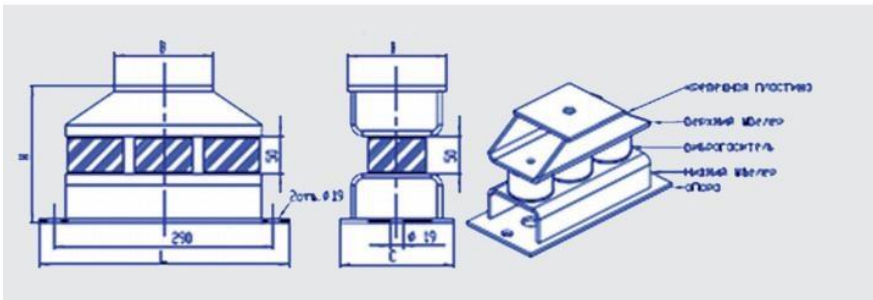
# ventilation control cabinet



## 1.21. Vibration dampers

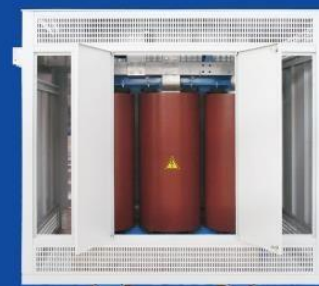
Vibration dampers reduce noise and vibrations transmitted from the operating transformer to a building construction by 20 to 25 %. Vibration dampers are installed in place of the transformer wheels.

### Design and dimensions of vibration mounts (vibration dampers)



Value	Power, kVA							
	25 to 250	400	630	1,000	1,250	1,600	2,000	2,500
H, mm	150	150	150	180	180	180	230	230
L, mm	330	330	330	330	330	330	330	330
B, mm	110	110	110	130	130	130	170	170
C, mm	120	120	120	150	150	150	180	180
Q-ty of vibration dampers	2	2	2	3	3	3	4	4

## 2. Protective enclosures for TSL transformers



The enclosure is a metal box protecting the transformer against foreign objects and water drops, depending on its design version. It is required in cases when the transformer TSL is installed outdoors (for example, in a production shop) or within high-humidity premises.

Dry-type cast coil transformers supplied in the enclosure are designated as TSZL, where "Z" means that the transformer is protected. The protection rating is designated by IP and a two-digit number, where the first digit indicates protection against foreign objects, while the second one means protection against water ingress. The enclosure-ensured protection rating of the transformer is IP10 to IP33, in accordance with the table below.

### Protection rating IP. Explanation table

Number	Brief description of ensured protection	Brief description of objects to be prevented from entering the enclosure housing
<b>First digit of the characteristic</b>		
0	No protection	
1	Protection against solid bodies larger than 50 mm	Big part of the human body (for example, hand) Solid bodies of no more than 50 mm in diameter
2	Protection against solid bodies larger than 10 mm	Rods, etc. no more than 80 mm in length Solid bodies of more than 12 mm in diameter
3	Protection against solid bodies larger than 2,5 mm	Tools, wire, and other objects over 2.5 mm in diameter or thickness Solid bodies of more than 2.5 mm in diameter
<b>Second digit of the characteristic</b>		
0	No protection	
1	Protection against vertically falling water drops	Vertically falling water drops shall not have an adverse effect
2	Protection against water drops falling at 15° to the vertical	Vertically falling water drops shall not have an adverse effect when the housing is inclined by 15° from its normal position
3	Protection against rain	Rain falling at 60° to the vertical shall not have an adverse effect
4	Protection against splashing water	Water splashes falling on the housing from all directions shall not have an adverse effect

"Transformer" manufactures enclosures for the whole power range of the transformers produced. Perfect metal treatment and high-quality painting guarantee durability and reliability of the products.

### 2.1. Design

The enclosure design provides as easy assembly and maintenance as possible. Hinged doors on the HV and LV sides allow easy switching and preventive maintenance, such as visual inspection of the transformer or re-tightening of contact and threaded connections.

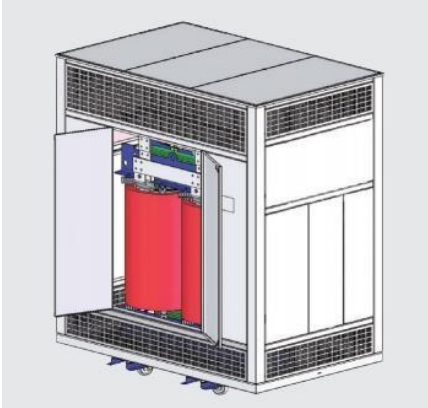
Connecting buses of the standard version are made of aluminum, while those of the nonstandard version are made of copper. Material of connecting buses is selected by the customer. Upon the customer's request, terminal areas of aluminum buses are subject to copper coating by gas dynamic spray. Dimensions of connecting buses depend on the power of the power transformer.

Enclosure grounding is terminated to two short sides. When the transformer is delivered as assembled with the enclosure housing, it is connected to the enclosure by flexible copper grounding strips. When the equipment is delivered disassembled, a set of grounding strips is attached.



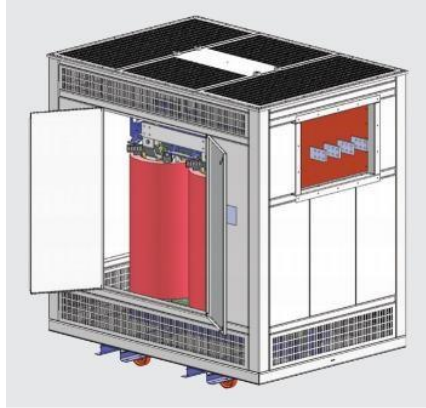
The enclosure is painted with powder paints with high metal adhesion and scratch resistance. The service life of the coating indoors is at least 15 years.

## ■ Designs of protective enclosures for transformers



**Enclosure IP21 with bottom HV and LV cable bushings**

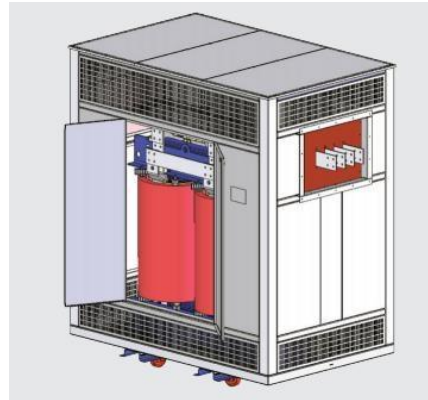
It is provided with a screen roof. The enclosure is characterized by a lower height due to vent holes in its roof. It is suitable for dry heated and ventilated premises (for example, at built-in substations, in industrial buildings, metro and railway station buildings, business and shopping centers, etc.).



**Enclosure with protection rating IP10/20/30**

Basic version

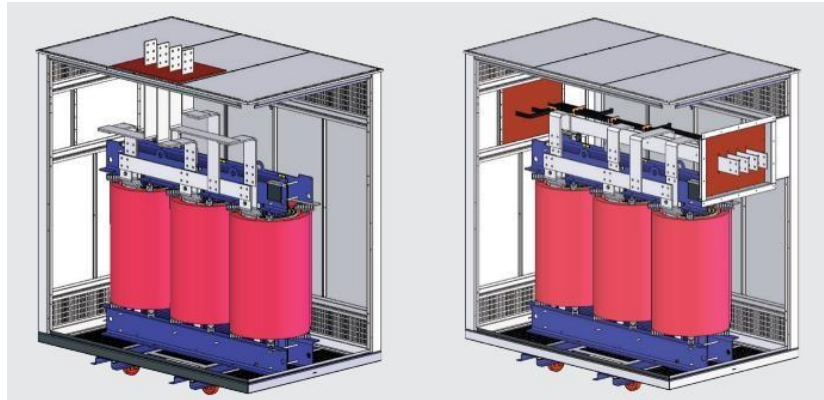
**Enclosure with protection rating 33**



It is provided with a leak-tight roof preventing ingress of moisture inside the enclosure.

This enclosure version is suitable for unheated premises with potential condensation or water drops falling from ceilings (for example, cold basements, hangars, warehouses, etc.).

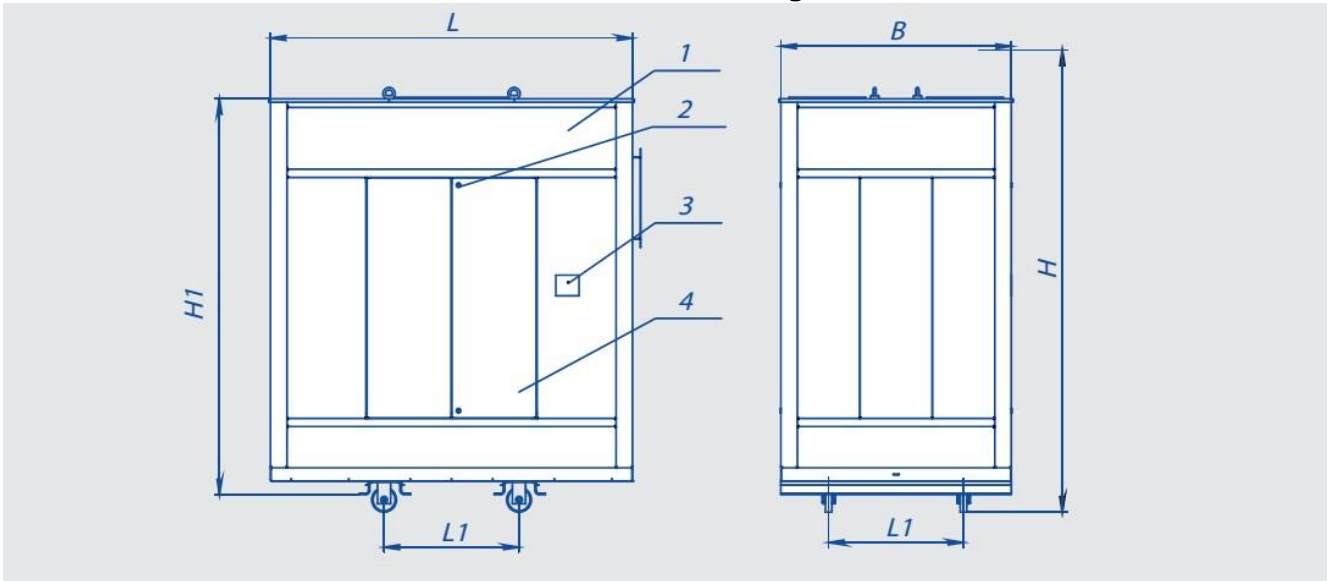
**Nonstandard version IP21–**



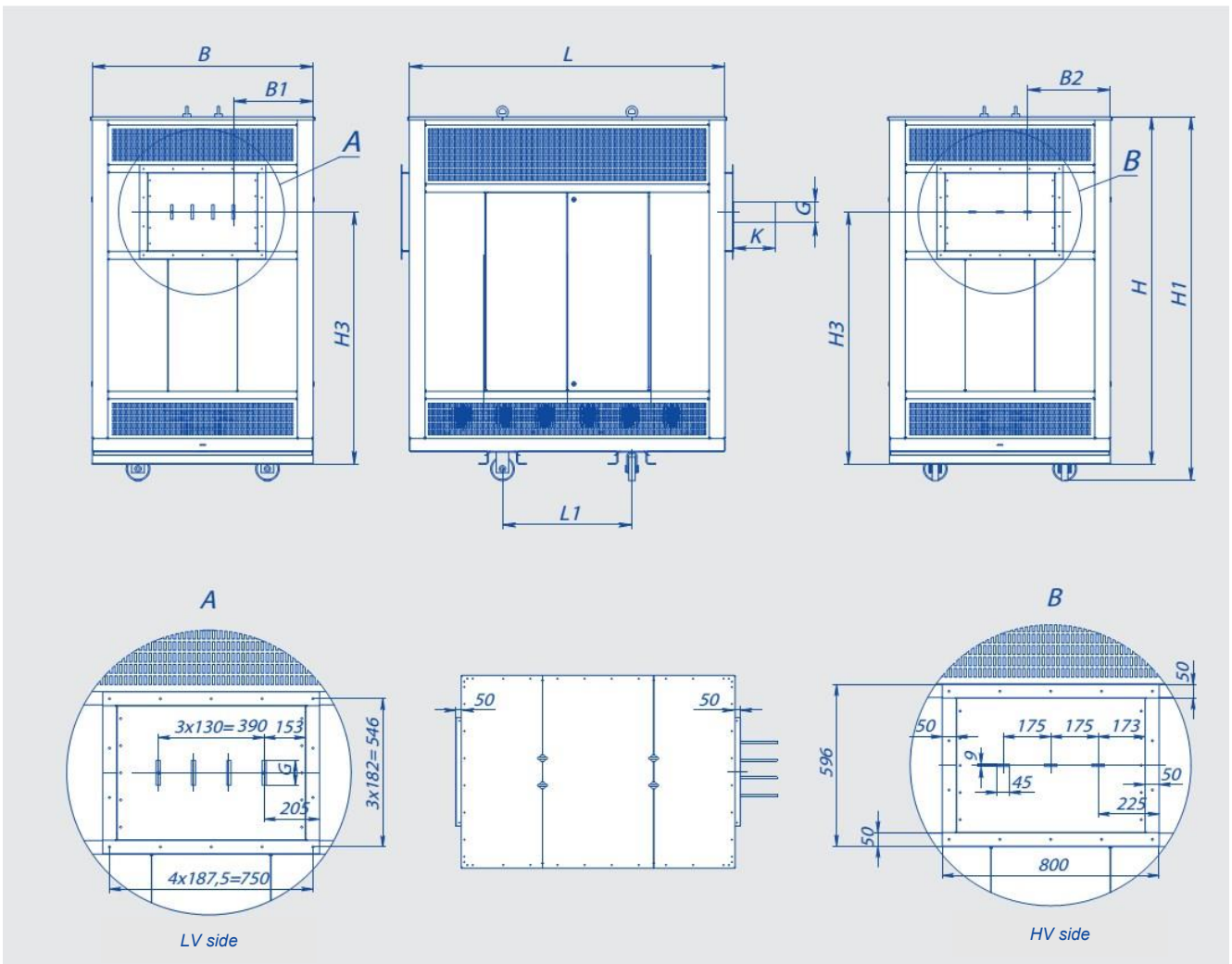
The nonstandard version covers enclosures with HV and LV busbar terminals terminated to the side wall through a flange with an insulation panel as well as with HV and LV busbar terminals terminated upwards through the insulation panel.

Upon the customer's request, HV and LV cables can be brought inside the enclosure through special gland connectors.

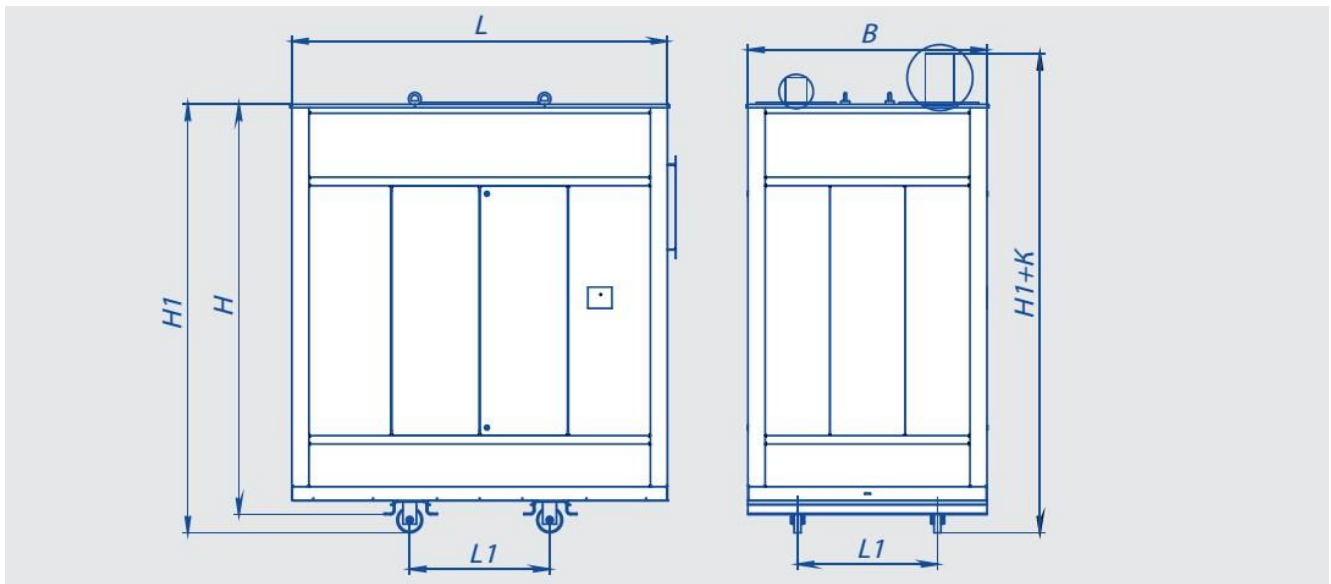
**General view of the enclosure with bottom cable bushings**



**General view of the enclosure with side HV and LV bushings**



### General view of the enclosure with top HV and LV busbar bushings



### Dimensions of TSZL-series transformers

Power, kVA	Length L, mm	Width B, mm	Height H, mm		Height H1, mm		H3, mm	Total weight, kg (max)
			IP10, IP20, IP30	IP11...IP33	IP10, IP20, IP30	IP11...IP33		
25	1,050	700	1,150	1,050	1,240	1,140	-	400
40								470
63	1,400	900	1,350	1,350	1,440	1,440	-	590
100								690
160	1,500	1,200	1,800	1,800	1,890	1,890	1,200	1,040
250								1,200
400	1,800	1,300	1,800	1,800	1,890	1,890	1,200	1,620
630	2,000	1,300	1,800	2,000	1,870	2,070	1,400	2,100
1,000	2,000	1,400	2,000	2,200	2,100	2,300	1,600	2,950
1,250	2,200	1,400	2,200	2,400	2,300	2,500	1,800	3,550
1,600								4,250
2,000	2,500	1,600	2,350	2,650	2,480	2,780	2,050	4,980
2,500								5,600

### Coupling dimensions of TSZL-series transformers

Power, kVA	Distance		G x S* mm (S* is a LV bus thickness)	Fig.	K, mm	M, mm	N, mm	D, mm
	L2, mm	L3, mm						
25	375	355	30x5	1	150	15	-	12.5
40								10.5
63	525	505	50x5	2	150	13	24	10.5
100			30x5	1		15	-	
160	575	555	50x5	2	150	13	24	10.5
250				3		12.5	25	
400	725	705	60x6	3	150	15	20	10.5

630	825	805	80x6	3	150	20	40	10.5
1,000	825	805	80x10	3	150	20	40	12.5
1,250	925	905	100x10	3	150	25	50	12.5
1,600			120x15	4	200	30	60	16.5
2,000	1,075	1,055	120x15	4	200	30	60	16.5
2,500								

## REQUEST FORM FOR TSL AND TSZL TRANSFORMERS

2016

ORGANIZATION NAME \_\_\_\_\_

CONTACT \_\_\_\_\_ PERSON \_\_\_\_\_

ADDRESS \_\_\_\_\_

TELEPHONE \_\_\_\_\_ FAX \_\_\_\_\_ E-MAIL \_\_\_\_\_

DELIVERY DATE: \_\_\_\_\_ PAYMENT CONDITIONS:

(50% 70% 100%)

REGION OF INSTALLATION: \_\_\_\_\_

TRANSFORMER TYPE  TSL  TSZL

No.	Technical data	Values
1	Rated power, kVA	
2	Primary voltage, kV	
3	Secondary voltage, kV	
4	Supply mains frequency, Hz	50
5	Vector group	<input type="checkbox"/> D/Yn-11 <input type="checkbox"/> D/Yn-5 <input type="checkbox"/> Y/Yn-0 <input type="checkbox"/> Other
6	No-load tap changing (NLTC) + 2 x 2.5%	<input type="checkbox"/> Yes <input type="checkbox"/> No
7	<p><b>Protection rating ensured by the enclosure</b>  <b>Standard version</b> (without enclosure) for TSL series – IP00  <b>Standard enclosure</b> (for transformers TSZL) with connection of Cable/Cable IP21 type  <b>Optional:</b> Enclosure fitted with a busbar bridge for LV/HV bushings (upon separate order, with approval of drawings, time of manufacture, and cost) (for transformers TSZL – IP2X- IP3X)</p>	<input type="checkbox"/> IP00 <input type="checkbox"/> IP20 <input type="checkbox"/> IP21 <input type="checkbox"/> IP22 <input type="checkbox"/> IP32 <input type="checkbox"/> IP23 <input type="checkbox"/> IP33
8	<p><b>Cooling</b>  AN (natural)      AF (forced)</p>	<input type="checkbox"/> AN <input type="checkbox"/> AF
9	<p><b>Thermal protection</b>  electronic relay Tecsystem T-154, thermal protection cabinet (TPC), thermal protection and ventilation control cabinet (TPVCC)</p>	<input type="checkbox"/> T-154 <input type="checkbox"/> TPC <input type="checkbox"/> TPVCC
10	Quantity of transformers, pc.	
11	For transformers TSZL (in enclosure), please additionally specify:	
	Enclosure	<p>HV bushing <input type="checkbox"/> Cable bushing <input type="checkbox"/> Busbar bushing</p> <p>LV bushing <input type="checkbox"/> Cable bushing <input type="checkbox"/> Busbar bushing</p>

	HV connection	<input type="checkbox"/> Top <input type="checkbox"/> Bottom <input type="checkbox"/> Side
	LV connection	<input type="checkbox"/> Top <input type="checkbox"/> Bottom <input type="checkbox"/> Side
	Delivery with the enclosure <a href="http://www.probiysk.ru/images/insertions/5733b.jpg">http://www.probiysk.ru/images/insertions/5733b.jpg</a>	<input type="checkbox"/> Assembly <input type="checkbox"/> Disassembled
12	Vibration dampers	<input type="checkbox"/> Yes <input type="checkbox"/> No
13	<b>Climatic version – U3</b> The transformer is designed for operation at a temperature of -250C to +400C	<input type="checkbox"/> U3 <input type="checkbox"/> Other
14	ADDITIONAL REQUIREMENTS	

Customer: \_\_\_\_\_ LS

## Three-phase oil-filled transformers

# 1. Transformers TMG in corrugated tank



### 1.1. Purpose

TM and TMG series transformers of 16 to 10,000 kVA with the voltage class of 6-10-20/0.4 kV are built in a corrugated tank filled with degassed oil in a vacuum chamber. The corrugated tanks provide the required cooling surface without use of any removable coolers.

TMG transformers are equipped with leak-tight tanks with no surge tank. The design with no surge tank prevents oil contact with the environment and thereby moisturization, oxidation, and sludge formation. As a result, oil maintains its dielectric properties throughout the whole service life.

The voltage is controlled by means of a NLTC switch (no-load tap changer), in the manual mode, under no load or voltage, by switching of HV winding taps.

### 1.2. Advantages

Advantages of oil-immersed sealed transformers by "KLM" are as follows:

- compact design;
- economical efficiency;
- improved technical specifications;
- overload resistance;  minimum operating costs;  safety.

Oil-immersed sealed transformers by "KLM" are designed specifically for energy-intensive customers in big cities. They are characterized by their compact size and high reliability. The TMG transformers by "Transformer" are an excellent solution for reconstruction of substations and newly constructed power facilities.

### 1.3. Design features

The **magnetic core** of the transformer is assembled from cold-rolled electric-steel laminations according to a Step-Lap stacking pattern. So far, this is the most advanced technology for manufacturing of transformers' magnetic cores. The use of high-grade steel (E3409, E3410, E3411) for magnetic-core production reduces no-load losses and the transformer noise level.

**HV windings** are the multilayer, cylindrical type and are made of copper/aluminum wire with paper or enamel insulation. A V-shaped arrangement of interlayer insulation increases its strength and, therefore, the service life of the transformer. **LV windings** are made of either aluminum/copper wire (up to 250 kVA) or aluminum/copper strip (over 250 kVA). The use of the strip decreases short-circuit axial stress approx. by 10 %. Advantages of the windings made of the strip also include a high dynamic resistance to short-circuit currents, significant simplification of the cooling-duct design, better uniformity of heat distribution along the winding, uniform distribution of the current density along the winding, and an insignificant potential difference between the adjacent turns.

**LV winding taps** are rectangular buses or wires.

The **corrugated tank** of the transformer is made of high-grade steel (1.2 mm thick steel sheet) by automatic welding of corrugated-wall joints using a robotic installation by Motoman. The tank design provides for an oil drain plug. All tanks are subject to pressure test for 12 hours.

The **active part** is connected to the transformer cover to ensure its rapid installation and removal from the tank without disconnection of HV and LV bushings.

**Sealing gaskets** are made of rubber-plug-type composite material that has a longer service life than similar rubber elements, especially at negative temperatures.

The **switch design** provides clear fixation of voltage control steps, preventing any intermediate switch positions.

The **design of rollers and legs** makes it possible to move the transformer both in the longitudinal and lateral direction.

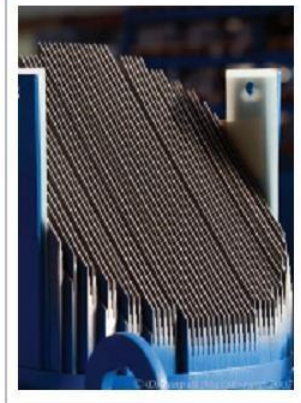
**Grounding** is made on both sides of the transformer.

The transformers are filled with treated degassed transformer oil (under vacuum) with a standard-gap dielectric strength of at least 45 kV.

## 1.4. Special offer

The special offer of "Transformer" includes low-loss cost-efficient transformers. For example, at full loading of the transformer TM(G)-1000, energy saving will be up to 1.3 kW per hour.

The plant also offers low-noise transformers TM(G)MSh.



## 1.5. Operating conditions

The transformer shall be operated in compliance with the Operation Manual of the manufacturing plant, the applicable Rules for Technical Operation, and the Electrical Installation Code.

Allowable overvoltages are +10 % of the rated voltage.

LV winding neutral bushings and taps of the transformers are designed for a continuous current load equal to 100 % of the rated LV winding phase current. Maximum allowable systematic loads and hazardous overloads of the transformer comply with the requirements of GOST 14209 and are specified in Tables 1 and 2.

The transformer allows for current surges. However, a ratio of load surge current to the rated one shall not exceed □

4.0 — in case of 3 current surges or less per day;

□ 2.0 — in case of 3 to 10 current surges per day;

□ 1.3 — in case of 100 to 1,000 current surges per day. The surge duration shall not exceed 15 s.

**Table 1. Allowable hazardous overloads without regard to the preceding load**

t, hour	Overload in rated current fractions, depending on the cooling-medium temperature at the time of overload							
	-25 °C	-20 °C	-10 °C	0 °C	10 °C	20 °C	30 °C	40 °C
0.5	2.0	1.9	1.7	1.7	1.7	1.5	1.4	1.3
1.0	1.9	1.9	1.7	1.7	1.6	1.4	1.3	1.3
2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.3
4.0	1.8	1.7	1.6	1.6	1.5	1.4	1.3	1.2

8.0	1.7	1.7	1.6	1.6	1.5	1.4	1.3	1.2
24.0	1.7	1.6	1.6	1.5	1.5	1.4	1.3	1.2



**Table 2. Allowable hazardous overloads without regard to the preceding load not exceeding 0.8 of the rated current**

t, hour	Overload in rated current fractions, depending on the cooling-medium temperature at the time of overload							
	-25 °C	-20 °C	-10 °C	0 °C	10 °C	20 °C	30 °C	40 °C
0.5	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8
1.0	2.0	2.0	2.0	2.0	1.9	1.8	1.8	1.7
2.0	2.0	2.0	1.9	1.9	1.8	1.7	1.6	1.5
4.0	1.9	1.8	1.7	1.7	1.6	1.5	1.4	1.3
8.0	1.7	1.7	1.6	1.6	1.5	1.4	1.3	1.2
24.0	1.7	1.7	1.5	1.5	1.5	1.4	1.2	1.2

## 1.6. Complete set

**The standard complete set of TM transformers (with a sealed type) is as follows:**

- a set of rollers;
- a metal-cased liquid-in-glass thermometer;
- an overpressure relief valve;
- surge tanks;
- a Buchholz relay—at a power up to 1,600 kVA (optional at a power over 1,600 kVA);

**The optional complete set of TM and TMG transformers (options) is as follows:**

- a set of rollers;
- a metal-cased liquid-in-glass thermometer;
- an overpressure relief valve;
- a float-type oil level indicator.
- a dial oil level indicator.
- brass contact terminals (for connection of buses and cables that are installed at a LV bushing of the transformer with a power of 32 kVA or more);
- vibration dampers (to reduce the noise level and vibrations generated during the transformer operation);
- a disruptive fuse (for protection of the LV winding against overvoltages generated in outgoing overhead lines);
- an electric contact thermometer (for remote control of temperature at upper oil layers);
- a pressure and vacuum gauge (for control of pressure inside the tank and protection of the transformer)—only for the TMG series;
- HV bushings may be completed with spark-gap switches to protect the transformer against lightning discharges when the device is installed outdoors in areas with a high thunderstorm activity.

Connecting wires for instrumentation are out of the scope of supply.

## 1.7. Packaging and transportation

The transformer is supplied as fully assembled, filled with transformer oil, and without any packaging. Upon the customer's request, the products may be packaged in transport containers (crates). The package type shall be agreed with the customer. For the period of transportation, insulators are protected against mechanical damage.

Instrumentation and signaling equipment not intended for operation under shaking and vibration conditions are not mounted at the transformer to be transported in the original package. Such equipment shall be installed by the customer.

The TM(G) transformers can be transported by any transport means, except for by sea, with mandatory keeping the transformer apart from the vehicle. The transformer shall be fastened at the vehicle so that to prevent its turnover, by means of ratchet straps or steel rods, with transport shackles located on the tank, with the shackles and straps not lying on the tank walls. To prevent lateral and longitudinal displacement, the transformer shall be kept apart by means of stop bars or spacer blocks attached to the vehicle floor (by nails, screws, bolts, etc.).

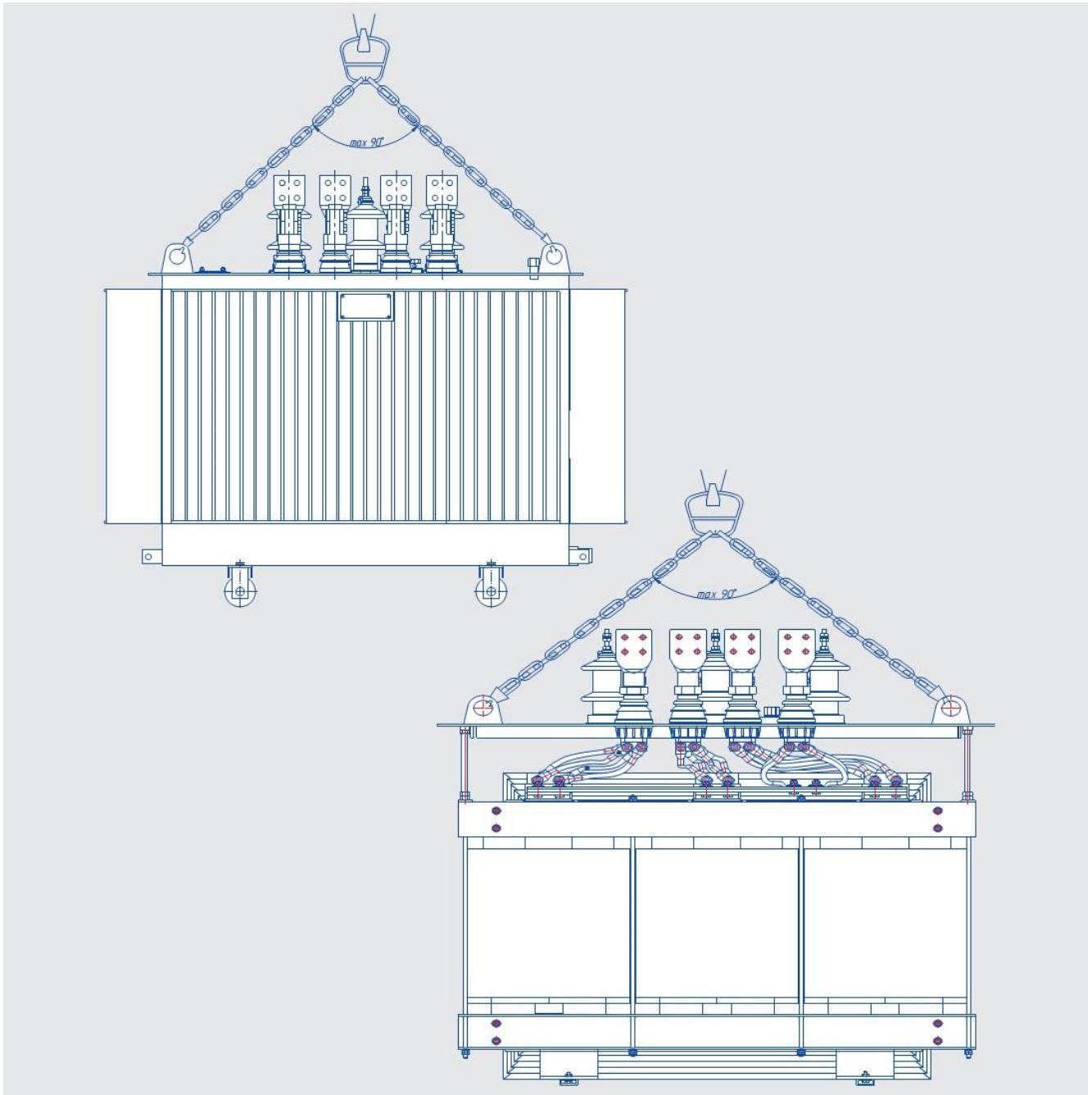
Transformer transportation conditions:

- in case of asphalt-surface roads (category 1 and 2)—to the distance up to 1,000 km with a speed of no higher than 80 km/h and to the distance of over 1,000 km with a speed of no higher than 70 m/h;

- in case of asphalt or concrete-surface roads (category 3)—to the distance up to 250 km with a speed of no higher than 70 km/h and to the distance of over 250 km with a speed of no higher than 60 km/h;
- in case of cobblestone and gravel roads (category 4)—to the distance up to 50 km with a speed of no higher than 40 km/h and to the distance of over 50 km with a speed of no higher than 30 km/h;
- transportation of the transformers by motor vehicles by category 5 soil roads with a speed higher than 30 km/h must not be allowed.

Hard braking and acceleration, excessive vibrations, and impact shocks during transportation on any roads must not be allowed.

### ■ Slings diagram for transformers TMG and the active part (during repair)



## 1.8. Warranty

Service life: **30 years**. The warranty period for transformers TM(G) is **5 years**.

The products are certified in accordance with the requirements of new GOST R 52719.

Experts of "Transformer" Production Group assist in issues of the product transportation to the installation site. Transportation services as well as transformer diagnostics, installation, and repair services are to be agreed by the parties on an individual basis.

## 1.9. Basic technical characteristics

Transformer type	TM, TMG
Power	16 to 10,000 kVA
Vector group	D/Yn-11, Y/Yn-0, Yn/D-11 others upon the customer's request
HV and LV winding material	aluminum/copper
Rated high voltage	(3, 6, 10, 20, 27.5, 35 kV)±2x2.5%
Rated low voltage	230V, 400V, 690V 6 kV, 10 kV
Rated value of climatic factors	U1, UKhL1 as per GOST 15150 and GOST 15543.1
Cooling	AN (natural)
Operation, transportation, and storage temperature	-45 to +40 °C for U1 -60 to +40 °C for UKhL1
Service life	30 years
Warranty period	up to 5 years
Regulatory documents	GOST R 52719, GOST 11677, GOST 30830 TU-3411-004-46854782-2007, TU-3411-005-46854782-2007

## Corrected sound power levels of TMG transformers

Transformer power, kVA	Corrected sound power level, no more than, Lpa, dBA	
	with normal noise level	with reduced noise level
16 to 63	68	50
100	59	52
160	62	54
250	65	56
400	68	58
630	70	62
800	72	64
1,000	73	65
1,250	74	67
1,600	75	68
2,000	76	69
2,500	76	70



## Power supply of normal-loss transformers TM(G) 6 kV, 10 kV, 20 kV

Power, kVA	Voltage		Winding circuit and vector group	U <sub>k</sub> , %	I <sub>xx</sub> , %	Losses, W			
	HV, kV	LV, V				x.x, W	short circuit, kW*		
16	6; 10	400 V 230 V 690 V kV* kV*	D/Yn-11 Y/Yn-0 Yn/D-11 Y/Zn-11	4.5	3.5	85	440		
25				5	3.5	115	720		
32	6; 10; 20			4.5	3.0	150	700		
40				5	3.0	155	920		
63	6; 10			4.7	1.6	220	1,280		
	20						1,330		
100	6; 10; 20			4.7	1.6	270	1,970		
160	6					410	2,700		
	10; 20						2,700		
250	6; 10; 20					4.5	1.2	530	3,850
400						4.5	1.2	870	5,600
630						5.5	1.2	1,240	7,600
800						5.5	1.0	1,370	9,600
1,000						5.5	1.0	1,600	10,800
1,250						6	1.0	1,800	12,400
1,600						6	0.6	2,100	16,500
2,000				6	0.5	2,600	24,000		
2,500				6	0.5	2,750	27,000		
3,200				6	0.5	3,500	36,000		
4,000			6	0.5	5,000	3,800			

## Power supply of low-noise transformers TM(G)MSh

Power, kVA	Voltage		Winding circuit and vector group	U <sub>k</sub> , %	I <sub>xx</sub> , %	Losses, W		
	HV, kV	LV, V				x.x, W	short circuit, kW*	
160	6	400 V 230 V 690 V kV* kV*	D/Yn-11 Y/Yn-0 Yn/D-11	4.5	1	320	2,650	
	10; 20						2,700	
250	6; 10; 20				4.5	0.8	425	3,700
400					4.5	0.8	600	5,600
630					5.5	0.8	800	7,600
800					5.5	0.8	1,100	9,600
1,000					5.5	0.6	1,250	10,800
1,600					6	0.3	1,500	16,500
2,000					6	0.3	2,000	23,000
2,300					6	0.3	2,300	27,000

## Power supply of low-loss transformers TM(G) 12

Power, kVA	Voltage		Winding circuit and vector group	U <sub>k</sub> , %	I <sub>xx</sub> , %	Losses, W	
	HV, kV	LV, V				x.x, W	short circuit, kW*
400	6; 10	400 V, 230 V	D/Yn-11 Y/Yn-0	4.5	0.8	610	4,600

1,000		690 V, kV* kV*		5.5	0.6	1,100	10,500
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### Overall and coupling dimensions of normal-loss transformers TM(G) of 6 kV, 10 kV, and 20 kV

Power, kVA	Overall dimensions											
	height				width				depth			
	H, mm	H1, mm	H2, mm	H3, mm	L, mm	A, mm	A2, mm	A3, mm	A1, mm	B, mm	b, mm	b1, mm
16	890	400	125	1,190	800	400	200	100	400	600	85	85
25	920	500	125	1,220	800	400	200	100	400	600	85	85
32	1,065	690	125	1,365	865	400	200	100	400	605	90	90
40	1,065	690	125	1,365	865	400	200	100	400	605	90	90
63	1,125	780	125	1,425	895	400	200	100	400	605	100	100
100	1,170	825	125	1,470	925	500	250	100	500	610	130	120
160	1,215	840	125	1,515	1,045	500	300	150	500	695	130	120
250	1,340	1,040	125	1,600	1,245	600	300	150	600	755	130	120
400	1,405	1,160	125	1,665	1,555	600	300	150	600	855	140	105
630	1,520	1,290	151.5	1,735	1,585	600	300	150	600	905	152	127
800	1,630	1,290	151.5	1,890	1,615	820	300	180	820	1,085	160	125
1,000	1,785	1,430	183	1,960	1,710	820	300	180	820	1,110	174	149
1,250	1,774	1,396	183	2,200	1,825	820	300	180	820	1,220	177	152
1,600	1,935	1,520	183	2,220	2,225	820	300	180	820	1,285	202	165
2,000	1,935	1,579	240	2,280	2,274	1,070	300	200	1,070	1,336	212	172
2,500	2,100	1,790	240	2,500	2,274	1,070	300	150	1,070	1,336	204	169

### Overall and coupling dimensions of low-noise transformers TM(G)MSh

Power, kVA	Overall dimensions											
	height				width				depth			
	H, mm	H1, mm	H2, mm	H3, mm	L, mm	A, mm	A2, mm	A3, mm	A1, mm	B, mm	b, mm	b1, mm
160	1,215	840	125	1,615	1,045	500	300	150	500	695	130	120
250	1,340	1,040	125	1,900	1,245	600	300	150	600	755	130	120
400	1,405	1,160	125	1,965	1,555	600	300	150	600	855	140	105
630	1,520	1,290	151.5	2,080	1,585	600	300	150	600	905	152	127
1,000	1,785	1,290	183	2,345	1,710	820	300	180	820	1,110	174	149
1,600	1,935	1,430	183	2,535	2,225	820	300	180	820	1,285	202	165

### Overall and coupling dimensions of low-loss transformers TM(G) 12

Power, kVA	Overall dimensions											
	height				width				depth			
	H, mm	H1, mm	H2, mm	H3, mm	L, mm	A, mm	A2, mm	A3, mm	A1, mm	B, mm	b, mm	b1, mm
400	1,405	1,160	125	1,965	1,555	600	300	150	600	855	140	105
1,000	1,785	1,430	183	2,345	1,710	820	300	180	820	1,110	174	149

### Weights of normal-loss transformers TM(G) of 6 kV, 10 kV, 20 kV

Power, kVA		Weight, kg
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	Voltage class, kV	active part	oil	gross TMG	gross TM
16	6; 10; 20	160	60	220	230
25		175	71	240	250
32		180	85	340	360
40		190	95	350	370
63		250	110	420	440
100		280	115	500	520
160		370	180	670	700
250		650	235	1,100	1,150
400		800	285	1,300	1,460
400		6; 10; 20; 35	870	455	1,600
630	6; 10; 20	1,050	415	1,850	1,895
800		1,200	530	2,180	2,270
1,000		1,400	620	2,600	2,710
1,250		1,550	820	2,900	3,020
1,600		1,950	950	3,650	3,800
2,000		2,050	1,150	4,200	4,370
2,500		2,450	1,490	5,650	5,880
2,500		6; 10; 20; 35	3,590	2,200	7,500
3,200	6; 10; 20	3,310	2,300	8,200	8,500
4,000		5,110	2,400	8,600	9,000

### Weights of low-noise transformers TM(G)MSH

Power, kVA	Weight, kg			
	active part	oil	gross TMG	gross TM
160	370	180	670	700
250	650	235	1,100	1,150
400	800	285	1,400	1,460
630	1,050	415	1,850	1,930
1,000	1,400	620	2,600	2,710
1,600	1,950	950	3,650	3,800

### Weights of low-loss transformers TM(G) 12

Power, kVA	Weight, kg			
	active part	oil	gross TMG	gross TM
400	800	350	1,400	1,460
1,000	1,400	650	2,600	2,710