DISTRIBUTION TRANSFORMER

Comprehensive solutions
from design to delivery

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TRANSFORMERS

Transformers are one of the primary components for the transmission and distribution of electrical energy. Their design results mainly from the range of application, the construction, the rated power and the voltage level. The scope of transformer types starts with generator transformers and ends with distribution transformers. Transformers from 100KVA to 2500KVA and up to 36kV on the high voltage side and 3.6kV on the low voltage side are referred as distribution transformers. In the last step, they distribute the electrical energy to the consumers by feeding from the high-voltage into the low-voltage distribution network. These are designed either as liquid-filled or as dry-type transformers. All transformers of higher ratings are classified as power transformers.

In addition, there are various special purpose transformers such as rectifier transformers, traction transformers which can be both in the range of power transformers and in the range of distribution transformers as far as rated power and rated voltage are concerned. Instrument transformers are available for high accuracy transformation of high current and high voltage levels down to low currents and low voltage outputs for measurement purposes. They are tailored to maintain reasonable accuracy even in extreme fault level conditions. TECHNO also manufactures variable autotransformers, which have a wide range of applications, including electronics testing. Variacs are low voltage autotransformers that provide a variable AC voltage.

The general overview of our manufacturing/ delivery program is shown in the table “Product Range”.

Standards and specifications, general

The transformers comply with the relevant IEC specifications. Therefore, they also satisfy the requirements of IS 2026, and standards and specifications (HD and EN) of the European Union (EU). Enquiries should be directed to the manufacturer where other standards and specifications are concerned. Only the US (ANSI/NEMA) and Canadian (CSA) standards differ from IEC by any substantial degree, however, a design according to these standards is also possible.

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ELECTRICAL DESIGN

POWER RATINGS AND TYPE OF COOLING

All power ratings in this guide are the product of rated voltage (times phase-factor for three-phase transformers) and rated current of the line side winding (at center tap, if several taps are rovided), expressed in kVA or MVA, as defined in IEC 76-1. If only one power rating and no coolingmethod are shown, natural oil-air cooling (ONAN or OA) is implied for oil-immersed transformers. If two ratings are shown, forced-air cooling (ONAF or FA) in one or two steps is applicable.

For cast resin transformers, natural air cooling (AN) is standard. Forced air cooling (AF) is also applicable.

Temperature rise

In accordance with IEC-76 the standard temperature rise for oil-immersed power and distribution transformers is:

65 K average winding temperature (measured by the resistance method)

60 K top oil temperature (measured by thermometer)

In accordance with IS 1180, reduced temperature rise transformers are also available.

The standard temperature rise for Energypac cast-resin transformers is

100 K (insulation class F) at HV and LV winding.

120 K (insulation class H) at HV and LV winding.

Whereby the standard ambient temperatures are defined as follows:

40 °C maximum temperature,

30 °C average on any one day,

20 °C average in any one year,

–25 °C lowest temperature outdoors,

–5 °C lowest temperature indoors.

Higher Ambient temperatures require a corresponding reduction in temperature rise, and thus affect price or rated power as follows:

1.5% surcharge for each 1K above standard temperature conditions, or

1.0% reduction of rated power for each 1K above standard temperature conditions.

These adjustment factors are applicable up to 15K above standard temperature conditions

Transformer losses and efficiencies

Losses and efficiencies stated in this guide are average values for guidance only. They are applicable if no loss evaluation figure is stated in the inquiry (see following chapter) and they are subject to the tolerances stated in IEC 76-1, namely +5% of the total losses, or +10% of each component loss, provided that the tolerance for the total losses is not exceeded.

If optimized and/or guaranteed losses without tolerances are required, this must be stated in the inquiry.

Altitude of installation

The transformers are suitable for operation at altitudes up to 1000 meters above sea level. Site altitudes above 1000 m necessitate the use of special designs and an increase/or a reduction of the transformer ratings as follows (approximate values):

- 2% increase for every 500 m altitude (or part there of) in excess of 1000 m, or
- 2% reduction of rated power for each 500 m altitude (or part there of) in excess of 1000 m.

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Connections and vector groups

Distribution
Transformers

The transformers listed in this guide are primarily three-phase transformers with one set of windings connected in star (wye) and the other one in delta, whereby the neutral of the star-connected winding is fully rated and brought to the outside. The primary winding (HV) is normally connected in delta, the secondary winding (LV) in wye. The electrical offset of the windings in respect to each other is either 30, 150 or 330 degrees standard (Dy1, Dy5, Dy11).
Details of autotransformers can be provided on request.

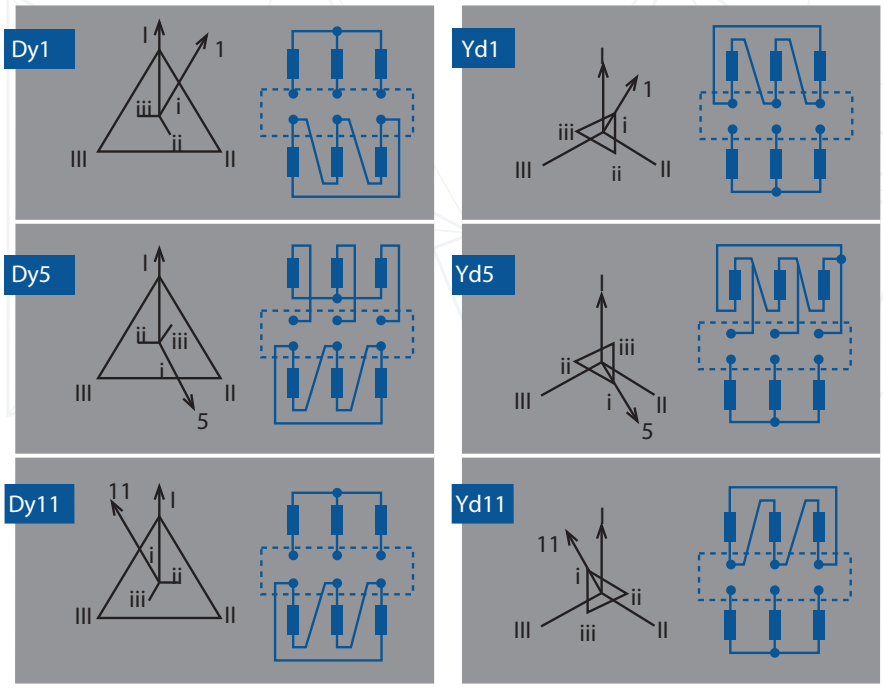


Fig.: Most commonly used vector groups

ELECTRICAL DESIGN

Insulation level

Power-frequency withstand voltages and lightning-impulse withstand voltages are in accordance with IEC 76-3, Para. 5, Table II, as follows:

Highest voltage for equipment U_m (r. m. s.)	Rated short duration powerfrequency withstand voltage (r. m. s.)	Rated lightning impulse withstand voltage (peak)	
		List 1	List 2
[kV]	[kV]	[kV]	[kV]
1.1	3	–	–
3.6	10	20	40
7.2	20	40	60
12	28	60	75
17.5	38	75	95
24	50	95	125
36	70	145	170
52	95	250	
72.5	140	325	
123	185	450	
145	230	550	
	275	650	
170	325	750	
	360	850	
245	395	950	

Higher test voltage withstand requirements must be stated in the inquiry and may result in a higher price.

Fig.: Insulation Level

Conversion to 60 Hz – possibilities

All ratings in the selection tables of this guide are based on 50 Hz operation.
For 60 Hz operation, the following options apply:

- Rated power and impedance voltage are increased by 10%, all other parameters remain identical.
- Rated power increases by 20%, but no-load losses increase by 30% and noise level increases by 3 dB, all other parameters remain identical (this lay out is not possible for cast-resin transformers).
- All technical data remain identical; price is reduced by 5%.
- Temperature rise is reduced by 10 K, load losses are reduced by 15%, all other parameters remain identical.

Overloading

Overloading of Energypac transformers is guided by the relevant IEC-354 " Loading guide for oil-immersed transformers" and the (similar) ANSI C57.92 "Guide for loading mineral-oil-immersed power transformers". Overloading of cast-resin transformers on request.

Routine and special tests

All transformers are subjected to the following routine tests in the factory:

- Measurement of winding resistance
- Measurement of voltage ratio and check of polarity or vector group
- Measurement of impedance voltage
- Measurement of load loss
- Measurement of no-load loss and no-load current
- Induced overvoltage withstand test
- Separate-source voltage withstand test
- Partial discharge test (only cast-resin transformers).

The following special tests are optional and must be specified in the inquiry:

- Lightning-impulse voltage test (LI test), full-wave and chopped-wave (specify)
- Partial discharge test
- Heat-run test at natural or forced cooling (specify)
- Noise level test
- Short-circuit test.

Test certificates are issued for all the above tests on request.

Transformer cell (indoor installation)

The transformer cell must have the necessary electrical clearances when an open air connection is used. The ventilation system must be large enough to fulfill the recommendations for the maximum temperatures according to IEC.

For larger power transformers either an oil/water cooling system has to be used or the oil/air cooler (radiator bank) has to be installed outside the transformer cell. In these cases a ventilation system has to be installed also to remove the heat caused by the convection of the transformer tank.

MECHANICAL DESIGN

General mechanical design for oil-immersed transformers:

Iron core made of grain-oriented electrical sheet steel insulated on both sides, core-type.

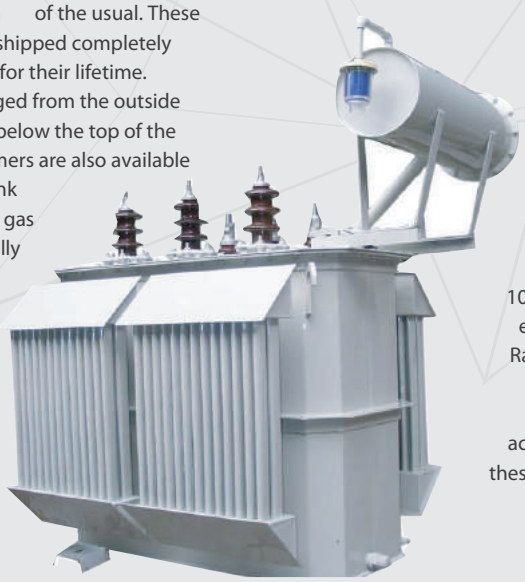
For oil-immersed transformers:

Iron core made of grain-oriented electrical sheet steel insulated on both sides, core-type.
Windings consisting of copper section wire or copper strip. The insulation has a high disruptive strength and is temperature resistant, thus guaranteeing a long service life.
Designed to withstand short circuit for at least 2 seconds (IEC).
Oil-filled tank designed as tank with strong corrugated walls or as radiator tank.
Transformer base with plain or flanged wheels (skid base available).
Cooling/insulation liquid: Mineral oil according to IEC 296. Silicone oil or biodegradable alternatives are available on request.
Standard coating for indoor installation. Coatings for outdoor installation and for special applications (e.g. aggressive atmosphere) are available.

Tank design

Corrugated fin tank distribution transformers

In ratings up to 3000KVA for 11kV and 6MVA for 33kV, the standard is corrugated fin tank transformers with conservator. The transformer is always completely filled with oil. Tanks are of the corrugated steel design, whereby the sidewalls are formed on automatic machines into integral cooling pockets. Suitable spot welds and braces render the required mechani cal stability. Tank bottom and cover are fabricated from rolled and welded steel plate. Conventional radiators are available. Oil expansion is taken up by the flexible corrugated steel tank (variable volume tank design), whereby the maximum operating pressure remains at only a fraction of the usual. These transformers are always shipped completely filled with oil and sealed for their lifetime. Bushings can be exchanged from the outside without draining the oil below the top of the active part. The transformers are also available in hermetically sealed tank without conservator and gas cushion. The hermetically sealed system prevents oxygen, nitrogen, or humidity from contact with the insulating oil. This improves the aging proper - ties of the oil to the extent that no maintenance is required on these transformers for their lifetime.



Detachable radioator type tank

This is the standard transformer design for all 11kV transformers from 3000kVA and all 36kV transformers from 7500kVA. The oil level in the tank and the top-mounted bushings is kept constant by a conservator vessel or expansion tank mounted at the highest point of the transformer. Oil-level changes due to thermal cycling affect the conservator only. The ambient air is prevented from direct contact with the insulating oil through oil traps and dehydrating breathers.

Power transformers

Power transformers of all ratings are equipped with conservators. Both the open and closed system are available. With the closed system the oil does not come into contact with the surrounding air. The oil expansion is compensated with an air bag. (This design is also available for greater distribution transformers on request). The sealing bag consists of strong nylon braid with a special double lining of ozon and oil-resistant nitrile rubber. The interior of this bag is in contact with the ambient air through a dehydrating breather; the outside of this bag is in direct contact with the oil. All tanks, radiators and conservators (incl. conservator with airbag) are designed for vacuum filling of the oil. For transformers with onload tap changers a separate smaller conservator is necessary for the diverter switch compartment. This separate conservator (without air bag) is normally an integrated part of the main conservator with its own magnetic oil level indicator. Power transformers up to 10MVA are fitted with weld-on radiators and are shipped extensively assembled; shipping conditions permitting. Ratings above 10 MVA require detachable radiators with individual butterfly valves, and partial dismantling of components for shipment. All the usual fittings and accessories for oil treatment, shipping and installation of these transformers are provided as standard. For monitoring and protective devices, see the listing on page 4/11.

CONNECTION SYSTEMS

Distribution transformers

All TECHNO transformers have top-mounted HV and LV bushings according to EN/DIN in their standard version. Besides the open bushing arrangement for direct connection of bare or insulated wires, three basic insulated termination systems are available:

Fully enclosed terminal box for cables

Available for either HV and LV side, or for both. Horizontally split design in degree of protection IP 44 or IP 54 (Totally enclosed and fully protected against contact with live parts, plus protection against drip, splash, or spray water). Cable installation through split cable glands and removable plates facing diagonally downwards. Optional conduit hubs. Suitable for single-core or three-phase cables with solid dielectric insulation, with or without stress cones. Multiple cables per phase are terminated on auxiliary bus structures attached to the bushings. Removal of transformer by simply bending back the cables.

Flange connection

Air-insulated bus ducts, insulated busbars, or throat-connected switchgear cubicles are connected via standardized flanges on steel terminal enclosures. These can accommodate either HV, LV, or both bushings. Fiberglass-reinforced epoxy partitions are available between HV and LV bushings if flange/flange arrangements are chosen. The following combinations of connection systems are possible besides open bushing arrangements:

HV	LV
Cable Box	Cable Box
Cable Box	Flange/throat
Flange	Cable Box
Flange	Flange/throat

Fig.: combinations of connection systems

Fig.: Terminal box for cables for distribution transformers

Power transformers

The most frequently used type of connection for transformers is the outdoor bushing. Depending on voltage, current, system conditions and transport requirements, the transformers will be supplied with bushings arranged vertically, horizontally or inclined. Up to about 110kV it is usual to use oil-filled bushings; condenser bushings are normally used for higher voltages. Limited space or other design considerations often make it necessary to connect cables directly to the transformer. For voltages up to 36kV air-filled cable boxes are used. For higher voltages the boxes are oil-filled. They may be attached to the tank cover or to its walls.

Fig.: High voltage transformer bushing

ACCESSORIES AND PROTECTIVE DEVICES

Buchholz relay

This is installed at a small angle (sloping from conservator to cover) between the conservator and the cover plate. Generally, isolating valves are provided on either side of the relay. A separate gas relay is provided for the conservator or partition for the on-load tap changer. The isolating valves help in opening or removal of the gas relay for inspection or maintenance purposes, without having to drain the oil from the conservator. The gas relay has alarm and trip contacts. The relay can be provided with a gas-sampling valve, which can be located at a convenient height for ease of use.

Fig.: Buchholz relay

Bushing & current transformers

Bushings for voltages less than or equal to 36 kV class are porcelain bushings but based on customer requirements, these can also be of the OIP type. For voltages above 36 kV, these are of the OIP type (oil impregnated paper). High current low voltage connections for core-coil assemblies are made with copper bus-bars, which are connected to the bushings by means of flexible risers. The terminations can be either on cover plate or on the sides of the tank. These can be housed in special cable boxes as per requirement.

Any specially required current transformers are housed either in separate turrets or on the cover plate or as part of the core-coil assembly. The secondary circuits of the current transformers are brought out in separate terminal boxes, from where the secondary is wired in to the marshalling box. The current transformers can either be for protection or for monitoring (for ammeters and temperature indicators).

Fig.: Bushing current transformers

All bushing current transformers provided are manufactured by Energypac unless otherwise requested by the customer.

Fig.: Dial type contact thermometer

Oil & winding temperature indicators

These are capillary dial type thermometers, the bulbs of which are immersed in oil filled thermometer pockets located on the cover plate. For the winding temperature indicator, the winding gradient is adjusted by means of thermal Imaging. This can be part of the thermometer pocket, which is heated by a resistance fed by representative current (through current transformer) or can be done externally by an adjustable shunt resistor, which is part of the temperature indicator. The temperature indicators are provided with alarm and trip contacts. They can also be provided with contacts for changeover from natural cooling to forced cooling (control of fans) at pre-determined temperatures.

Oil level gauge

This gives a clear visible indication of the oil level in the conservator. It is normal practice to use magnetic oil level gauges with low level alarm and trip contacts. This can also be of the plain glass or prismatic type. The oil level gauge is marked to indicate minimum, normal and maximum oil levels in the conservator (as a function of conservator capacity). The conservator (or partition) for on-load tap changer carries its own oil level gauge. For bigger units, it is our standard practice to fit a normal oil level gauge on the tank also.

Fig.: Oil level gauge

ACCESSORIES AND PROTECTIVE DEVICES

Dehydrating breather

This is to prevent ingress of moisture in to the conservation system, where air circulation is controlled by liquid seal and special re-chargeable moisture absorbing material. The volume of charge in the breather is a function of the oil quantity in the transformer. The breathers are located at convenient height for inspection and recharging. Separate breathers are provided for the conservator (or partition) of the on-load tap changer. The charge is placed in a visible container so that the changes in the colour of the charge are easily visible.

Self dehydrating breathers are also available on request.

Fig.: Dehydrating breather

Other accessories

1. Pressure relief device with or without contacts
2. Explosion vents with diaphragm
3. Bi-directional roller bases
4. Lightning arresters
5. Tap changer control panels
6. Remote measurement systems for temperature monitoring
7. Valves for oil filling, draining, filtering and sampling, with locking facility.

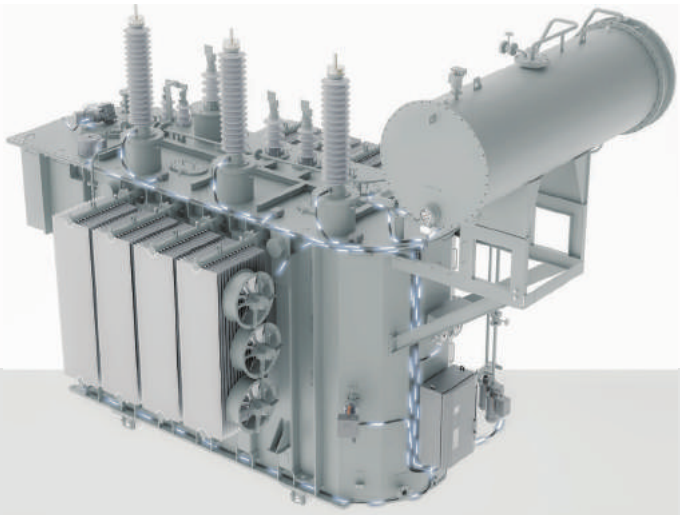


Fig.: Online dissolved gas monitoring system

Marshalling box

As the name implies, this is the master control panel for the protection devices. This is a panel with a door, part of which is with glass, allowing easy visibility of the instruments and their readings. This houses the indicating instruments. In addition, all the secondary wiring of the transformer from current transformers, relays, oil level gauges etc., are terminated on to terminal blocks, from which cables can be taken to the supply and control connections. The necessary control switches, contactors etc., are housed in this cabinet. The cabinet may be provided with heating and anti-condensation facility. The cabinet has a ventilation facility, which is protected against insect entry. The fixing is carried out with anti-vibration pads.

Fig.: Marshalling box

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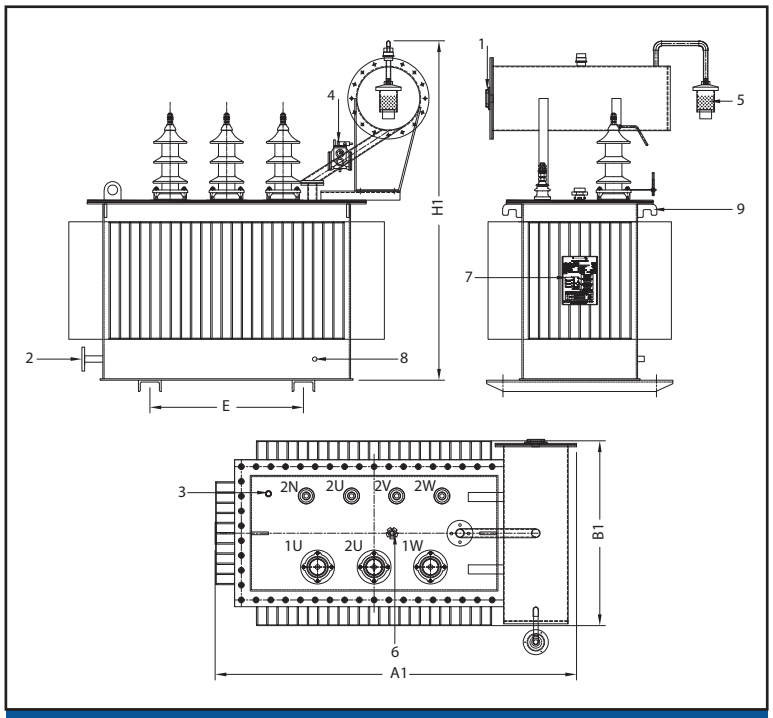
TECHNICAL DATA
DISTRIBUTION TRANSFORMERS, OIL FILLED



01. Oil level gauge
02. Oil drain plug
03. Thermometer pocket
04. Buchholz relay (optional extra)
05. Dehydrating breather (optional extra)
06. Adjustment for off-load tap changer
07. Rating plate (relocatable)
08. Grounding terminals
09. Lifting lug

Notes: Tank with strong corrugated walls shown in illustration is the preferred design for HV ratings up to 33/11kV and related power up to 6.25MVA and HV ratings > 11/0.415kV and related power up to 2500kVA. The conservator is fitted on the long side just above the LV bushings.

Fig.: Details of corrugated fin tank.

Oil-immersed three-phase distribution transformers

Standard:	DIN 42500
Rated power:	100–2500 kVA
Rated frequency:	50 Hz
HV rating:	up to 36 kV
Taps on	± 2.5% or ± 2 x 2.5%
HV side:	
LV rating:	400–720 V (special designs for up to 12 kV can be built)
Connection:	HV winding: delta LV winding: star (up to 100 kVA: zigzag)
Impedance	4% (only up to HV voltage at rated rating 24 kV
and current:	£ 630 kVA) or 6% (with rated power ³ 630 kVA or with HV rating > 24 kV)
Cooling:	ONAN
Protection class:	IP00
Final coating:	RAL 7033 (other colors are avea)ilabl

U_m	LI	AC
[kV]	[kV]	[kV]
1.1	–	3
12	75	28
24	125	50
36	170	70

LI Lightning-impulse test voltage
AC Power-frequency test voltage

Losses

The standard IS-1180 (= DIN 42500 Part 1) applies to three-phase oil-immersed distribution transformers 50 Hz, from 100kVA to 2500 kVA, up to 36kV. For total load losses (Pk), three different listings, level - I, II and III are specified. Transformers of this kind with additionally reduced losses are especially economical with energy (maximum efficiency > 99%). The higher costs of these transformers are counteracted by the energy savings which they make.

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TECHNICAL DATA

DISTRIBUTION TRANSFORMERS, OIL FILLED

UP TO 36 kV

Rated power [kVA]	Max. rated volt. HV side [kV]	Impedance voltage [%]	50% Load [W]	100% Load [W]	Material
100	12	4.5	435	1500	Copper
		4.5	475	1650	Copper
		4.5	520	1800	Copper
	24	4.5	455	1575	Copper
		4.5	500	1730	Copper
		4.5	545	1890	Copper
	36	4.5	470	1610	Copper
		4.5	510	1770	Copper
		4.5	560	1940	Copper
150	12	4.5	570	1700	Copper
		4.5	670	1950	Copper
		4.5	770	2200	Copper
	24	4.5	600	1790	Copper
		4.5	700	2050	Copper
		4.5	810	2300	Copper
	36	4.5	610	1830	Copper
		4.5	720	2100	Copper
		4.5	827	2370	Copper
200	12	4.5	670	2100	Copper
		4.5	780	2300	Copper
		4.5	890	2700	Copper
	24	4.5	705	2200	Copper
		4.5	820	2410	Copper
		4.5	935	2830	Copper
	36	4.5	720	2260	Copper
		4.5	840	2470	Copper
		4.5	955	2900	Copper

Fig.: Selection table of distribution transformer, oil filled 100 to 200kVA

*Available in aluminium windings as request.

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TECHNICAL DATA
DISTRIBUTION TRANSFORMERS, OIL FILLED
UP TO 36 kV

Rated power [kVA]	Max. rated volt. HV side [kV]	Impedance voltage [%]	50% Load [W]	100% Load [W]	Material
250	12	4.5	920	2700	Copper
		4.5	980	2930	Copper
		4.5	1050	3150	Copper
	24	4.5	966	2835	Copper
		4.5	1030	3075	Copper
		4.5	1100	3310	Copper
	36	4.5	990	2900	Copper
		4.5	1055	3150	Copper
		4.5	1130	3385	Copper
315	12	4.5	955	2750	Copper
		4.5	1025	3100	Copper
		4.5	1100	3275	Copper
	24	4.5	1000	2890	Copper
		4.5	1075	3255	Copper
		4.5	1155	3440	Copper
	36	4.5	1025	2960	Copper
		4.5	1100	3335	Copper
		4.5	1180	3520	Copper
400	12	4.5	1150	3330	Copper
		4.5	1225	3450	Copper
		4.5	1300	3875	Copper
	24	4.5	1205	3500	Copper
		4.5	1285	3620	Copper
		4.5	1365	4070	Copper
	36	4.5	1235	3580	Copper
		4.5	1315	3710	Copper
		4.5	1400	4170	Copper

Fig.: Selection table of distribution transformer, oil filled 250 to 400kVA

*Available in aluminium windings as request.

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TECHNICAL DATA
DISTRIBUTION TRANSFORMERS, OIL FILLED
UP TO 36 kV

Rated power [kVA]	Max. rated volt. HV side [kV]	Impedance voltage [%]	50% Load [W]	100% Load [W]	Material
500	12	4.5	1430	4100	Copper
		4.5	1510	4300	Copper
		4.5	1600	4750	Copper
	24	4.5	1500	4300	Copper
		4.5	1585	4515	Copper
		4.5	1680	4990	Copper
	36	4.5	1535	4405	Copper
		4.5	1625	4620	Copper
		4.5	1720	5110	Copper
630	12	4.5	1745	4850	Copper
		4.5	1860	5300	Copper
		4.5	2000	5855	Copper
	24	4.5	1835	5090	Copper
		4.5	1355	5565	Copper
		4.5	2100	6145	Copper
	36	4.5	1875	5210	Copper
		4.5	2000	5700	Copper
		4.5	2150	6290	Copper
800	12	4.5	1510	6050	Copper
		4.5	1600	6400	Copper
		4.5	1710	6855	Copper
	24	4.5	1585	6355	Copper
		4.5	1680	6720	Copper
		4.5	1795	7200	Copper
	36	4.5	1625	6500	Copper
		4.5	1720	6880	Copper
		4.5	1840	7370	Copper

Fig.: Selection table of distribution transformer, oil filled 500 to 800kVA

*Available in aluminium windings as request.

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TECHNICAL DATA

DISTRIBUTION TRANSFORMERS, OIL FILLED

UP TO 36 kV

Rated power [kVA]	Max. rated volt. HV side [kV]	Impedance voltage [%]	No-load losses [W]	Load losses [W]	Material
1000	12	5	2620	7000	Copper
		5	2790	7700	Copper
		5	3000	9000	Copper
		5	2800	10200	Copper
	24	5	2750	7350	Copper
		5	2930	8085	Copper
		5	3150	9450	Copper
	36	5	2815	7525	Copper
		5	3000	8280	Copper
		5	3225	9675	Copper
1250	12	5	3220	8400	Copper
		5	3300	9200	Copper
		5	3600	10750	Copper
	24	5	3380	8820	Copper
		5	3465	9660	Copper
		5	3780	11290	Copper
	36	5	3460	6500	Copper
		5	3550	6880	Copper
		5	3870	7370	Copper
1600	12	6.25	3970	11300	Copper
		6.25	4200	11800	Copper
		6.25	4500	13500	Copper
	24	6.25	4170	11865	Copper
		6.25	4410	12390	Copper
		6.25	4725	14175	Copper
	36	6.25	4270	12150	Copper
		6.25	4515	12685	Copper
		6.25	4840	14515	Copper

Fig.: Selection table of distribution transformer, oil filled 1000 to 1600kVA

*Available in aluminium windings as request.

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TECHNICAL DATA
DISTRIBUTION TRANSFORMERS, OIL FILLED
UP TO 36 kV

Rated power [kVA]	Max. rated volt. HV side [kV]	Impedance voltage [%]	No-load losses [W]	Load losses [W]	Material
2000	12	6.25	4790	14100	Copper
		6.25	5050	15000	Copper
		6.25	5400	17000	Copper
	24	6.25	5030	14800	Copper
		6.25	2300	15750	Copper
		6.25	5670	17850	Copper
	36	6.25	5150	15160	Copper
		6.25	5430	16130	Copper
		6.25	5805	18280	Copper
2500	12	6.25	5900	17500	Copper
		6.25	6150	18500	Copper
		6.25	6500	20000	Copper
	24	6.25	6195	18380	Copper
		6.25	6455	19430	Copper
		6.25	6825	21000	Copper
	36	6.25	6340	18810	Copper
		6.25	6610	19890	Copper
		6.25	6990	21500	Copper

Fig.: Selection table of distribution transformer, oil filled 2000 to 2500kVA

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