

ENERGOMONT

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Production of power transformers

Decade of experience in repairing of power distribution transformers and repairing substations resulted as a decision to start to produce power distribution transformers. The production of transformers is carried out in accordance to SRPS EN 60076 standard.

The production of power distribution transformers is made of several steps:

- Projecting
- Production of magnetic core of power transformer and transformer tank
- Production of primary (high-voltage) and secondary (low-voltage) windings
- Mounting (assembly) of power transformer
- Final examination
- Making technical documentation and preparing for delivery



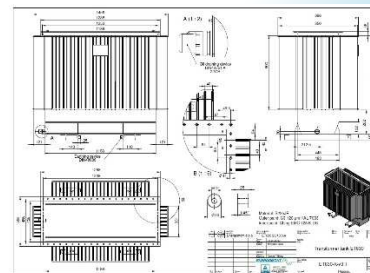
With the sophisticated software tools the following elements of power transformers were made:

- Core and yoke
- Primary (high-voltage) windings
- Secondary (low-voltage) windings
- Transformer tank (tank with radiator and cover of tank)



Making of workshop drawings:

- Making of drawings of all elements which are defined by the calculation
- Scheme of relations inside the transformer tank (connecting the endings of windings with tap changer and connecting flags with high-voltage and low-voltage)
- Position of elements on cover of transformer tank
- Drawings of all helping elements for fixing the active part of power transformer

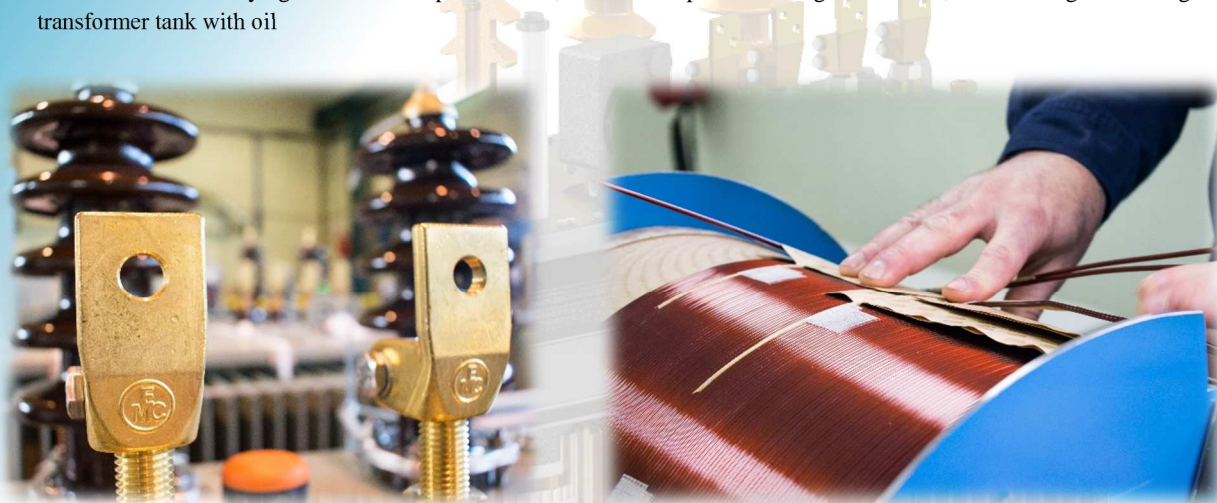


For the production of windings, we use TUBOLY machines, which can produce a large number of windings at high speed.



Mounting (assembly) of power transformer is made of several elements:

- Thermal treatment of primary and/or secondary windings before putting on a core, in order to make a thermal processing of isolated materials in a defined way (if needed)
- Putting high-voltage and low-voltage windings on a core and fixing of windings and yoke of magnetic core, connecting the connecting of windings, over the connecting flags
- Mounting the cover of the tank, mounting of elements on the cover of the tank (isolators, seals, flags...)
- Vacuum drying of the active part of transformer – this is one the most important elements in the mounting phase, in other words, this process guarantees a safe and long term exploitation of power transformer in normal circumstances in a plant without disorder. Energomont has a vacuum dryer in which the vacuum level and the temperature is regulated. All this is managed by SCADA and PLC. Every processed power transformer has a graphic documentation which is a proof that the process of vacuum drying is made by the provided technology. This document can be shown to the purchaser if needed
- Transformer oil processing by vacuum drying with storing in controlled conditions (before filling the transformer oil in the tank, tgδ of the oil is measured and after confirmation of correctness, the permission is given for filling the transformer tank)
- When the vacuum drying of the active part is done, the next step is mounting in the tank, then sealing and filling the transformer tank with oil



Final examination is the verification of the project values with the certificate that the power transformer works correct. The examination consists of the following steps:

- Measuring of winding resistance, measuring of transformation ratio, measuring of turns ratio, as much as the detection of compound (Analyzer of windings Tettex 2293)
- Measuring of insulation resistance of the windings (Teraohm 5kV Metrel)
- Measuring of breakdown voltage of transformer oil (OTS80PB Megger)
- Measuring of tgδ of transformer oil (MIDAS micro 2883)
- The testing station performs the following:
 - No load testing
 - Short circuit testing
 - External voltage testing $2U_n + 10kV$
 - Inter-bandage test (200Hz)
- Heating testing (Analyzer of windings Tettex 2293) - this belongs to testing the types but Energomont carries out this test on every new unit



Beside the complete transformer production, complete documentation is done, technical description of details, preparation of documents for the final user. Energomont has the complete documentation of interfacial calculation of every single power transformer, complete documentation of drying process (diagram records from SCADA), all the experiments performed, which can be shown to the user if needed. Beside the complete documentation, the final user gets the guarantee for every new power transformer for a period of 24 months with a lifetime service and repair for the territory of Serbia Republic.

Three-phase oil power transformer 160kVA

Manufacturer	Energomont		
Type	ETR1 160-IEC		
Power	Sn	160	kVA
Voltage	U ₁ / U ₂₀	20 / 0.42	kV
Current	I ₁ / I ₂	4.62 / 220	A
Short circuit voltage	u _k	3.80	%
Short circuit losses	P _k	2000	W
No load current	I ₀	0.84	%
No load losses	P ₀	300	W

Three-phase oil power transformer 250kVA

Manufacturer	Energomont		
Type	ETR1 250-IEC		
Power	Sn	250	kVA
Voltage	U ₁ / U ₂₀	20 / 0.42	kV
Current	I ₁ / I ₂	7.22 / 344	A
Short circuit voltage	u _k	4.0	%
Short circuit losses	P _k	2750	W
No load current	I ₀	0.46	%
No load losses	P ₀	425	W

Three-phase oil power transformer 400kVA

Manufacturer	Energomont		
Type	ETR1 400-IEC		
Power	Sn	400	kVA
Voltage	U ₁ / U ₂₀	20 / 0.42	kV
Current	I ₁ / I ₂	11.54 / 549	A
Short circuit voltage	u _k	4.0	%
Short circuit losses	P _k	3850	W
No load current	I ₀	0.41	%
No load losses	P ₀	610	W

Three-phase oil power transformer 630kVA

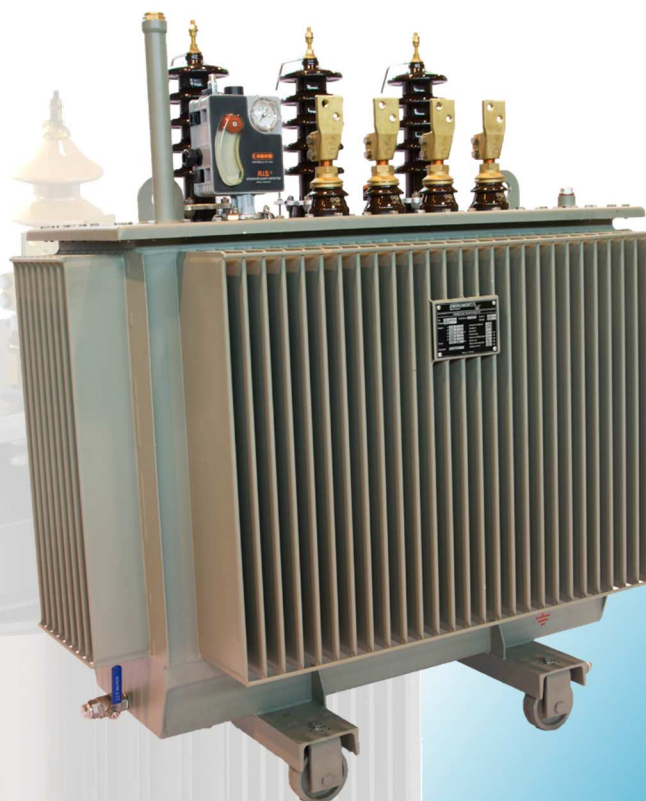
Manufacturer	Energomont		
Type	ETR1 630-IEC		
Power	Sn	630	kVA
Voltage	U ₁ / U ₂₀	20 / 0.42	kV
Current	I ₁ / I ₂	18.19 / 866	A
Short circuit voltage	u _k	4.0	%
Short circuit losses	P _k	5400	W
No load current	I ₀	0.41	%
No load losses	P ₀	860	W



Three-phase oil power transformer 1000kVA			
Manufacturer	Energomont		
Type	ETR1 1000-IEC		
Power	Sn	1000	kVA
Voltage	U ₁ / U ₂₀	20 / 0.42	kV
Current	I ₁ / I ₂	28.8 / 1374.6	A
Short circuit voltage	u _k	5.7	%
Short circuit losses	P _k	9000	W
No load current	I ₀	0.29	%
No load losses	P ₀	1100	W

Three-phase oil power transformer 1250kVA			
Manufacturer	Energomont		
Type	ETR1 1250-IEC		
Power	Sn	1250	kVA
Voltage	U ₁ / U ₂₀	20 / 0.42	kV
Current	I ₁ / I ₂	36.08 / 1718.30	A
Short circuit voltage	u _k	6.0	%
Short circuit losses	P _k	11000	W
No load current	I ₀	0.8	%
No load losses	P ₀	1350	W

Three-phase oil power transformer 1600kVA			
Manufacturer	Energomont		
Type	ETR1 1600-IEC		
Power	Sn	1600	kVA
Voltage	U ₁ / U ₂₀	20 / 0.42	kV
Current	I ₁ / I ₂	46.19 / 2199.43	A
Short circuit voltage	u _k	6.0	%
Short circuit losses	P _k	14000	W
No load current	I ₀	0.8	%
No load losses	P ₀	1700	W



Our distributive transformer has an official certificate issued by the national institute for research, development and testing in the field of electrical engineering.

The product is in compliance with applicable EU standards.

In addition to the distribution power transformers, Energomont LTD can also respond to special requirements for power transformers up to 2 MVA.

Repair and service of power transformer

Reparation of distribution substations consists of a set of operations in order to check the functionality of every element which is in the station, checking the electrical values and detection of all the disorders by which preventive removal comes to a reliable energy image of each object.

No matter what is the cause the power transformer came on service in Energomont, the process of repairing is always the same but the number of operations taken depends on the type of the failure:

- After the power transformer is brought on service, first a visual inspection is performed, after that special receive- checklists are fulfilled
- Cleaning of the power transformer exterior is performed
- In the testing station, testing and diagnosis of the fault degree and the damage cause are performed (The equipment for testing the power transformer is defined more detailed in the testing station chapter)

After the diagnosis of the failure, the way of repair is determined, which contains the following:

- The oil from the transformer vessel is taken to the provided place, the active part of power transformer is taken out from the tank and a visual inspection of the condition of the active part and the inside is performed
- The oil and the vessel are further treated in the way to be prepared for the refill of transformer tank (the inside of the tank is cleaned and the oil filtering is performed, after that it is stored if the quality is satisfying)
- Failure removal on the inside of the power transformer is performed:
 - Re-winding of one or all three, primary windings
 - Re-winding of one or all three, secondary windings
 - Removal of any physical damage on elements for fixing or yoke
 - Replacing of any of the elements for fixture of winding on the core, if there is a damage on any of it
 - Replacing of the tap changer



When the needed activity is performed, an interfacial examination of the active part is performed – measuring the resistance of windings, turns ratio and phase shifts. If the active part of power transformer is correct, on every power transformer which is brought to the standard service, the following activities are taken:

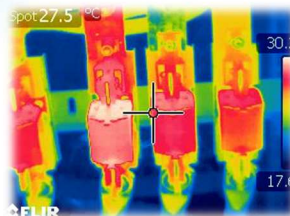
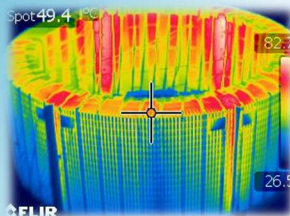
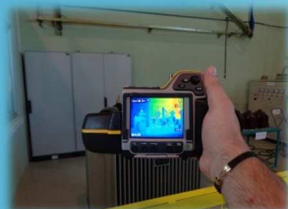
- Drying of the active part of power transformer in vacuum dryer. Vacuum drying of the active part is performed by the control of the vacuum level and the control of the temperature while vacuum drying of the active part is performed. The whole process of the drying is carried out in a special device which is created for this purpose and the whole process of the drying is performed over SCADA and PLC. The role of the operator is only monitoring the process and controlling. Vacuum drying is performed in stages by predefined protocol and a process of such drying lasts 72 hours
- After the vacuum drying of the active part of power transformer is done, setting the active part and oil filling in the transformer tank is carried out by vacuum technique so that air bubbles would not be captured in the transformer tank, which can cause big problems (a set of new seals are placed before filling)
- After the filling, final examination is performed which contains the following:
 - Measuring of resistance and transformation-phase shift relation
 - Measuring the isolation resist of windings
 - Measuring of breakdown voltage of transformer oil
 - The testing station performs the following:
 - No load testing
 - Short circuit testing
 - External voltage testing $2U_n + 10kV$
 - Inter-bandage test (200Hz)
- If all obtained values are within acceptable limits, power transformer is transported to be painted and on final preparation for delivery
- Preparing the testreport with all the values of measurements



Every repaired transformer besides the documentation gets also the guarantee for all the works done.

Thermography

Energomont Ltd. has its trained staff with the needed certificates, for work with thermo camera and for processing the received datas.



Device for relay testing SVERKER 780

Sverker 780 is primarily used for testing the protective equipment, but can also be used for different kinds of testings and moderatings. With Sverker it is possible to test all the single phases relay equipment where it is not necessary to change the frequency.

With Sverker 780 it is also possible to test the three-phase relay protective devices by testing every phase. Besides that, many protective relay systems which require phase shifting, can be tested with this device.



ODEN AT/3X

ODEN AT/3X is designed for using in high-voltage stations and industrial plants as much as for laboratory exams.

ODEN AT/3X is primarily designed for:

- Testing relay equipment (primary exams)
- Testing switch with overload breaker
- Testing turns ratio of current transformer
- Testing turns polarity of current transformer

ODEN AT/3X can generate huge currents on its output, continuous current max. 4000A and current from 8000A in 3 seconds lasting.



Power analyzer CIRKUTOR ARL-5

The term “Power analyzer” is related to special measuring instruments which are provided for measuring different parameters of electrical networks. In general, these are digital microscopic instruments which from samples of voltage and currents counts effective values of voltage and current, active and reactive power, as much as more harmonious components of electrical values. It is a power analyzer of mobile equipment which has its own memory and allows data to be transferred by serial connection on personal computer for further analyze.



Eight-channel precision power analyzer LMG 500

Voltages and currents can be measured in wide dynamic scope which makes it proper for all professional measurings. Instrument has a characteristic that with a properly selected filter, it suppresses the harmonics of high value, and in this way, when measuring, it takes into account only the basic harmonics from network, which provides accuracy and reliability of measuring.

This device is one of the most important measuring elements in testing station because it has high accuracy of measured values at low power factor (lower than 0.1).



Analyzer of windings TETTEX 2293

When testing a power transformer Analyzer of windings Tettex 2293 is used for:

- Measuring ohmic resistance of windings
- Measuring turns ratio
- Detection of connections
- Demagnetization of core
- Experiment of transformer heating



Measuring of breakdown voltage of oil Megger OTS80PB

Megger OTS80PB device is used for measuring of breakdown voltage of transformer oil, in other words, penetrability.

Every sample of power transformer oil during the repair, the revision or the assembly of a new power transformer goes under control of this instrument. This instrument is autonomous and also suitable for field measurements.



System for diagnosis and analyze of isolation MIDAS micro 2883

MIDAS micro 2883 device is used for measuring $\tan \delta$ of isolation in power transformers in order to determine the quality of the isolation. This instrument has a special addition for measuring $\tan \delta$ of isolation in power transformer.

This is a very sophisticated instrument which can show the quality of the isolation of windings, in other words, the level of obsolescence, in case of a power transformer which was already in plant. Furthermore, maybe an even more important element of this instrument is an addition which is used for measuring $\tan \delta$ of oil. Every sample of oil which is planned for filling the transformer tank, whether it is a new or repaired power transformer, it has to undergo measuring $\tan \delta$ oil, in order not to disturb the quality of the dried active part and the entire power transformer.



Stable testing station of distribution power transformer IS-01-15

The company owns a testing station which is designed based on many years of experience, research and developing on this field.

Types and methods of measuring satisfy all the regulatory requirements for making reports about the quality of power transformer.

The experiment items can be distribution power transformers from 50kVA to 1600kVA, voltage level 20/10/0.4kV.

Most important elements of the testing station are:

- Three-phase regulatory transformer with servo regulation of power 100kVA, with a possibility of output voltage regulation 0V - 450V, $I_n = 150A$. There is a possibility of voltage regulation by phase
- Stabilization of output voltage is solved with PLC regulation
- Oiled cooled measuring transformer is designed and made with turns ratio 1:3, power 100kVA
- The source of testing voltage of 200Hz with a regulation scope 0V - 800V is provided with a rotation generator
- The source of external voltage is a monophas high-voltage oil transformer with voltage 0.23/35 /70kV, rated power of 20kVA
- For special measurings at heat testing, a rotate regulation transformer is used with a braked rotor and forced cooling voltage range of 10V - 800V, $I = 200A$, and dry measuring transformer of turns ratio 1:2, $I = 200A$

Siemens PLC runs the testing station with Siemens WinCC SCADA system. The measuring process is displayed on SCADA from devices in network PAC4200 analyzer and LMG500 power analyzer. There is a database of measurements with reports on the computer.

The work of testing station manages the PLC device with a software from its own development.

Testings consists of standard, and also specialized measurings by using the modern highly precised instruments.

Standard measurings:

- Measuring of no load losses P_0
- Measuring of short circuit losses P_k

It is important to mention that these two measurings are done by a specialized precise wattmeter.

- ZES ZIMMER - Multiphase Precision Power Meter LMG500

In addition to numerous benefits for measuring of this type, the mentioned instrument has the possibilities of measuring at very low $\cos \varphi$ (< 0.1)

- Testing external voltage (max. 70kV)
- Testing induced voltage (200Hz)
- Measuring resistance of windings (Analyzer of windings 2293 Tettex instruments)
- Detection of type of connection (Analyzer of windings 2293 Tettex instruments)
- Measuring of turns ratio (Analyzer of windings 2293 Tettex instruments)
- Measuring of breakdown voltage of transformer oil (Aut. test. Of breakdown voltage of Transformer oil OTS 80 PB Megger)
- Measuring of isolation resistance (by 5kV METREL measing scope TΩ)
- Machine for oil filtering (two-leveled vacuum filter of transformer oil ZYD-30 2000 l/h)

Besides these standard measurings, we also carry out specialized measuring on power transformers:

- Experiment of heating and cooling
- Measuring of the angle of losses $\tan \delta$ (MIDAS Micro 2883, measuring of resistance isolated windings also in field conditions)



Transport

Vehicles of Energomont in addition to passenger cars has a multi-purpose trucks by which the company is ready to respond to various challenges that arise in the present business.

List of trucks in Energomont Ltd:

- Truck brand Volvo, type FH 42 T, with a semitrailer brand Schwarzmuller, type S1
- Truck brand Man, type 26.413 FNLC, with a trailer brand Wecom, type AWZ 218 LZ
- Truck with a mechanical arm brand Iveco, type EURO CARGO ML 180E25
- Truck/van brand Mercedes, type SPRINTER 208D
- Passenger car brand Peugeot, type PARTNER TEPEE



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