

# HIGH-VOLTAGE TRANSFORMERS



POWER GRIDS

# POWER MACHINES

is the largest power plant engineering company in Russia, possessing international experience and competence in the field of design, production and complete delivery of equipment for thermal, nuclear and hydraulic power plants.

Power Machines develops efficient integrated projects for the world electric power industry on the basis of the 150-year experience of the company's production plants and applying the latest achievements in science and technology.

Power Machines combines:

- the largest production assets with international references and unique experience in development, manufacture, installation and service of produced equipment;
- joint ventures for production of power equipment established in cooperation with international corporations Siemens and Toshiba;
- strongest design and engineering centers.

- Equipment produced at the plants of Power Machines is installed and operates

IN 57 COUNTRIES OF THE WORLD



65% SHARE

of Russian and CIS countries' market



OVER 300 GW

of installed capacity



[WWW.POWER-M.RU](http://WWW.POWER-M.RU)

## ABOUT COMPANY



**SMTT High-Voltage Solutions LLC**, is an enterprise that is part of LLC NordEnergogroup.

The plant for the production of power transformers has been constructed in Metallostroy industrial area (Kolpinsky district of Saint Petersburg).

The full-cycle production comprises blanking and welding, assembly, warehousing, winding and insulation shops, as well as the test center.

The technology level of production shop, which is fitted out with equipment of the world's leading producers, meets the highest world standards.

The plant was put into operation at the end of 2013; the full-scale production was launched in 2014.

**25,000 sq. m.**

--- total area of the plant

**MORE THAN 10,000 MVA  
PER YEAR**

--- production capacity of the plant

The capabilities of the enterprise allow to solve the task of complex modernization of the electricity transmission network of Russia and CIS countries, using the most advanced and innovative technologies.





## PRODUCTS & SERVICES



### Products:

- 110-750 kV power transformers;
- 220-750 kV autotransformers.

### Services

The service center provides comprehensive services for the supplied equipment:

- technical supervision of installation, tests, commissioning and putting into operation of transformers within the warranty period;
- engineering supervision over the produced equipment during its whole operation life;
- installation of transformers as part of turnkey contracts;
- technical supervision of repair works;
- supply of spare parts;
- technical supervision of diagnostics;
- diagnostics of power transformers as part of turnkey contracts;
- gathering and analysis of information concerning the condition of transformer fleet;
- participation in investigation of disturbances, failures and accidents of transformers;
- oil analyses in the plant laboratory in order to monitor the condition of power transformers during the whole period of operation;
- provision of technical maintenance training to customer personnel.

## COMPANY'S ADVANTAGES

The plant has been established by two world's leading power engineering companies, Power Machines and Toshiba Corporation, possessing a long track record of successful business, as well as production and development potential.

Quality control and technical policy have been jointly defined by Russian and Japanese ("Toshiba") standards.

Application of advanced design and production practices, implementation of a strict quality management system enable the joint venture to ensure manufacturing of reliable products with high operational characteristics.

# TECHNOLOGY FEATURES AND ADVANTAGES

## Magnetic systems

### Technologies

Transformer magnetic cores are manufactured on the most advanced and fully automated cutting and stacking lines for electrical steel by Georg (Germany), which also eliminate manual stacking and enable an efficient use of electrical steel.

Cut core legs are uniformly clamped by a binding clamp method, impregnated with insulating resin and subsequently heat treated. As a result, the magnetic system is assembled without stacking the upper yoke with previously assembled core legs, thus significantly reducing the level of mechanical stress on core plates.

Modern types of electrical steel are used for manufacturing magnetic cores. Prior to being used in production, electrical steel is tested in the plant laboratory for compliance with electrical behaviour and insulation characteristics stated by manufacturing plant.

### Results

- reduction of product costs;
- improvement in the efficiency of transformer;
- decrease in construction dimensions;
- long-lasting operational life;
- reduction in noise level;
- compliance to rules and quality standards of the plant ensures failure-free operation of manufactured products.



## Insulation

### Technologies

The installed modern technological equipment, including a milling machining center and a throughfeed planer moulder produced by SCM Group s.p.a. (Italy), allow to produce a wide range of insulating parts with improved quality and accuracy characteristics.

The use of low-shrinkage thick cardboard sheets and wood laminates of the leading global manufacturers alongside with the high finish accuracy of automated

processing centers enables to achieve high quality and assembling accuracy of complex insulating components during the manufacture of transformer windings and assembly of active parts, and also ensures increased electrodynamic resistance.

### Results

- improvement of reliability and providing stable functioning of insulation;
- assurance of reliability and service durability of insulation.



## Windings

### Technologies

The use of modern vertical CNC winding machines as well as horizontal winding machines produced by L.a.e. (Italy) and fitted with accessories for decoiling, wire tensioning control, separate axial and radial pressing with preset force, ensures the production of windings of all types and designs with consistently high quality.

The windings are dried in vacuum drying cabinets produced by HEDRICH (Germany) using the technology of cyclic vacuuming at the stage of heating-up under a specific isostatic pressure. Manufacturing of windings is carried out in production premises with controlled humidity and temperature where dust content is constantly controlled.

### Results

- significant reduction of human mistake factor during the production of windings;
- reduction of manufacturing complexity;
- stabilization of solid winding insulation;
- ensuring high quality and reliability of windings by preventing intrusion of dust and foreign particles;
- ensuring necessary geometric height of each winding, and prevention of its dimensional change due to moisture absorption.



## Active parts

### Technologies

Unit assembly of windings as well as the first and the second assembly of transformers is carried out in special clean rooms where dust content is controlled. Assembly works are performed with the use of lightweight mechanical racks which facilitate the mobility of production. In-shop transportation is carried out with air cushion platforms. Assembly of electrical scheme of transformer active parts is carried with the wire forming and

crimping equipment, which allows 100% control of all nondetachable connections. Drying of active parts of transformers is carried out in vacuum chambers produced by HEDRICH (Germany), using the technology of vapour-phase drying with cyclic vacuum evaporation, under isostatic pressure on windings during drying.

### Results

- assurance of a better quality in a shorter time;
- elimination of necessity to carry out overhauls of transformers after 12-15 years of operation, ensuring repair-free service life of transformers within at least 30 years;
- reduction of moisture content in the transformer insulation (less than 0,3%);
- shortening of duration of the drying process;
- ensuring stabilization of solid insulation of active parts;
- reduced duration of stay of the active part in the open air at the stage of final assembly of the transformer.





# Tank

## Technologies

Advanced equipment is used throughout the manufacturing of transformer tank metal structure:

- CNC plasma cutter;
- equipment for bar sections cutting;
- CNC machines for precise bending of sheet metal and tubes of circular cross-section;
- drilling-and-milling machines and lathes for mechanical parts processing.

Welding works are carried out with:

- gas-shielded welding machines for welding with consumable and non-consumable electrode;
- mechanical units for welding of round and longitudinal seams.

Preparation and application of a coating on metal structures is performed in modern shot blasting chambers and painting-drying chambers.

## Results

- precise manufacturing of component parts of transformer tank;
- high-quality manufacturing of welded metal structures;
- reliable coating, preserving the appearance for the whole service life.



# Tests

## Technologies

Computer-aided measurement systems are applied at all stages of testing.

The test center is equipped with a powerful capacitor bank, high-voltage pulse generator and a powerful frequency converter with a frequency range of up to 50-200 Hz.

Installed systems enable to carry out high-voltage impulse testing, routine tests and heat-run tests. Test center is accredited by Federal Accreditation Service of Russia for technical competence, independence and compliance with GOST ISO / IEC 17025-2009.

## Results

- product quality improvement;
- increase of measurement accuracy;
- increase of product reliability.



# Components and materials

## Technologies

- HV bushings with RIP insulation;
- on-load tap changers with vacuum contacts;
  - maintenance-free air dryers;
  - quality fastening with hot dip galvanizing.

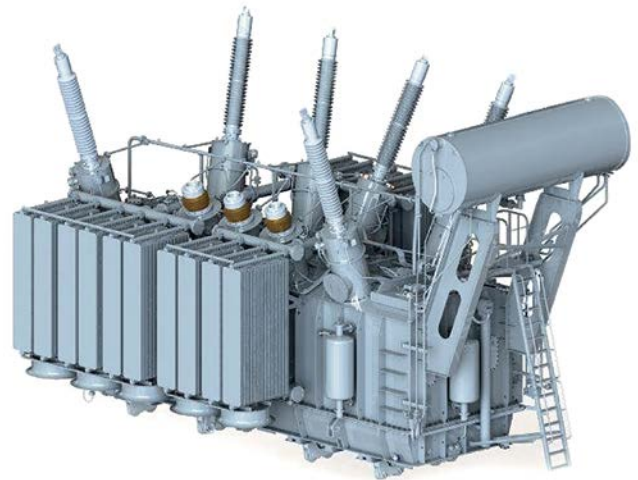
## Results

- the rated operation life of parts exceeds 30 years

LLC "SMTT. High-voltage solutions" is an enterprise in which quality control and technical policy are defined jointly by Russian and Japanese standards.

## Design

- Deep analysis of the terms of reference is standardized **in collaboration with Japanese experts**.
- Calculations of the transformer are performed in **the Toshiba software package**.
- Design in the SolidWorks environment according to **Toshiba design standards** with the creation of a 3D model of the transformer.
- The assembly of large assemblies in 3D is **automated** to eliminate the human factor.
- Development of such a unique solution for the Russian market as **a phase-shifting transformer**.



## Components

- SMTT uses components and materials according to GOST and IEC and **excluding a resource reduction transformer**.

## Production

- The production of transformers is carried out in a full cycle on modern equipment in **strict accordance with the design documentation**. Implemented 5S system.

## Quality control

- Double control of all stages of design, production and materials, which supplied to the enterprise.
- SMTT is licensed to design and manufacture equipment for the nuclear power industry.

## Tests

- The test center is equipped with a powerful capacitor bank, a high-voltage pulse generator, and a powerful frequency converter ranging from 50 to 200 Hz.
- The installed systems allow performing high-voltage impulse tests, acceptance-pass tests and heating tests.
- The use of **computerized measurement systems** at all stages of testing increases the accuracy of the measurement processes.



# QUALITY ASSURANCE AND QUALITY CONTROL

The quality management system of SMTT High-Voltage Solutions meets the requirements of the international standard ISO 9001:2015 and Russian national standard GOST R ISO 9001-2015.

Quality management system of the company is based on the principles which have been elaborated and successfully applied in the production process of Toshiba Corporation for decades.

The company has obtained the licenses for design and manufacture of equipment for nuclear power plants.



The company has an on-site test center and laboratory.

The fully automated test center enables to carry out full-scale type and routine tests of transformers with voltage ratings of up to 750 kV.

The company's laboratory is equipped with the newest measuring equipment, which provides test performance at the top technical level, with high degree of processes automation.



# PRODUCTS

## 1. 110-150 kV voltage class

<b>1.1. Series of two-winding transformers with split low-voltage windings (TRDN type in accordance with the technical requirements of GOST 12965)</b>	
Standard range of capacity, MVA	25, 40, 63, 80, 100, 125
Low-voltage (LV), kV	6.3, 6.6, 10.5, 11.0, 38.5
Cooling system	ONAN (Oil Natural), RUS: M ONAF (Oil Natural Air Forced), RUS: Д OFAF (Oil Forced Air Forced), RUS: ДЦ
<b>1.2. Series of two-winding transformers (TDN type in accordance with the technical requirements of GOST 12965)</b>	
Standard range of capacity, MVA	25, 40, 63, 80, 100, 125
Low-voltage (LV), kV	6.3, 6.6, 10.5, 11.0, 38.5
Cooling system	ONAN (Oil Natural), RUS: M ONAF (Oil Natural Air Forced), RUS: Д OFAF (Oil Forced Air Forced), RUS: ДЦ
<b>1.3. Series of three-winding transformers (TDTN type in accordance with the technical requirements of GOST 12965)</b>	
Standard range of capacity, MVA	25, 40, 63, 80
Low-voltage (LV), kV	6.3, 6.6, 10.5, 11.0
Medium voltage (MV), kV	38.5 or as required
Cooling system	ONAN (Oil Natural), RUS: M ONAF (Oil Natural Air Forced), RUS: Д OFAF (Oil Forced Air Forced), RUS: ДЦ
<b>1.4. Two-winding main (generator) transformers</b>	
Standard range of capacity, MVA	25, 40, 63, 80, 100, 125, 160, 200, 250 or as required
Low-voltage (LV), kV	20, 24 or as required
Cooling system	ONAF (Oil Natural Air Forced), RUS: Д OFAF (Oil Forced Air Forced), RUS: ДЦ

## 2. 220 kV voltage class

<b>2.1. Series of two-winding transformers with split low-voltage windings (TRDN type in accordance with the technical requirements of GOST 17544)</b>	
Standard range of capacity, MVA	25, 40, 63, 80, 125, 400, 630
Low-voltage (LV), kV	6.3, 6.6, 10.5, 11.0, 38.5
Cooling system	ONAF (Oil Natural Air Forced), RUS: Д OFAF (Oil Forced Air Forced), RUS: ДЦ
<b>2.2. Series of two-winding transformers (TDN type in accordance with the technical requirements of GOST 17544)</b>	
Standard range of capacity, MVA	25, 40, 63, 80, 100, 125, 160, 200, 250
Low-voltage (LV), kV	6.3, 6.6, 10.5, 11.0
Cooling system	ONAF (Oil Natural Air Forced), RUS: Д OFAF (Oil Forced Air Forced), RUS: ДЦ
<b>2.3. Three-phase autotransformers (ATDCTN type in accordance with the technical requirements of GOST 17544)</b>	
ATDCTN–63000/220/110 (RUS: АДЦТН–63000/220/110)	
ATDCTN–125000/220/110 (RUS: АДЦТН–125000/220/110)	
ATDCTN–200000/220/110 (RUS: АДЦТН–200000/220/110)	
ATDCTN–250000/220/110 (RUS: АДЦТН–250000/220/110)	

### 3. 330 kV voltage class

<b>3.1. Series of two-winding transformers (TDN type in accordance with the technical requirements of GOST 17544)</b>	
Standard range of capacity, MVA	63, 80, 100, 125, 160, 200, 250
Low-voltage (LV), kV	6.3, 6.6, 10.0, 10.5, 11.0, 38.5
Cooling system	ONAF (Oil Natural Air Forced), RUS: Д OFAF (Oil Forced Air Forced), RUS: ДЦ ONAN (Oil Natural) / ONAF (Oil Natural Air Forced) / OFAF (Oil Forced Air Forced), RUS: М/Д/ДЦ
<b>3.2. Two-winding main (generator) transformers</b>	
Standard range of capacity, MVA	63, 80, 100, 125, 160, 200, 250, 400, 630 or as required
Low-voltage (LV), kV	20, 24 or as required
Cooling system	ONAF (Oil Natural Air Forced), RUS: Д OFAF (Oil Forced Air Forced), RUS: ДЦ OFWF (Oil Forced, Water Forced), RUS: Ц
<b>3.3. Three-phase autotransformers (ATDCTN type in accordance with the technical requirements of GOST 17544)</b>	
ATDCTN–125000/330/110 (RUS: АДЦТН-125000/330/110)	
ATDCTN–200000/330/110 (RUS: АДЦТН-200000/330/110)	
ATDCTN–250000/330/150 (RUS: АДЦТН-250000/330/150)	
<b>3.4. Single-phase autotransformers (AODCTN type in accordance with the technical requirements of GOST 17544)</b>	
AODCTN–133000/330/220 (RUS: АОДЦТН-133000/330/220)	

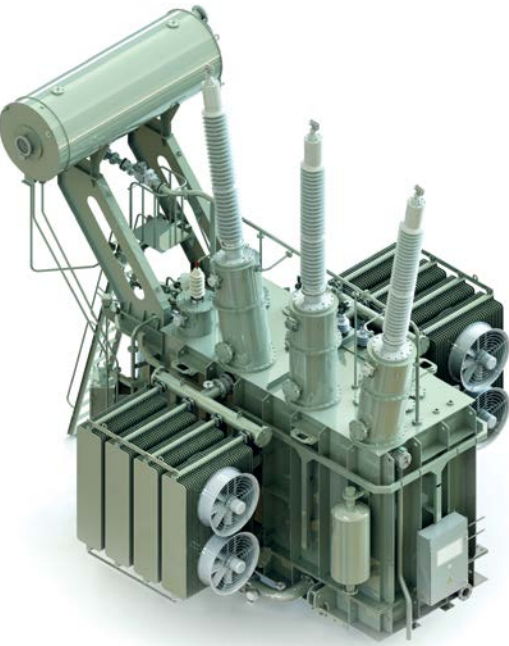
### 4. 500 kV voltage class

<b>4.1. Three-phase main (generator) transformers</b>	
Standard range of capacity, MVA	200, 250, 400, 630 or as required
Low-voltage (LV), kV	20, 24 or as required
Cooling system	OFAF (Oil Forced Air Forced), RUS: ДЦ OFWF (Oil Forced, Water Forced), RUS: Ц
<b>4.2. Single-phase main (generator) transformers</b>	
Standard range of capacity, MVA	333, 533 or as required
Low-voltage (LV), kV	20, 24 or as required
Cooling system	OFAF (Oil Forced Air Forced), RUS: ДЦ OFWF (Oil Forced, Water Forced), RUS: Ц
<b>4.3. Three-phase autotransformers (ATDCTN type in accordance with the technical requirements of GOST 17544) or as required</b>	
ATDCTN–500000/500/220 (RUS: АДЦТН-500000/500/220)	
ATDCTN–250000/500/110 (RUS: АДЦТН-250000/500/110)	
<b>4.4. Single-phase autotransformers (AODCTN type in accordance with the technical requirements of GOST 17544) or as required</b>	
AODCTN–167000/500/220 (RUS: АОДЦТН-167000/500/220)	
AODCTN–167000/500/330 (RUS: АОДЦТН-167000/500/330)	
AODCTN–267000/500/220 (RUS: АОДЦТН-267000/500/220)	
AOCTN–417000/500/220 (RUS: АОЦТН-417000/500/220)	



5. 750 kV voltage class

5.1. Three-phase main (generator) transformers	
Standard range of capacity, MVA	250, 400 or as required
Low-voltage (LV), kV	20, 24 or as required
Cooling system	OFAF (Oil Forced Air Forced), RUS: ДЦ OFWF (Oil Forced, Water Forced), RUS: Ц



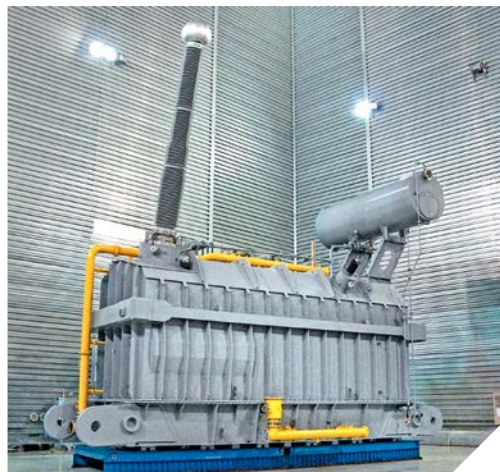
# PRODUCTION EXPERIENCE

## Object KALININ NPP ОРЦ-417000/750-Y1

### Discription:

Conformity assessment in the form of acceptance and testing in compliance with РД ЭО 1.1.2.01.0713-2013.  
Safety Class as per OPB-88/97 (NP-001-97) – 4.

**Commissioning:** 2019 year



## Object Rooppur NPP ОРДЦ-533000/420-TB1

### Discription:

QA3/Quality assurance category in compliance with QAP(D) – QA3.  
Safety Class as per OPB-88/97 (NP-001-97) – 4.

**Prepared for shipment**



## Object LENINGRAD NPP АОДЦТН-417000/750/330-Y1

### Discription:

Conformity assessment in the form of acceptance and testing in compliance with РД ЭО 1.1.2.01.0713-2013.  
Safety Class as per OPB-88/97 (NP-001-97) – 4.

**On trials**



# PHASE-SHIFTING TRANSFORMER (PST)

**01** PST consists of an autotransformer and a booster transformer

**02** The use of PST avoids:

- overloading of low-power lines;
- bandwidth limitations of powerful lines;
- surplus losses of electricity.

**03** The result of using PST

- overall improvement in energy efficiency and cost reduction, including due to the abandonment of the construction of new transmission lines.

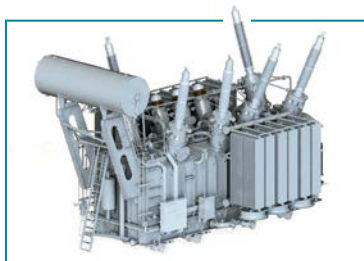
**04** Case: PST for PJSC "RusHydro" – Volzhskaya HPP

- the cost of connecting the increased capacity to the power system has been reduced by more than 6 times;
- economic effect from the implementation of a technical solution – 3 billion rubles.



## DIGITALIZATION OF TRANSFORMERS

Example of a SCADA system of a phase-shifting transformer



► **Signal** ► **Processing** ► **SCADA** ►



- visualization of operating modes of transformers at the operator's workplace;
- signaling an emergency operation by SMS.



# PRODUCTION

Phase-shifting transformer  
ТДЦТНФ-195260-220 for Volzhskaya HPP  
(PJSC "RusHydro")



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