



# REP HOLDING



Full-scale supplies of power equipment



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## Key Competences

REP Holding is a leading Russian power machine building enterprise, a designer, manufacturer and supplier of new generation power machines

We design, manufacture and provide package supplies of power and electrical equipment for oil & gas, metallurgical and chemical industries, power generation and distribution facilities.

Our company-owned large scale production facilities Nevsky Zavod and Elektropult Plant located in St. Petersburg provide strong foundation for engineering and production of high quality competitive products. REP Holding incorporates an in-house Power Machine Building and Electrical Engineering Research Institute and several joint ventures. REP Holding has been part of Gazprombank Group since 2010.

### Excellence

- Scientific and technological capacity, application of unique design and process solutions;
- High capacity production and engineering facilities;
- Successful state-of-art foreign technologies localization experience;

- Advanced energy-saving turbomachinery production in accordance with API standards;
- Integrated production management system;
- Full production cycle from engineering to service;
- Turn-key packaged supplies;
- High reliability and availability of products;
- Automated production technologies;
- Outstanding environmental performance.

### Products

- New generation 16, 22/25 and 32 MW gas-pumping units;
- 6 to 25 MW steam turbines;
- 4, 6.3 and 12.5 MW complete electrically driven gas-pumping units;
- Up to 32 MW centrifugal compressors;
- 0.5 to 32 MW steam & gas turbine driven power generating units;
- Up to 100 MW variable frequency drives;
- Automatic electric power control, adjustment, distribution and conversion systems;
- Electrical equipment;
- Integrated automation systems for industrial facilities.



## Key Competence of REP Holding companies

### Structure of REP Holding

REP Holding is a group of manufacturing, R&D and service enterprises with total number of employees more than 2000 persons. To ensure the leading position of Russian outputs in the worldwide power engineering market, REP Holding has combined two large-scale production plants of Saint-Petersburg “Nevskiy Zavod” and “ELECTROPULT Plant”, which together formed a prominent platform for design and manufacture of the up-to-date high-quality competitive products.

CJSC “Nevskiy Zavod” produces the modern gas-pumping units of different rate (GPU, EGPU), steam and gas turbines, compressors of medium power output (up to 100 MW), internal metallurgical facilities (steel and iron casting).

JCS “ELECTROPULT Plant” produces the electrical equipment, production of power control, distribution and converting systems.

Holding structure also incorporates Engineering Center which provides R&D, experimental development, innovative engineering solutions, examination of the equipment technical condition, upgrading and service life extension, research, design, experimental development (research and development work), innovative engineering solutions.

Partnership with the world leaders in the power plant industry contributes to the active introduction of innovative developments and international management standards in manufacture, as well as successful experience in the localization of foreign advanced technology and strengthening the position in the international power generation market.

All Holding companies are the legal entities which support all stages of the manufacturing cycle and fully manage their basic current activities.

The Holding companies operate within the Unified Management System — the Integrated Management System. Conformance to the requirements of the international and Russian standards is proved by the available certificates.

All Holding companies have a common information area which ensures better project quality and shorter manufacturing time, lower production costs and higher work efficiency.



Production site “Nevskiy Zavod”, Power Plant Engineering Complex



Production site “ELECTROPULT Plant”, Electrical Equipment Complex



# Key Competence of REP Holding companies

## Integrated service

Our company provides full range of services for all our products, including maintenance, overhaul and customer personnel training.

Our service expertise extends to long-term maintenance service of gas-pumping units, power generation plants, steam turbines and compressors.

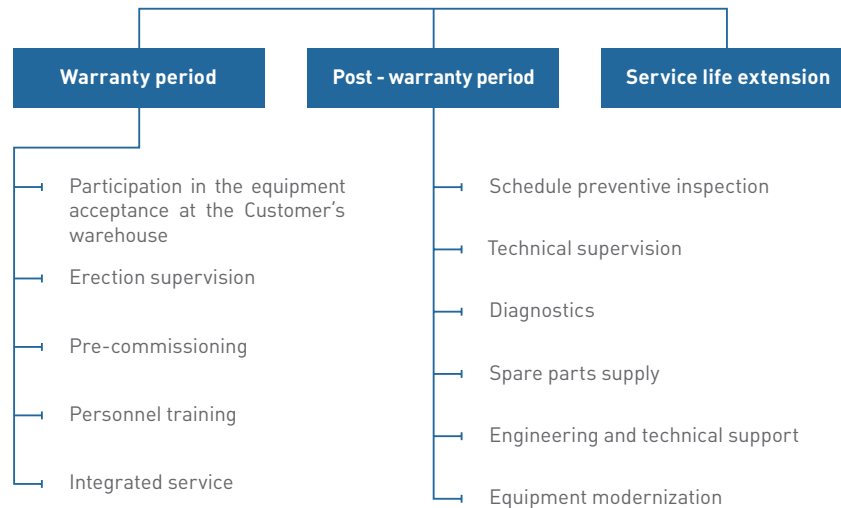
Integrated maintenance includes warranty and post-warranty service, life extension, equipment modernization for longer MTBF, efficiency and reliability increase.

Dedicated REP Holding business units provide maintenance service and parts supply during lifespan of in-house manufactured and sourced machines. Our company employs highly qualified field service engineers (FSE) to perform pre-commissioning & commissioning operations, warranty and post-warranty service and equipment monitoring throughout the whole life cycle.

Our field service engineers get trained, certified and qualified at foreign partner's production sites on the regular basis.

## Field service scope provided by REP Holding includes the following activities:

- Pre-commissioning and commissioning supervision
- Maintenance and repair operations scheduling (MRO)
- MRO management and implementation
- FSE urgent call-outs and ensured equipment supplier representatives field presence
- Applicable MRO documents supply
- Equipment, assembly units and parts service life extension and service evaluation
- Spare part kits delivery to the operating companies
- Equipment modernization
- Customer personnel training and technical support



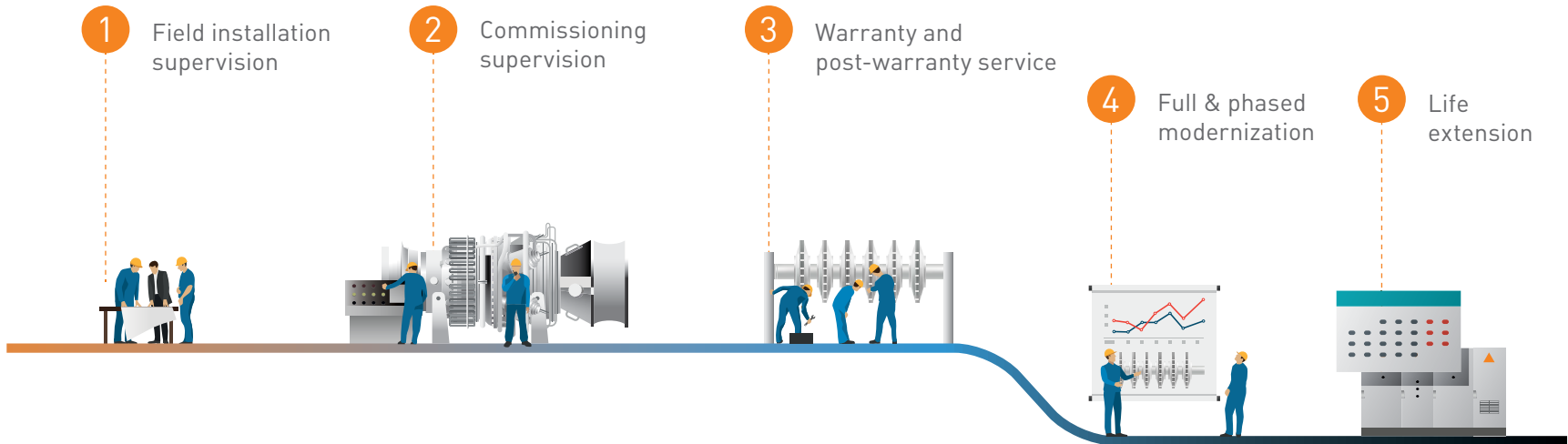
## Excellence

- State-of-art production facilities
- Large-scale in-house spare parts production and equipment maintenance
- Reduced shutdowns by means of package service solutions, state-of art technologies and modern equipment
- Integrated technical support
- Advanced service solutions
- Remote monitoring capability
- Advanced equipment operation monitoring technologies
- Cost reduction through the use of highly qualified local service engineering, with no foreign experts being engaged.
- Cost reduction and time saving within a long-term service contract implementation
- On-site parts stock management, customer logistics and warehousing costs reduction
- Customized approach to service contracts
- Wide range of Russian manufactured and sourced equipment maintenance experience





# Key Competence of REP Holding companies



1 High efficiency

2 User friendly

3 Cost reduction



# Key Competence of REP Holding companies

## Services

- manufacture and package-supply of the power-generating equipment;
- engineering solutions and design;
- engineering, design and pre-commissioning work;
- erection and commissioning;
- upgrading and reconditioning;
- modernization and technical re-equipment of the industrial facilities.

When designing and manufacturing the Products, REP Holding specialists apply unique engineering and process solutions. The Products are manufactured considering any severity level of the operation

conditions, the Customer's requirements and the applicable National and International Standards.

Every year the Holding companies develop and master manufacturing processes for new types of equipment, remaining the only Russian manufacturers who produce stationary gas turbines rated at 32 MW.

### Global sales geography:

- >40 Russian regions;
- >20 foreign countries;
- >6500 machines in operation.



## "REP Holding" Clients and Partners







## Manufacturing Facilities

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## Manufacturing Facilities

Success of the REP Holding is mainly based on timely and permanent upgrading of the technical equipment of the Holding companies.

Due to the applied high-tech equipment, procedures, and materials the Holding offers to the Customer high-quality Products, able to meet competition.

All production sites of REP Holding are equipped with modern automated machines and equipment manufactured by the leading world-known manufacturers (Mori Seiko, Okuma, Tos Varnsdorf, Skoda, etc.).

### Structure of REP Holding production facilities:

- Electrical equipment complex:
  - Electrical equipment production;
  - Container production;
  - Mechanical work and assembly.
- Power plant engineering complex:
  - Machinery production;
  - Metallurgical production;
  - Boiler and welding production.
- Test facilities.

The manufacturing process of REP Holding subsidiaries is organized as a closed-circuit small-batches or single-item manufacturing procedure as required by the specific application of the Products. In-house metallurgical section provides castings and forgings

which are then transferred to the machining-and-assembling department.

This department machines and manufactures single items, and then assembles units and products. The machining-and-assembling department includes the test benches which are used for testing of the manufactured units.

### Electrical Equipment complex

Its purpose is to manufacture electrical equipment, electric power

control, distribution and conversion systems for the metallurgical, power-generating, nuclear, gas, oil, machine-building, and ship-building industries.

### Electrical Equipment Production

Electrical Engineering Section consists of:

- assembling and installation department;
- staging area;
- switchgear and control gear assembling area;

- ACS and frequency converters' cabinet assembling area;
- package transformer substation assembling area;
- cable harness manufacturing area;
- low-voltage machines manufacturing area;
- packing area;
- electrical engineering control;
- design control department;
- production planning department;
- testing department;
- electrical products' quality control bureau;
- storages for external completing units, materials, finished products.



Electrical engineering section



# Manufacturing Facilities

## Container Production

Its purpose is to design and manufacture easy-assembled hangars, portacabins, and to provide them with the electrical equipment.



Container Production Section



Container Production Section

## Mechanical work and assembly

Its purpose is to manufacture metal structures for the electrical equipments.

### Mechanical work and assembly includes:

- metal sheet processing site;
- metalwork and assembling site;
- powder painting site;
- machining site.



Metal Sheet Processing Site



Painting Site

## Power-Plant Engineering complex

Its purpose is to manufacture steam and gas turbines, and compressors and superchargers.

### Machinery production

#### Machinery production includes:

- assembly operations;
- rotor production;
- casing production;
- blades production;
- tools and mechanical production;
- manufacture of magnetic bearings;
- test bed department.



Rotor department



Blades production facilities



Electric drives production



Impregnation of electric motor stators



# Manufacturing Facilities



Tools mechanical production



Packaging area



Casing production department



Assembling department



# Manufacturing Facilities

## Up-to-Date Machine-Tool Fleet



Okuma five-coordinate machining center



Coburg machine for casings and large-size parts machining



Shenk high-speed balancing and overspeed facility



Okuma five-coordinate machining center



Skoda machine for casings and large-size parts machining



Okuma portal-type machining center



Shenk high-speed balancing and overspeed facility



WFL Milturn multi-purpose machining center



# Manufacturing Facilities

## Metallurgical Production

- steel casting. Casting of carbon, alloyed (corrosion-resistant, non-magnetic, etc.) steel parts required for machine building facilities which weigh from 2,0 tonnes;
- iron casting. Casting of grey and high-strength cast iron parts (weight from 2,5 tonnes) for general purposes and for power-generating units;
- manufacturing of ingots made of carbon, alloyed and heavy alloyed steel grades which weigh from 0.5 to 3.0 tonnes.

## Metallurgical Section consists of:

- mold making department;
- metallurgical department.

## Boiler and Welding Production

Manufacturing of welded structures for various application in the power-plant engineering industry.

## Boiler and Welding Section consists of:

- assembly-and welding:
  - base-plates area;

- piping area;
- area for assembly of compressor wheels and cylinders;
- assembly-and welding area;
- blank-and-mechanical production:
  - gas cutting and forging area;
  - mechanical area;

- package production:
  - packaging area;
  - testing area;
  - painting area;
  - electrical equipment assembly, mounting and adjustment area;
  - assembly-and-welding area.



Metallurgical Section



Casing Production Department



Auxiliaries' Frame Production Site



## Manufacturing Facilities

### Testing Center

The production sites of REP Holding are equipped with the unique high-tech test benches.

On these benches combined mechanical, thermal, and investigation testing of the manufactured turbocompressor equipment is carried out.

### Test Benches:

- Gas Turbine test bench;
- Steam Turbine test bench;
- Centrifugal Compressor test benches;
- Test benches for axial compressors.
- Vibration test bench;
- High-Voltage Testing;
- Electric Drive test bench;
- High-speed and low-speed balancing machines.



Steam turbine test bench



Electric drive test bench



Centrifugal Compressor test bench



Test bench for Electrically-Driven Gas Pumping Unit (EGPU)



## Manufacturing Facilities



Gas Turbine test bench



Installation of GTU-32 on the test bed of Nevskiy Zavod



T16 gas turbine test bench





## Manufacturing Facilities

### Testing Laboratory

Assurance and control of the product quality is done by the special department of CJSC REP Holding, i.e. the interplant metrology, testing and quality control laboratory.

The laboratory does examination, and issues a report which is then submitted to the Quality Control Department inspectors so that they can decide further.

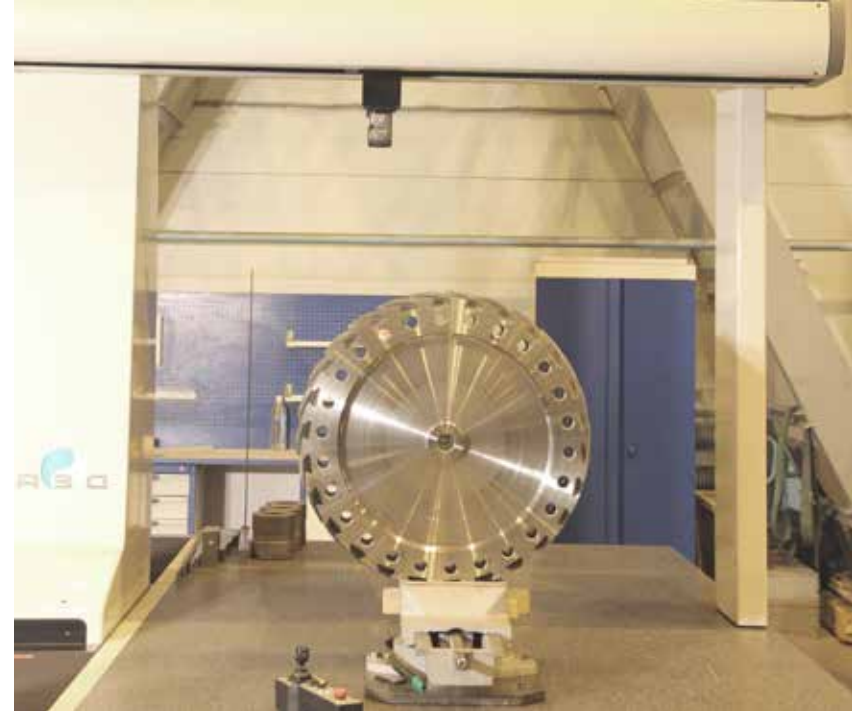
### The laboratory does four types of inspection:

- metrological inspection (linear and angular measurements, radio metering, thermal measurements, metrological examination of documents);
- destructive tests (mechanical tests, metallographical tests, chemical and spectral analysis, etc.);
- non-destructive tests (NDT) (X-ray inspection, ultrasonic and penetrant inspection, etc.);
- the express-laboratory of the metallurgical complex performs express-control of metal during melting in the emission vacuum spectrometer ARL3460.

### The laboratory is equipped with the modern equipment from the leading foreign manufacturers:

- spectrometer ARL 3460 Advantage;
- sample preparation machines Herzog VNU 300 and the grinding machine Herzog HT 350, express chemical analysis machines used during melting of steel and cast iron in the smelters;
- non-destructive test instrument P920 Magnaflux for the magnetic particle testing of the rotor components and of the turbine and compressor casing castings;
- equipment of the company Zwick (Germany) for checking of the metal mechanical properties (strength and ductility) i.e. testing machine Z250 and impact testing machine RKP450.

The laboratory carries out a wide variety of tests, e.g. X-ray testing, chemical analysis, spectral analysis, magnetic powder test, ultrasonic test, etc.



DEA measuring machine



Taking measurements by means of the coordinate measuring machine



## Products of Metallurgical Workshop

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# Products of Metallurgical Workshop

## Manufacturing Facilities

Metallurgical segment is the most important element of the equipment production-packaged-supply cycle of REP Holding.

In 2010 the metallurgical segment was fully modified, the modern equipment, complying with the strictest requirements for production quality, safety, environmental safety and efficiency, was installed.

### Pattern-Making Workshop

Makes wooden patterns for items made of cast iron and steel. Also the site produces expanded polystyrene patterns.



Dinamic FC 4000 CNC 5-coordinate machine to manufacture patterns

### Foundry Workshop

It consists of:

- Molding area;
- Melting-and-casting area;
- Casting dressing area;
- Heat-treatment area;
- Machining area;
- Testing.

#### Molding area

Produces sodium silicate and resin-coated ( $\alpha$ -set process) molding and core sands by means of a batch-type screw mixer. Thus obtained sand mixtures are used for making of the cores and the molding boxes.

### Melting-and-casting area

Capacity is 4300 tonnes of molten metal/year.

The modern DC melting units of WWOCCU-3 (wide-wave oven of constant current universal) and WWOCCU-0.5 series from "Ekta" company are used for melting.



Pattern-Making Site



Melting-and-casting area



Molding Site



## Products of Metallurgical Workshop

### Casting dressing area

Ejecting of the castings from the mold, dressing and rough machining.



Casting dressing area

### Heat Treatment Site

Heat treatment of castings includes: annealing, normalizing and tempering, stress-relief tempering, double-normalizing with tempering, and quenching.

The site is equipped with four heat-treatment furnaces and a quenching tank Bosio.



Heat Treatment Site

### Machining area

The site is purposed for rough machining of the castings and forgings. Also samples are cut-out for check of the metal chemical composition and mechanical properties.

The site is equipped with the thread-cutting lathes, the vertical lathes, the horizontal boring machines, the rough-grinding machines, the vertical-milling machine and other machines for machining of the castings weighing up to 2.5 tonnes.

### Testing

The products of the metallurgical section shall pass the following tests:

- ultrasonic testing;
- X-ray testing;
- magnetic particles testing;
- express-analysis of metal during melting process by means of the emission vacuum spectrometer ARL3460;
- check of the mechanical properties using metal samples.



Metal casting in the melting-and-casting area of "Nevskiy Zavod"



## Products of Metallurgical Workshop

### Iron Casting

Casting of gray iron items weighing from 0.02 to 2.5 tonnes for general purposes and for power-plant purposes.



Suction Plenum Body



Exhaust Plenum of the LP Turbine

### Product Specifications

Products	Grade of Cast Iron	Weight Range, tonnes
Vane Carriers of the gas turbines	C425, B440	0,5-2,5
Pump Bodies	C425	
Suction Plenums of the gas turbines	C425, B440	
Diaphragm with steel blades of the steam turbines	C415, C420, C425, C430	
Covers and gearbox bodies	C415, C420, C425	
Molding boxes for steel ingots	C415	
Bearing bodies of the steam turbines	C415, C420, C425	
General-purpose plates	C415, C420, C425	

### Steel Ingots

Production of steel ingots (weighing from 0.5 to 3 tonnes) of carbon, alloyed, and high-alloyed steel grades.



Steel ingots on the production site Nevskiy Zavod



## Products of Metallurgical Workshop

### Steel Casting

Casting of carbon, alloyed (corrosion-resistant, non-magnetic, etc.) steel items weighing from 0.1 to 2 tonnes for the machine-building industry.



Compressor Body



Turbine Body

### Product Specifications

Products	Steel Grade	Weight Range, tonnes
HP cylinders of the steam turbines	20ХМЛ, 15Х1М1ФЛ, 20ХМФЛ	up to 2,0
Feed Spout	20ГСЛ, 25Л, 35Л	up to 2,0
Centrifugal wheel	20ГСЛ, 25Л, 30Л	up to 2,0
Steam chest and nozzle box	15Х1М1ФЛ, 20ХМЛ, 12ХМЛ, 20ХМФЛ, 25Л	0,1-2,0
Dampers, shutoff valves	15Х1М1ФЛ, 20ХМЛ, 12ХМЛ, 20ХМФЛ, 25Л	0,1-2,0
Nonmagnetic pressure ring	НЛ-30 (30Х3Н17Г2Л)	up to 2,0

### The supply objects

The most part of the products is manufactured as a part of the supplied package of the power-generating equipment of JSC REP Holding. Apart from the internal application of the products of the metallurgical segment, these Products are supplied to the external large metallurgical plants, e.g. the Saint-Petersburg office of OJSC Power Machines - LMZ; KMZ "IZHORA-METALL"; CJSC "Northern Metallurgical Company"; LLC "OMZ-Foundry"; CJSC "The Ural Turbine Works", etc.



## Equipment for Gas Industry

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## Gas-Pumping Units

Design and manufacture of the equipment for gas industry is one of the top-priority lines of the REP Holding activities.

A new line of gas-turbine units (GTU) in the power range from 16 to 32 MW has been developed at REP Holding. REP Holding offers manufacture and supply of gas-pumping units rated at 16.25 and 32 MW, produced and assembled on its own manufacturing sites.

### Gas-Pumping Unit GPU-32 "Ladoga"

REP Holding produces a high-technology gas-pumping unit "Ladoga-32" for operating conditions of any degree of complexity, remarkable in its high efficiency (36 %), low emissions and prolonged service life.

GPU-32 "Ladoga" is a key link in the strategic program of reconstruction of the Russian gas transmission system. This is a new high-efficient unit designed for the Russian market on the basis of the MS5002 base gas turbine family which has been successfully operating at many compressor stations in Russia, and the total operating time all over the world today is more than 16 million hours.

### Advantages:

- technologically perfect product for transmission of natural gas under a pressure of 120 atmospheres;
- high efficiency;
- low level of harmful emissions meeting the up-to-date environmental requirements;
- high reliability and operational availability;
- turn-key delivery.

### Unit components:

- gas turbine unit MS5002E rated at 32 MW:
  - MS5002E turbo-unit;
  - auxiliary base plate of the MS5002E GTU;
  - heat-and-noise insulating enclosure of the MS5002E auxiliary base plate;
  - heat-and-noise insulating enclosure of the MS5002E gas turbine compartment;

- natural gas compressor 400-21-1C;
- integrated automatic control system;
- filter house;
- power supply system;
- instrumentation (control and measuring devices).

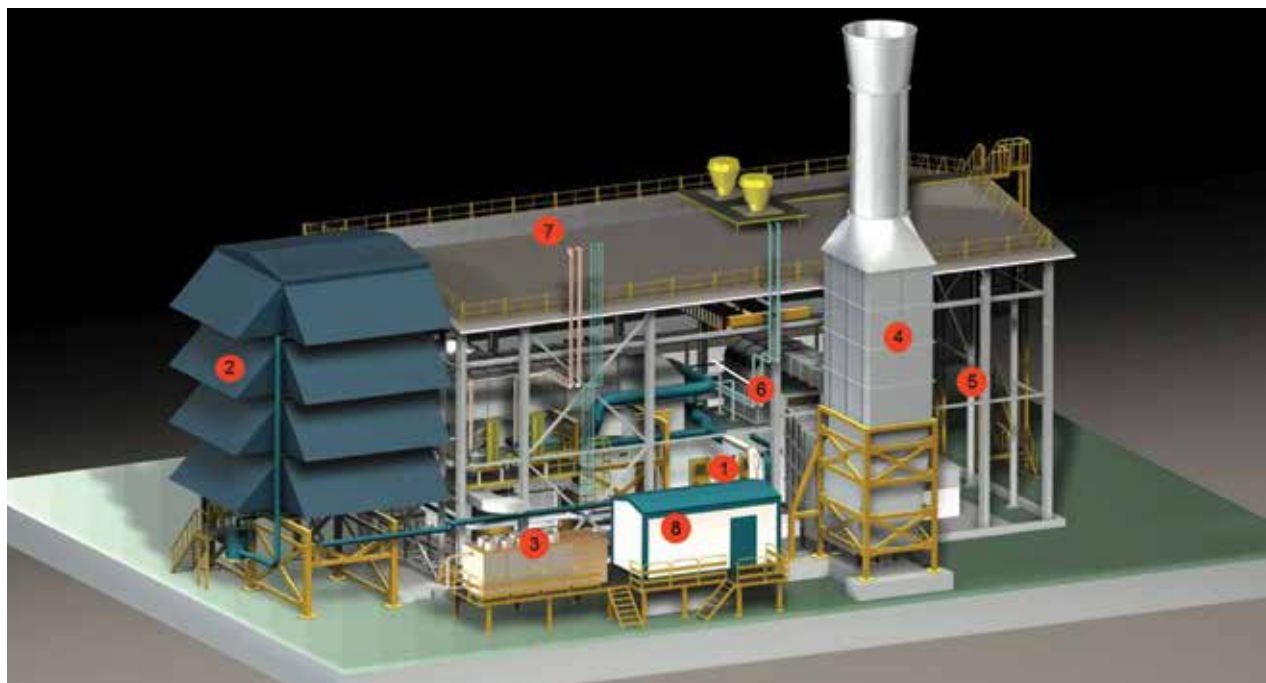


GPU-32 "Ladoga" in the packaging shop on the site of Nevskiy Zavod



GPU configuration options at compressor stations





## GPU-32 "Ladoga" components

- 1 — MS5002E gas turbine unit
- 2 — Filter house
- 3 — Oil cooler
- 4 — Exhaust system
- 5 — 400-21-1C compressor
- 6 — Integrated automatic control system consisting of two units—ACS unit and electrical unit
- 7 — Individual hangar-type building
- 8 — Building Heating Unit

## The Main Technical Characteristics of the GPU-32 "Ladoga"

Name of parameter	GPU-32	GPU-32-02	GPU-32-03
Nominal coupling power in the station conditions, MW, no less than		31,2	
Volume capacity referred to the nominal conditions (0.1013 MPa, 20 °C), mil m <sup>3</sup> /day.	78,6	62,0	66,0
Polytropic efficiency of the centrifugal compressor, no less than, %	85	80	80
GTU effective efficiency when operating at nominal power in the station conditions, %		36,0	
Nominal gas working pressure, abs., at the centrifugal compressor outlet, MPa	11,86	7,45	7,45
Pressure ratio	1,4	1,44	1,38
Nominal speed of the GTU power turbine rotor		5714	
Temperature downstream the turbine, °C (nom./max)		510/600	
Fuel gas flow, kg/s		1,78	



### MS5002E Gas Turbine Unit

- MS5002E is a high technology turbine produced by JSC "REPH" rated at 32 MW under the license of GE Oil & Gas (Nuovo Pignone S.p.A.).
- this is a new generation machine, for operating conditions of any degree of complexity.

#### Application:

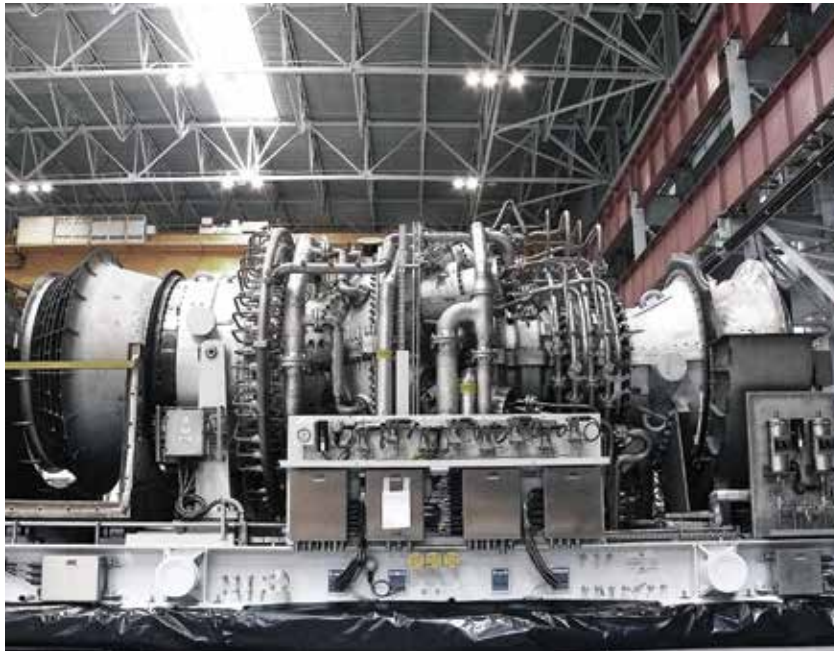
- as part of gas-pumping units at compressor stations of gas-main pipelines;
- as part of combined-cycle gas turbines at Combined Heat and

Power Plants and Central Heating and Power Plants;

- in ship-building as the main propulsion plant for ships and vessels.

#### Advantages:

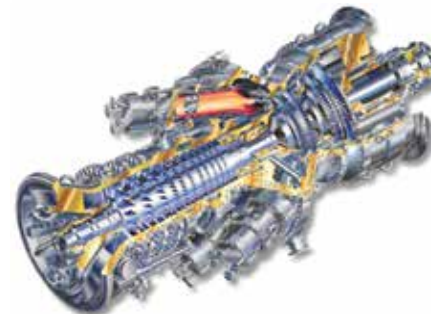
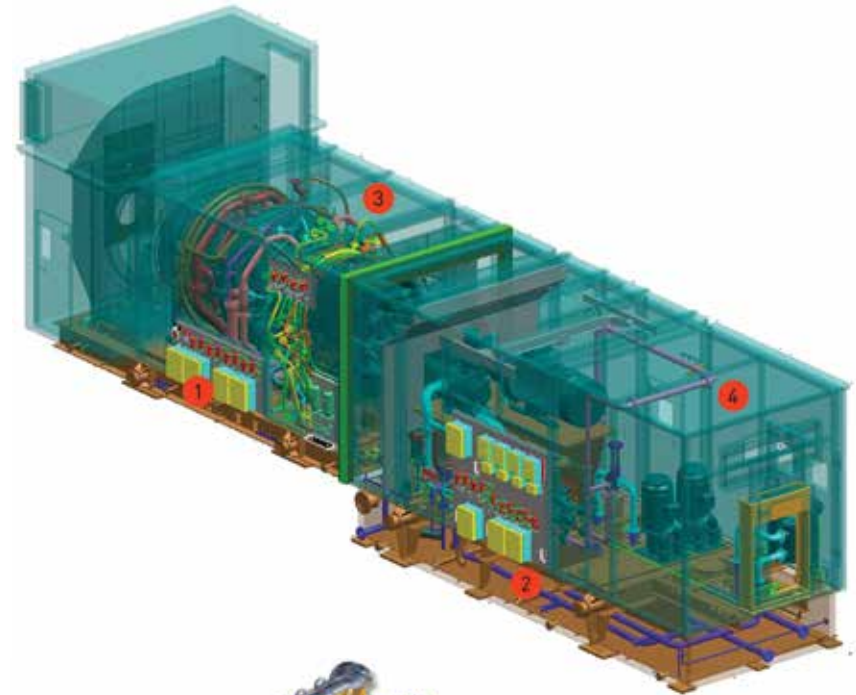
- nominal power — 32 MW;
- high efficiency — 36 %;
- improved environmental measures, low level of emissions (NO<sub>x</sub>=18ppm);
- long service life, high level of reparability;
- MS5002E is a multipurpose turbine.



MS5002E GTU on the site of Nevskiy Zavod

### The Main Systems of the Gas Turbine Unit:

- 1 — MS5002E turbo-unit on its own base plate
- 2 — Auxiliary base plate with all the GTU operation support systems mounted on it: starting system, oil supply system and fuel system
- 3 — Heat-and-noise insulating enclosure of the GTU
- 4 — Heat-and-noise insulating enclosure of the auxiliary base plate



Longitudinal section of MS5002E GTE



## The Main Parameters of the MS5002E Gas Turbine Unit

Name of Parameter	Value
Nominal mechanical power at shaft under ISO conditions, MW, no less than	32,0
Mechanical efficiency at shaft under ISO conditions and nominal load, %, no less than	36,0
Nominal speed of the LPT rotor, rpm	5714
Variation range of the LPT rotor speed, % of the nominal value	70 to 105
Direction of the LPT rotor rotation, if viewed from the side of the loading device	Clockwise, GOST 22378-77
Time of startup and acceleration to the minimum operating mode (from the hot standby condition), min	5
Nominal fuel gas flow, kg/s	1,74
Fuel gas pressure, MPa	3,1 to 3,5
Irrecoverable oil losses, kg/h, no more than	0,25
Nominal/maximum temperature of exhaust gases downstream the turbine (across section of the turbine exhaust duct), °C	510/600
Inlet air flow in the nominal operating mode, kg/s	100
Exhaust gas flow (across section of the turbine exhaust duct), kg/s	101,7
Air pressure ratio in the axial compressor	17,0
Harmful substance content of exhaust gas (measured in the dry sample at 0°C, 0.1013 MPa and standard oxygen concentration of 15%):	
–NO <sub>x</sub> , mg/m <sup>3</sup> , no more than	50
–CO, mg/m <sup>3</sup> , no more than	34,7
Rate of noxious substance emission with combustion products at nominal power conditions:	
–NO <sub>x</sub> , g/s, no more than	3,7
–CO, g/s, no more than	2,6



## MS5002E Auxiliary Base Plate

A welded structure with the GTU auxiliary equipment mounted on it. The auxiliary base plate is at the same time a tank to store oil, is provided with heat-and-noise insulation.

### Purpose

Designed to arrange the MS5002E auxiliary equipment: oil supply system, fuel supply system and starting system.



MS5002E auxiliary base plate, 3D-model



MS5002E auxiliary base plate

## Heat-and-noise Insulating Enclosures of the MS5002E Auxiliary Base Plate and Gas Turbine Compartment

### Purpose

Reduction of noise level, thermal insulation and protection of the MS5002E GTU auxiliary base plate against the weather conditions impact.



Heat-and-noise insulating enclosure of the auxiliary base plate



GTU heat-and-noise insulating enclosure

### Advantages:

- temperature range from -55 to +35 °C;
- maximum temperature inside the enclosure +100 °C;
- maximum temperature on the surface of the panels +60 °C.

The turbine and the auxiliary base plate are supplied in the noise — protective ventilated enclosures. The enclosure is equipped with its own fire-fighting and leakage detection system.

The exhaust system has been developed with consideration for using an off-gas utilizer.



## Natural Gas Compressor of 400-21-1C

Compressor of 400-21-1C is a part of the gas pumping unit with the capacity of 32 MW and used for the compression and the movement of gas via the gas-main pipelines. The basic variant of the compressor — 400-21-1C is designed for operation on gas-main pipelines with working pressure of 11,86 MPa. Superchargers 400СПЧ1, 44/76-32S and 400СПЧ1, 38/76-32C are intended for operation on gas-main pipelines with working pressure of 7,45 MPa.

### Advantages:

- efficiency no lower than 0.85;
- pressure ratio 1.44;
- capacity referred to the initial conditions 505m<sup>3</sup> rpm;
- design speed of the compressor rotor 5550 rpm.

Compressors 400-21-1C, 400СПЧ1, 44/76-32C and 400СПЧ1, 38/76-32C are fully unified in their casings, running gears and drive coupling. Compressors are made centrifugal, two-stage with «dry» seals and oil bearings.

### Design features:

- application of flow passages differing in their geometry, which provides the gas flow and gas compression values required by the Customer;
- application of forged casings providing working capacity of the unit at the larger end of the pressure, and having a better resource.

The 400-21-1C base compressor is equipped with a flow passage with vaned diffusers, compressors 400СПЧ1,4 4/76-32C and 400СПЧ1, 38/76-32C have flow passages with vaneless diffusers. All the compressors are supplied with gas dynamic seals made by "John Crane Iskra".

### Technical characteristics

Name of parameter	400-21-1C	400СПЧ 1,44/76-32C	400СПЧ 1,38/76-32C
		(СПЧ – replaceable flow passage)	
Capacity referred to the normal conditions (0.1013 MPa and 20 °C), million m <sup>3</sup> /day	78.9	62.0	66.0
Volume capacity referred to the initial conditions, m <sup>3</sup> /min	505	748	780
Power consumed, MW	30.4	29,5	28,3
Polytropic efficiency, no less than, %	85.0	85.0	84.0
Pressure ratio	1.4	1.44	1.38
Final gas pressure (abs.), MPa	11.86	7.45	7.45
Compressor inlet temperature, °C	5	15	20
Compressor rotor speed, rpm.	5550	5550	5550



Natural gas compressor 400-21-1C

### Note

The compressor parameters values can be changed for specific operating conditions required.



The main parameters of the 400-21-1C compressor correspond to the specified values at the following initial design conditions

Name of parameter	Value
Gas pressure, abs., at the inlet of the compressor suction branch pipe, MPa	8,45
Gas temperature at the inlet of the compressor suction branch pipe, °C	5
Gas density referred to 20 °C and 0.1013MPa, kg/m <sup>3</sup>	0,689
Design speed of the compressor rotor, rpm	5550

**Note:** Design speed of the compressor rotor is 97-98 % of the turbine nominal speed in accordance with para 5.23 of “Standard Technical Requirements for Gas Turbine GPU and their Systems” STO Gazprom 2.3.5-138–2007.

## Integrated Automatic Control System of GPU-32 “Ladoga”

Domestic high-efficiency integrated control system MSKU-5000 for gas-pumping units based on innovative engineering concepts. Structurally the integrated control system is arranged in two containerized units: electrical unit and ACS unit.

### Components:

- integrated multiprocessing control system;
- low-voltage factory-assembled distribution and control equipment;
- GTU ACS (MSKU 5000-01 or MARK-VI);
- GTU low-voltage switchgear (PY-207 or MS5002E);
- GPU group control panel consisting of:
  - standby control panel (from the GPU integrated control system) — one for a GPU;

- operator’s workstation — one for two GPU;
- communicating unit;
- server appliance;
- complete set of network equipment;
- complete set of service equipment CO-02;
- SPTA.

### Advantages:

- provides complete automation of the unit and compressor workshop operation with a possibility to switch over to minimally manned operation;
- provides constant maintenance of the maximum efficient operating modes of the unit;
- increases the service life of the GPU;
- increases the scheduled interval of the GPU operation;
- provides compliance of the environmental parameters of the unit to the European norms.

## Filter House

Name of parameter	Value
Degree of filtering the atmospheric air coming into the GTU as per GOST R 51251 and European norms EN 779 and EN 1822	F9
Inlet air filtering, kg/s	100
Degree of filtering the atmospheric air supplied for cooling under the GTU enclosure as per GOST R 51251 and European norms EN 779 and EN 1822	G4
Filtering the atmospheric air supplied for cooling under the GTU enclosure and the purge air cooler, Nm <sup>3</sup> /h	81000
Nominal hydraulic resistance of the inlet duct (difference between the atmospheric pressure and total pressure upstream the GTU IGV), no more than, Pa	1000
Equivalent sound level at a distance of 1 m and elevation of 1.5 m from the GPU with the GTU operating, no more than, dBA	80
Availability of the anti-icing system	As one set

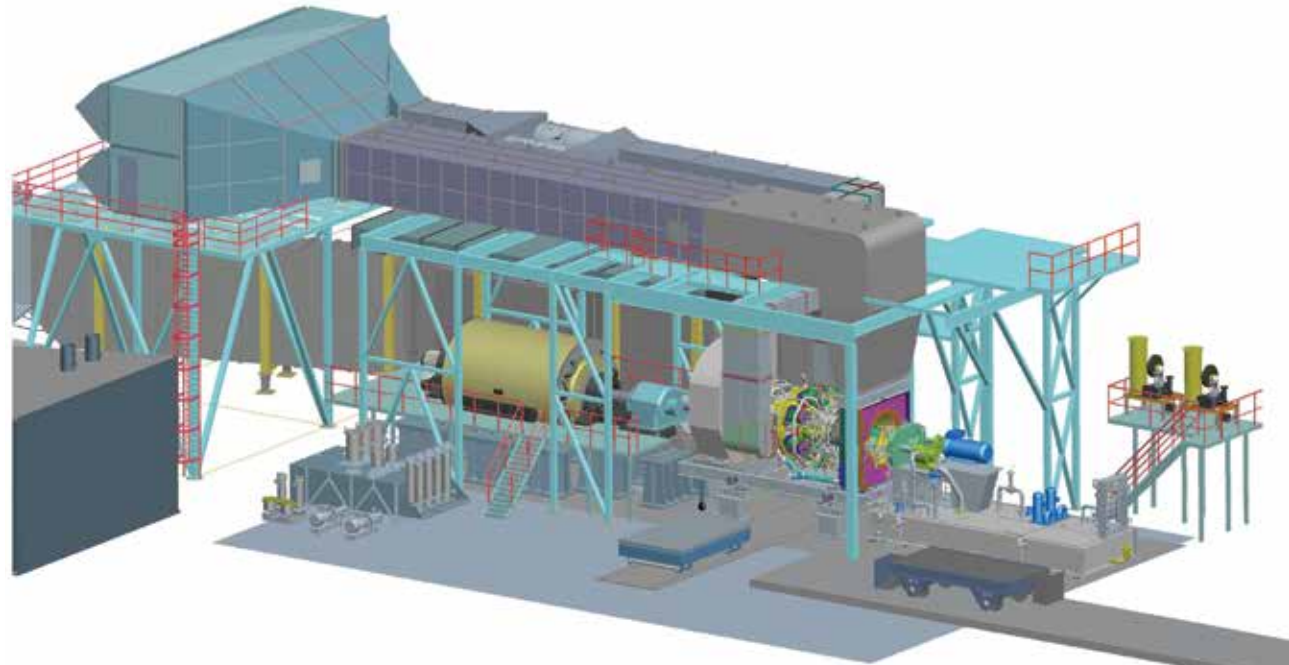


### Test Bed for GPU-32 "Ladoga"

On the site of CJSC "Nevskiy Zavod" is built a high-technology test bed to perform mechanical, thermal and research tests of gas turbine units, to check the GTU readiness for shipment and operation. The annual testing program provides for 20 units per year.

#### Test objective:

- to verify the correctness of the GTU manufacture and assembly;
- to check the interaction of assemblies in the test bed conditions and compliance of the GTU with the GTU Technical Specification for supply;
- to verify the GTU mechanical and thermal characteristics;
- research tests in accordance with internal procedures.



Test bed for GPU-32 "Ladoga", 3D-model



Installation of T32 GTU on the test bed of Nevskiy Zavod manufacturing site



### Gas-Pumping Unit GPU-25 "Ladoga"

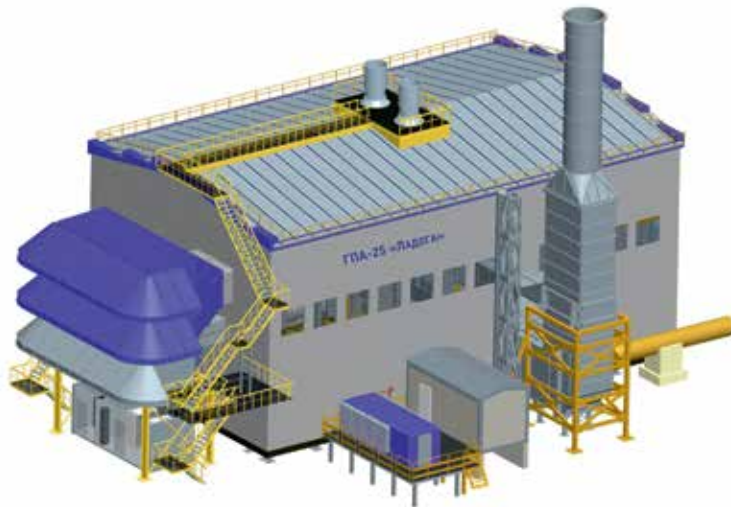
REP Holding offers manufacture of GPA- 25 "Ladoga" for installation at compressor stations of the gas trunk-lines with operating pressure from 5.5 to 12.0 Mpa.

GPA-25 "Ladoga" is designed for natural gas transmission and can be used both for reconstruction of existing gas compressor stations, and for construction of new ones for gas trunk-lines. It is supplied in the individual hangar-type building, in complete ready-to-use modules.

The unit design allows for operation in any climatic zones and provides for maximum maintainability in the compressor stations conditions.

### GPA Configuration

- Gas turbine unit rated at 22.4 MW;
- Natural gas centrifugal compressor;
- Integrated Automatic Control System (KSAU);
- Filter house;
- Exhaust system;
- GTU cooling system;
- Axial compressor washing system;
- Dry gas dynamic control systems;
- Separation and buffer gas treatment units;
- Oil supply system of the turbine and compressor;
- Fuel gas treatment and supply unit;
- Individual easy-to-assemble hangar-type building with the system of forced draft, exhaust, emergency ventilation and heating, lighting, gas detection, gas detection, fire-fighting and alarm.



### Gas turbine unit

High-tech simple cycle T25 gas turbine features highest economic efficiency in this power class, with a low level of harmful emissions.

### GTU-T25 components:

- Gas turbine;
- Starting system;
- Fuel system;

- Lubrication oil system;
- Turbotronic 4 control system;
- Oil tank - frame;
- Electric wiring on the base plate;
- Pipelines and headers;
- Inlet duct of the turbine air-intake;
- Turbine exhaust duct;
- Noise- and heat-proof enclosure;
- Ventilation system;
- Fire-detection and fire-fighting system;
- Gas detection system.



GTU-T25 on the test bed





## The main parameters of the GTU-T25

Description	Unit	Value
Shaft power	MW	22.4
Turbine efficiency	%	40.0
Exhaust gas flow	kg/s	68.24
Exhaust gas temperature	°C	465
Fuel gas flow ( $Q_{ph}=50\ 000\ \text{kJ/kg}$ )	kg/s	1.11
Output shaft speed, nominal	rpm	6300
Emission (at 15% $O_2$ in dry combustion products):		
- nitric oxide	mg/m <sup>3</sup>	≤50
- carbon oxide	mg/m <sup>3</sup>	≤50

## The main indicators

- 22.37 MW - shaft power;
- 40% - efficiency, mechanical drive;
- 38.9% - efficiency, electrical (simple cycle);
- 200 ths. hours – full service life;
- NO<sub>x</sub> emissions – no more than 25 ppm.

## GTU-T25 advantages

- high reliability;
- the best efficiency in its class;
- high economical efficiency at different operating conditions;
- lateral roll-out of the turbo-unit for holding a technical maintenance.

## T25 Gas turbine unit configuration

- inlet section;
- axial compressor;
- annular combustion chamber;
- high pressure turbine (gas generator turbine);
- power turbine.

### Power Turbine

#### – Low Pressure Turbine

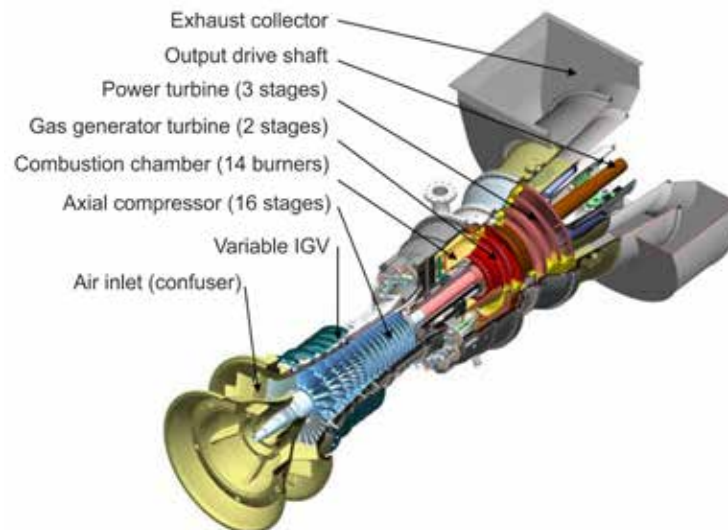
- Three uncooled stages;
- 1st and 2nd st. rotor blades are equipped with interrelated peripheral damping shrouds to minimize vibration;
- The power turbine module is supplied completely assembled and is attached through a gas-tight flange connection to the end face of the gas generator turbine casing.

## High Pressure Turbine

- 2-stage, with cooled nozzles and rotor blades.

### Axial Compressor

- 16-stage, with 6 rows of variable guide vanes, high pressure ratio (24:1) and extractions:
  - for anti-surge valve - downstream of the 9th stage;
  - to cool the power turbine - downstream of the 11th stage.
- Rated mass flow of cycle air – 67.3 kg/s.
- Inlet guide vanes and guide vanes of the first five stages are variable, controlled by a special driving actuator.



Axial Compressor



## Combustion Chamber

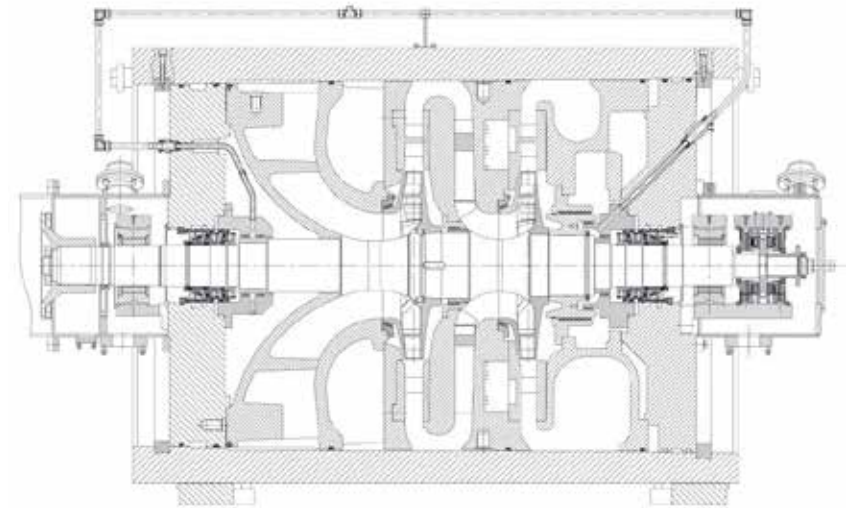
- Annular
  - SoLoNO<sub>x</sub> or common (conventional);
  - Fuel: gas, liquid fuel, dual fuel, associated gas;
- Expanded operating range
  - Load range: 40% - 100%;
- LPT outlet temperature: 465 °C;
- Fuel burners: can be maintained on site.

## Centrifugal Compressor

Parameter	Value
Capacity referred to the initial conditions, m <sup>3</sup> /min	340
Gas pressure at the suction branch pipe inlet, MPa	8.24
Final gas pressure, abs., at the discharge branch pipe outlet, MPa	11.86
Pressure ratio	1.44
Polytropic efficiency, no less than	0.88
Power consumed by the compressor, MW	21.5
Compressor rotor speed, rpm	6300



Unified body of Centrifugal Compressor for T25



Centrifugal Compressor for GPU-25 "Ladoga", plan



## Gas-Pumping Unit GPU-16 "Ladoga"

REP Holding offers to manufacture "Ladoga" series GPU-16 to be installed on the compressor stations of the main gas pipelines with the operating pressure from 5.5 to 12.0 MPa.

GPU-16 "Ladoga" is designed to transport the natural gas, and can be used both for re-construction of existing gas transfer stations, and for construction of new gas transfer stations on the main gas pipeline. The unit is delivered as a turnkey package along with the individual hangar-type shelter building.

16 MW Gas-Pumping Unit is manufactured and assembled by the Holding at the manufacturing facilities of Nevskiy Zavod.

### Unit Components

- 16 MW Gas-Turbine Unit ;
- Centrifugal Natural Gas Compressor;
- Complex Automatic Control System (KSAU);
- Filter House, including the Anti-Icing System;
- Dry Gas Seal Control System;
- Separation and Buffer (Sealing) Gas Treatment and Supply System;
- Oil Supply System;
- Instrument Air Treatment and Supply System;
- Fuel Gas Conditioning and Supply System;
- Exhaust System;
- GPU Fire Fighting System;
- Turbounit Cooling System;
- Axial Compressor Washing System;
- Hangar-type Shelter Building together with emergency, exhaust, and supply ventilation, lighting, heating systems, etc.;
- Lifting Equipment inside the Building;
- Air Heating Unit of the Building;
- Auxiliary Equipment as specified by the individual requirements of the Customer and as required by the construction climatology.



Gas turbine unit T16

Modular structure of T16 significantly facilitates maintenance of GTU due to the fact that the roof and the lateral enclosure panels can be quickly disman-

ted without disassembling of the the ventilation, anti-icing and heating air ducts.

T16 arrangement on the base plate provides lateral roll-out of the high and low pressure parts, as well as the entire unit, which makes it possible to perform comprehensive prompt technical maintenance.



Low Pressure Turbine Rolling-Out



Rolling-Out of Gas-Generator



Rolling-Out of the Entire Turbounit



## Gas-Turbine Unit

GTU T16 "Ladoga" is a new standard of 16 MW turbines.

Hi-tech gas-turbine unit T16 rated for 16.5 MW is designed and is manufactured by REP Holding in cooperation with GE Oil & Gas at the manufacturing site of Nevskiy Zavod.

The new GTU T16 is designed to be a mechanical drive and to generate power is noted for its high efficiency together with low emission level, and exceptional operational readiness. T16 refers to the industrial GTU with a prolonged service life and high flexibility for on-site service maintenance, which is achieved by the modular maintenance concept.



GTU-T16 on frame



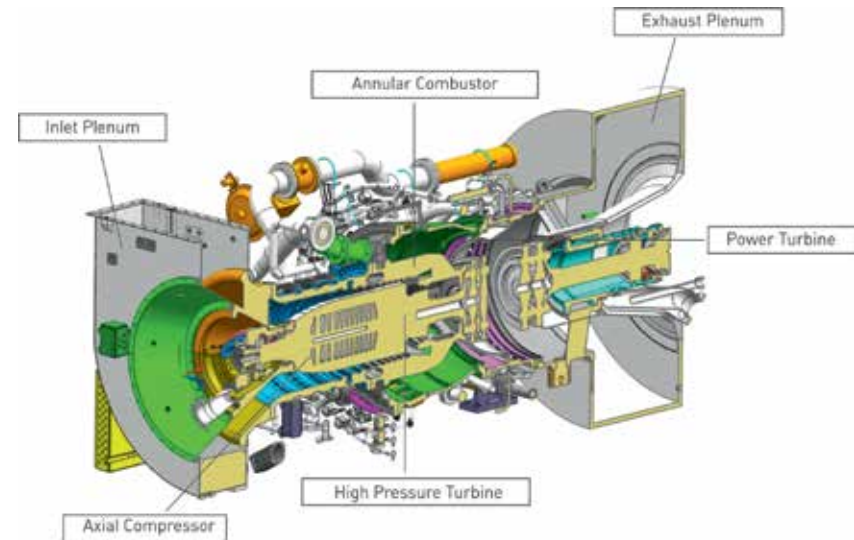
GTU-T16 on frame inside enclosure

## Components of GTU -T16

- Turbounit on Frame;
- Auxiliary Equipment on Frame;
- Automatic Control System;
- Noise-and Heat-Insulating Enclosure of GTU (Enclosure).

## Key Features

- 16.5 MW is the shaft output;
- 37% is the efficiency of the mechanical drive;
- 36% is the electrical efficiency (simple cycle);
- 80% is efficiency of the combined power and heat generation plants ;
- 200 000 hours - full life cycle;
- NOx emission - no more than 25 ppm;



Longitudinal Profile of T16 Turbine

## Design Features

- Type of GTU is a stationary two-shaft unit;
- 2 stage HPT and 2 stage LPT;
- 12 stage axial compressor, compression ratio is 19;
- Low-emission Combustion Chamber;
- Two-stage high pressure turbine with cooled blading;
- The two-stage low pressure turbine with the 1st stage variable nozzle assembly, maintains high efficiency over a wide working range;
- The combustion chamber ensures NOx emission no more than 25 ppm;
- Three stages of the axial compressor with variable guide vanes assembly.



## The Main Parameters of GTU-T16

Name of Parameter	Value
Nominal mechanical power at shaft under ISO conditions, MW, no less than	16.5
Efficiency, calculated on the basis of the power turbine coupling power, as specified in the item 1 as per ISO conditions, not less than, %	37.0
Power on the power turbine coupling in the site, MW, not less than	16.0
Efficiency, calculated on the basis of the power turbine coupling power, as specified in the item 3, not less than, %	36.5
Maximum power on the driver's coupling in the site at the negative ambient air temperature, MW, not more than	19.2
Nominal/maximum temperature of exhaust gases downstream the turbine (across section of the turbine exhaust duct), °C	492*/600*
Nominal speed of the HPT rotor, rpm	10 204*
Nominal speed of the LPT rotor, rpm	7800*
Direction of the LPT rotor rotation	Clockwise when viewing from the compressor side GOST 22378
Variation range of the LPT rotor speed, % of the nominal value	70*/-105*
Time of startup and acceleration to the minimum operating mode (from the hot standby condition), min	25
Nominal fuel gas flow (at the fuel specific energy 50 MJ/kg), kg/s	0.88
Fuel gas pressure upstream of the isolation valve (Gauge), MPa	from 3.4 to 3.7*
Inlet air flow in the nominal operating mode (reference value), kg/s	53.7*
Air pressure ratio in the axial compressor	19*

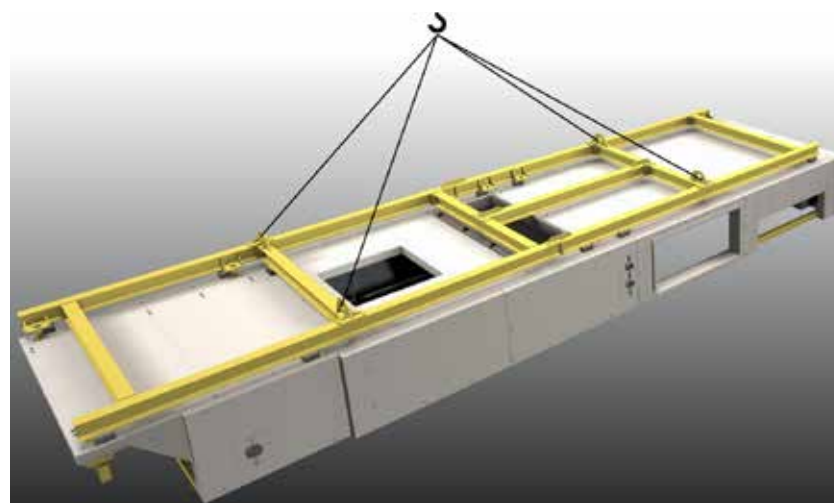
### Note

\*The parameters are to be corrected on the design phase.

GTE Weight is 58 000 kg without the Enclosure and 66 000 kg with the Enclosure.

## Advantages of GTU-T16

- High Performance;
- Classic Environmental Performance;
- Long Service Life;
- Easy for Maintenance;
- High level of Operational Availability;
- Lateral Rolling-Out of both Turbounit, and LPT and Gas-Generator;
- Delivery in turnkey condition due to modular and compact structure of GTU.



Delivery of GTU-T16 in the turnkey condition



## Centrifugal Compressor, GTU-T16 Project

Description of Parameter	Centrifugal Compressor Type			
	650-11-1C	650-11-1C	650-11-1C	650-11-1C
Efficiency at 20 °C and 0.1013 MPa, mln.nm <sup>3</sup> /day	62.3	45.6	32.7	21.4
Volumetric Efficiency under the initial conditions, m <sup>3</sup> /min	658	522	385	315
Initial absolute gas pressure at the inlet of the compressor's suction pipe, MPa	5.96	5.52	5.17	4.38
Initial Gas Temperature at the inlet of the compressor's suction pipe, °C	15			
Pressure Ratio	1.25	1.35	1.44	1.7
Polytropic Efficiency	0.89	0.89	0.88	0.87
Compressor Power Consumption	15.2	15.1	15.1	15.4
Rated Rotor Speed, rpm	7800	7800	7800	7800
Operating Speed Range, % of the rated value	70 ÷ 105			

Pressure ratio	1.25	1.35	1.44	1.5	1.7
Flow Patch Type	with one impeller	with one impeller	with two impellers	with two impellers	with two impellers
Gas pressure at the outlet of the Centrifugal compressor (for a line compressor station), MPa	5.5 7.45	5.5 7.45	5.5 7.45 8.3 10.0 12.0	5.5 7.45 8.3 10.0 12.0	7.45 8.3 10.0 12.0



### Standardized Gas-Pumping Units Based on Heavy-Duty GTU

REP Holding develops and manufactures standardized gas-pumping units based on gas-turbine engines of various power ratings.

The design features of the auxiliary systems and hangar-type buildings make it possible to use all engines, currently available at REP Holding, as well as gas-turbine units with similar dimensions and technical parameters as part of the standardized gas-pumping unit.

The main objective of the GPU standardization is to avoid unnecessary diversity of the elements of the same purpose and the type variety of their parts, bringing, as far as possible, the methods of their manufacture, assembly, testing and servicing to being uniform.

### Standardization of the unit systems makes it possible to:

- significantly reduce the volume of design work and time for design;
- reduce the time of the new equipment creation;
- reduce the cost of new products mastering;
- increase the level of mechanization and automation of the production processes by increasing the seriation level and reducing labor input;
- reduce the nomenclature of spare parts and repair costs of the GPU.

Standardization contributes to higher quality of the GPU elements, their reliability and durability. Standardization improves the basic technical-economic indicators, both those of the manufacturers and operating organizations.

During the construction of new pipelines using standardized GPA makes it possible to significantly reduce the time of development and the cost of the design documentation, as well as to reduce the metal consumption. In addition, this offers an additional opportunity to manage the delivery of the equipment in order to meet the deadline for installation of GPU.



### Configuration of the Standardized Gas-Pumping Unit

1. GTU
2. Inlet Filter House
3. Exhaust System
4. Air/Oil Cooler
5. Building Heating Unit
6. Instrument Air Treatment Unit
7. Metal Framework of the Hangar-Type Shelter Building
8. Lifting Equipment
9. Ventilation System of the Building



### Level of Standardization of Auxiliary Systems

No.	GPU's Auxiliaries	Level of Standardization of Different Motors, (%)
1	GPU Exhaust System	100
2	Oil Supply System	90 (depending upon oil capacity)
3	Oil Mist Separation System	100
4	GTU VAC System	97 (depending upon air flow)
5	Washing system for Engine Air-Gas Path	100
6	Draining System	100
7	DGS and Buffer Gas Systems	100
8	Separation Gas System	100
9	Fuel Gas Feeding and Treatment System	90-100 (depending upon gas composition)
10	Air Intake System	100
11	Electrical Equipment	100
12	Lighting of Hangar-Type Shelter Building	100
13	Earthing	100
14	Instrumentation	90
15	Instrument Air System	100
16	Hangar-Type Shelter Building	100
17	Maintenance Platforms, Ladders and Supports	100
18	Building Ventilation and Heating Systems	100
19	Integrated ACS (KSAU) of GPA	100 (container)
20	CCTV System	100
21	Fire Suppression System	90 (not standardized inside the Enclosure)
22	Fire and Gas Detection System	100





### Electrically Driven Gas - Pumping Units (EGPU)

REP Holding produces in series EGPU rated at 4, 6.3 and 12.5 MW. These units are designed for compression of natural gas at compressor stations and its transmission via gas-main pipelines. The Holding facilities produce direct-drive oil-free units mounted on an active magnetic bearing, with dry gas-dynamic seals (DGS) and variable-frequency electric drive with a possibility of remote access. The new generation EGPU are designed to replace the out-of-date electrically driven units during the reconstruction of the compressor stations.



Electrically Driven gas-pumping unit



4.0 MW EGPU at CS "Volodino" of the Main Gas Transfer Pipeline "Parabel-Kuzbass"



## Technical characteristics of the EGPU

Name of parameter/ component	UOM	Value			
		EGPU-4,0/8200-56/1,26-P	EGPU-6,3/8200-56/1,44-P	EGPU-12,5/6500-76/1,5-P	EGPU-12,5/6500-76/1,44
Nominal input voltage	V	6000/10000	6000/10000	6000/10000	6000/10000
Volume capacity referred to 20°C and 0.1013 MPa	mil m <sup>3</sup> /day.	12.5	12.0	22.137	24,50
Pressure ratio	p.u.	1.26	1.44	1.5	1.44
Drive efficiency (without compressor) in the nominal conditions, no less than	p.u.	0.93	0.93	0.96	0.96
Nominal drive power	kW	4000	6300	12500	12500
Nominal speed	rpm	8200	8200	6500	6500
Working speed range, % of the nominal value, without exceeding the nominal power	%	70 to 105	70 to105	70 to 105	70 to 105
Accuracy of the working speed maintenance (% of the nominal speed), no lower than	%	1.0	1,0	2,0	2.0
Time for acceleration to the nominal speed, no more than	min	2	2	2	2
Volume capacity referred to the initial conditions	m <sup>3</sup> /min	220	202	280	303
Final gas pressure, abs., at the compressor outlet, no more than	MPa	4.41	5.49	7.45	7.45
Initial gas pressure, abs., at the compressor inlet no more than	MPa	3.50	3.81	4.966	5.174

### EGPU components:

- natural gas centrifugal compressor;
- asynchronous high speed electric motor;
- semiconductor frequency converter;
- automatic control and governing system of the unit;
- gas air-cooler with a valve electric drive;
- active magnetic bearing system (AMBS);
- electric power supply system.



## Centrifugal Compressors 220-11-1SMP, 200-21-1SMP, 300-21-1SMP and 320-31-SMP

Compressor power: 4, 6 and 12 MW.

The centrifugal compressors are equipped with:

- dry gas dynamic seals system;
- active magnetic bearing system of the rotor (complete set of bearings) produced under the license of S2M;
- confusor, complete set of transducers to measure gas flow for operation of the anti-surge protection and in-process measurement of the centrifugal compressor capacity with an accuracy of no more than 4 %;
- complete set of tools for assembly and disassembly of the compressor.

The compressor rotor is equipped with two radial magnetic bearings and a double-sided axial magnetic bearing, the electric motor rotor — with two radial magnetic bearings. Safety bearings (included in the AMBS) provides the runaway of the unit rotors in case of emergency power cutoff of the magnetic bearing system. Also, uninterrupted power supply for the magnetic bearing system by accumulators is provided in case of the main power supply failure. The active magnetic bearing system of the centrifugal compressor is controlled and monitored from the dedicated control cabinet. Explosion protection of the magnetic bearing is provided by the compressor design.



220-11-1SMP centrifugal compressor at Volodino compressor station

### Technical characteristics

Name of parameter	220-11-1, EGPU 4,0*	200-21-1, EGPU 6,3*	300-21-1, EGPU 12,5*	320-31-1, EGPU 12,5 *
Volume capacity referred to 20 °C and 0.1013 MPa, mil Nm <sup>3</sup> /s	12.5	12	22.137	15.85
Volume capacity referred to the initial conditions, m <sup>3</sup> /min	220	202	280	320
Final gas pressure at the compressor outlet, MPa, abs.	4.41	5.49	7.45	5.59
Pressure ratio	1.26	1.44	1.5	1.747
Polytropic efficiency, no less than	0.85	0.85	0.85	0.84
Power consumed by the compressor, MW	3.8	6	12.0	12.1
Initial conditions				
Initial gas pressure at the compressor inlet, MPa, abs.	3.5	3.81	4,966	3.2
Gas temperature at the compressor inlet, °C	15	15	15	15
Gas density referred to 20 °C, 0.1013 MPa, kg/m <sup>3</sup>	0.682	0.682	0.682	0.7071
Nominal rotor speed, min. <sup>-1</sup>	8200	8200	6500	6500

\* Magnetic Bearing System with dry seals and magnetic bearing



All the EGPU are supplied in fully «dry» version (with dry gas dynamic seals and the AMBS), excluding the use of oil, which in turn significantly reduces operating costs.

### Active Magnetic Bearing System

The motor and compressor design employs an active magnetic bearing providing non-contact suspension of the compressor and motor rotors in the controlled magnetic field before startup, during operation and shutdown of the unit.

The active magnetic bearing system is produced on Nevskiy Zavod site according to the licensed technology of S2M (SKF).

The bearings are completed with:

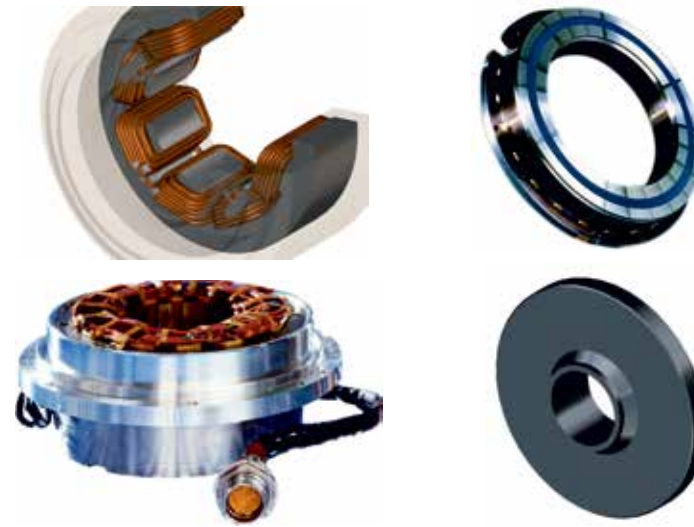
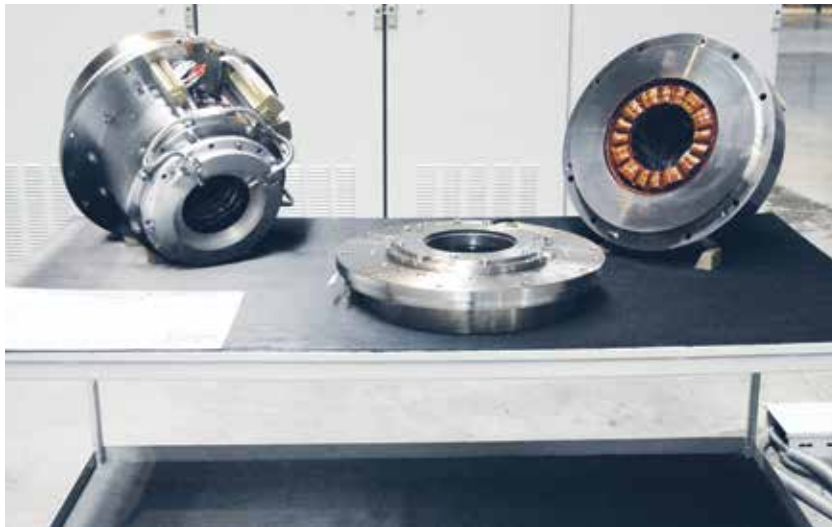
- auxiliary bearings providing up to 20 emergency “falls” emergency falls of the rotor at the nominal speed;
- temperature sensors;
- inductive transducers of radial and axial movement;
- the rotor speed transducers.

Advantages of the system:

- lower operating costs;
- longer service life of the bearing parts;
- higher efficiency due to absence of mechanical losses;
- fewer additional equipment;
- higher reliability;
- better environmental characteristics.



Active magnetic bearing control cabinet



Active magnetic bearing system



## Semiconductor frequency converters

Produced under the license of Convertteam or Joint Venture “Siemens–Electric Drive”.

The semiconductor frequency converters are equipped with an input matching transformer (transformers), cooling system, providing the output parameters of the electric drive to the preset accuracy in case of changing supply voltage, acceleration and deceleration of the electric motor at a preset rate within the allowable output current of the semiconductor frequency converter.

## High speed electric motors

The el. motor power rating — 4.0; 6,3 and 12.5 MW.

The el. motors produced at the “Siemens–Electroprivod” Co., Ltd. are designed to drive the centrifugal compressor having squared relationship between the torque on the shaft and speed. The torque of the electric motor is transmitted directly to the compressor shaft by means of an intermediate flexible shaft.

The electric motor operates as part of the frequency variable electric drive with power supply from the frequency converter.

The 4 and 6 MW el. motors are cooled by air. The 4.0 MW el. motor is equipped with a built-in fan; the

6.3 MW el. motor is provided with an external ventilation unit. The 12.5 MW el. motor has a combined air–liquid cooling with an internal heat–exchanger.

The control system of the semiconductor frequency converter is microprocessor–based and provides control of the el. motor, control, diagnostics and protection of the semiconductor frequency converter.

The operating area of the semiconductor frequency converter relay protection covers both the electrical circuits of the semiconductor frequency converter proper, and the el. motor stator coils.

The cooling system of the semiconductor frequency converter allows for any number of starts of the EGPU without limiting the interval between starts.

## Converter protection

Type of protection	Protection implementation
Current protection against external multi-phase shorting	Current cutoff without time delay
Current protection against single - phase ground short circuit	Current protection without time delay, operating for trip
Protection against overload	Operates for reduction of the motor rotor speed
Current protection against phase failure	Operates for trip without time delay
Protection against the internal cooling system failures	Its operation is determined by the algorithms specified in the operational documentation
Protection against voltage rise	Operates for trip
Protection against voltage drop	Operates for trip with a delay and possible use of kinetic energy store of the motor rotor to maintain voltage



High-speed electric motor



### Automatic Control and Governing System of the EGPU

The ACS is similar to that of the EMCM (electronic means of control and management) type and is designed to provide the preset operating conditions and to control the main parameters of the gas-pumping unit, its continuous and trouble-free operation.

The ACS provides the operation of the EGPU both completely independently, and as part of the compressor station under control of the dispatcher level systems.

The EGPU ACS is made as an integrated complete control and information system for the EGPU and its auxiliary equipment based on the industrial and proven hardware, information and software, using the rational number of the information representation formats.

#### ACS components:

- control cabinet — one per compressor;
- monitoring and control panel consisting of:
  - standby control panel — one per compressor;
  - operator's workstation — two compl. sets (one — the main for a group of compressors and the other — standby).

### Advantages of the EGPU produced by REP Holding:

- application of the frequency variable electric drive;
- application of magnetic bearings and dry gas dynamic seals;
- decrease in the operating costs due to employment of the direct drive and absence of the oil system;
- complete automation of the equipment, application of the minimally manned technologies;
- energy saving up to 30 %;
- possibility of remote operation of the compressor station equipment;
- compliance with the up-to-date environmental requirements;
- packaged turnkey supply of the unit.



Frequency converter



Automatic control and governing system



### Centrifugal Compressors for Gas-Pumping Units driven by GTU

This group of units includes compressors of a new generation that differ from the previously developed in the availability of forged barrel-type casings.

#### General description of the design

Packages of compressors, consisting of the stator elements, rotor, bearings, seals and butt parts, are fixed in boring casing thrust rings, perceiving the pressure of the gas.

The compressor is driven directly by the turbine, without a gear unit, through a flexible coupling.

The compressor rotor consists of the shaft with fitted-on three impellers, balancing piston, thrust disc, bush and axial replacement transducer disc.

The dry gas seal (DGS) assemblies are made as single one-piece modules arranged as "double serial seals with supply of barrier air for purging the double end labyrinth". The DGS assemblies are supplied in the reversible version. The compressor is equipped with appliances that make it possible to perform full and partial disassembly inside the compartment for further maintenance or repair.

#### 125-31-1C, 170-31-1C Compressors

##### Purpose

The 170-31-1C, 125-31-1C compressors are incorporated into the GPU-4RM-03 and GPU-4RM-03 and are designed for compression and movement of natural gas via the gas-main pipelines in the CS conditions with a high pressure.

##### The main components of the compressor:

- compressor casing;
- compressor package;
- ACS system;
- lubrication system;
- dry gas seals system;
- compressor rotor.

##### Design features

The package is secured in the casing by means of the split thrust ring that allows to quickly disassemble the compressor. The compressors differ in the geometry of the flow passage.

The gas turbine unit power rating is 4MW, the nominal speed is 10300 rpm. The compressor is driven directly by the turbine, without a gear unit.

The compressors are unified with the 151-21-1C and 47-71-1C compressors in its general concepts and the assemblies used.

The flow passages of the compressor is made with three-level impellers, which have small inlet and outlet angles of blades to provide a wide range of steady operation. The compressor casings

are made from steel forgings with welded-on discharge branch and suction pipes. The compressor is packaged into a common container with all the operation support systems.



170-31-1C Compressor



## 151-21-1C Compressor

### Purpose

The 151-21-1C compressor is incorporated into the GPA-4RM-01 and is designed for compression and movement of natural gas via the gas pipelines. The 151-21-1C compressor is unified with the 47-71-1C compressor in its general concepts and the assemblies used.

### The main components of the compressor:

- compressor casing;
- compressor package;
- ACS system;
- lubrication system;
- dry gas seals system;
- compressor rotor.

### Design features

The compressor casing is made from a steel forging with welded-on discharge branch and suction pipes. The suction branch pipe is arranged at 45° on the side opposite to the discharge branch pipe. Fully assembled a package of compressor start in the cylinder bore all the way up the Burt and is fixed from the axial movement of the split ring.

The compressor is packaged into a common container with all the operation support systems. The compressor is driven by the gas turbine unit.

## 385-21-1 Compressor

The 385-21-1 compressor is part of the gas-pumping unit GTNR-16 and is designed to compress and transmit natural gas via gas main pipelines with a working pressure of 7.45 MPa.

The gas-pumping unit GTNR-16 is designed for the reconstruction (re-equipment) of the GTK-10-4 unit.

### Design features

The compressor is driven by the 16 MW gas turbine.

The compressor is of centrifugal type, two-staged, with a radial admission and tangential removal of gas, oil bearings and oil end face seals (can be completed with dry gas dynamic seals at the Customer's request).

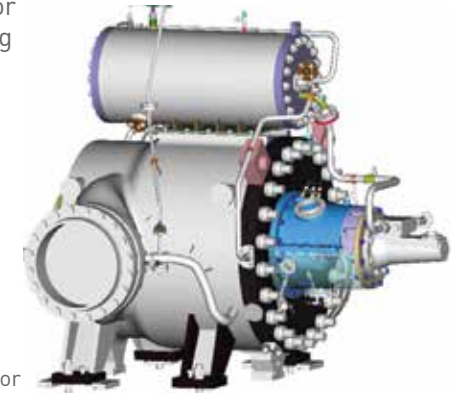
The compressor casing is made of cast steel and has circumferential grooves that present the channels of the flow path. The inlet and outlet ducts are cast as a single piece with the cylinder and have welded flanges Dnom 700 for connection to the gas pipeline.

The cylinder together with the package forms the flow path of the compressor. The sense of the compressor rotor rotation is right-handed, as per GOST 22376-77 (clockwise, if the compressor is viewed from the drive side).

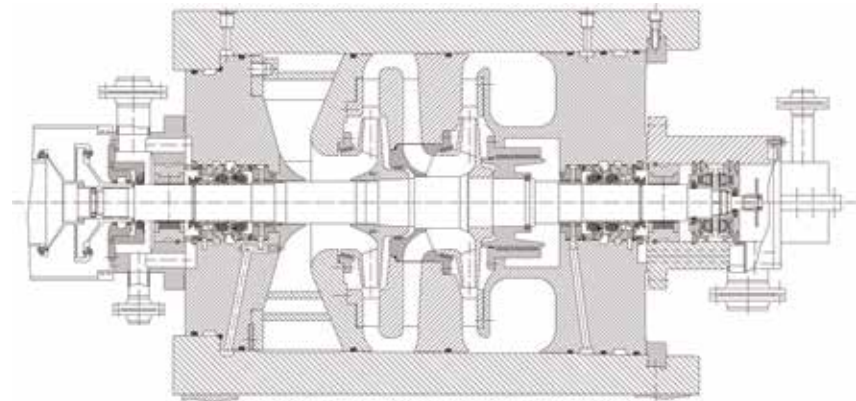
The compressor design provides for installation of a dry gas seal with the adequate modification of the oil supply system. The startup and shutdown of the compressor is performed with the full working pressure in the loop.

### The unit part components:

- casing;
- package;
- oil end face seals;
- oil bearings;
- oil supply system;
- joint part;
- oil accumulator;
- foundation frame.



385-21-1 compressor



Sectional view of the 151-21-1C Compressor





## Compressor 125-32-1C

### Purpose

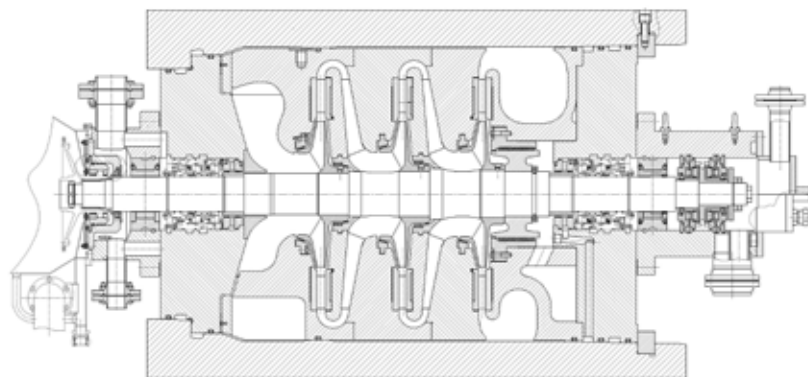
Compressor 125-32-1C, being equipped with the dry gas seals and the oil bearings, is a part of the 4MW gas-pumping unit, and is purposed to transfer the natural gas via the main pipeline with the outlet pressure of 5.56 MPa and the compression ratio of 1.8.

### Design Features

Direction of compressor's rotor rotation is clockwise when the compressor is viewed from the driver side. The gas feeding (suc-

tion) pipe is located from the left side (when the compressor is viewed from the driver side – i.e. gas flows from left to right), the pipe branch is positioned at the angle of 45°. The discharge pipe branch is located horizontally. The compressor's pipe branches are connected to the process lines by means of flanges.

The compressor is driven by the 4MW gas-turbine engine. The rotation frequency of the power turbine rotor is 10500 rpm in the rated power mode.



Longitudinal Section of Compressor 125-32-1C

## Compressor 215-61-1C

### Purpose

Compressor 215-61-1C, equipped with the dry gas seals and the oil bearings, is a part of the 5MW gas-pumping unit, and is purposed to be applied at the booster compressor station.

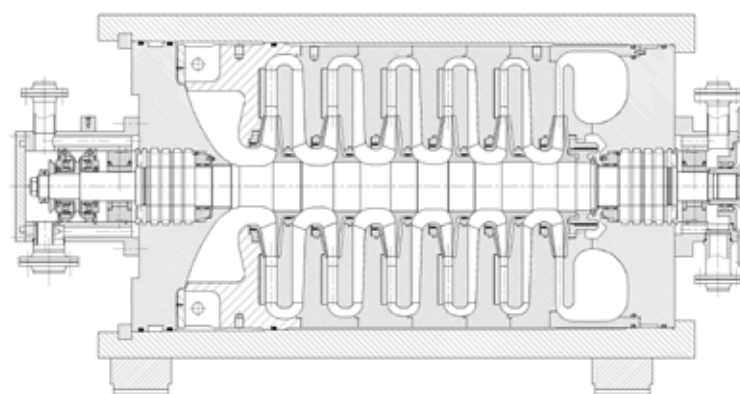
### Design Features

Direction of compressor's rotor rotation is clockwise when the compressor is viewed from the driver side. The location of inlet and outlet pipe branches (when viewed from the driver side) is as follows: inlet pipe branch – from the right side,

the outlet pipe branch – from the left side located from the left side. The compressor's pipe branches are connected to the process lines by means of flanges.

The compressor is driven by the 5MW gas-turbine engine. The rotation frequency of the power turbine rotor is 10000 rpm in the rated power mode.

The compressor's casing accommodates the replaceable flow passage (bundle) with the pressure ratio up to 4.0 in the nominal mode.



Longitudinal Section of Compressor 215-61-1C



## The Main Technical Characteristics of the Compressors

Name of parameter	Value						
	170-31-1C	125-31-1C	170-31-1C	125-31-1C	151-21-1C	151CПЧ1,6 5/4,83C	385-21-1
Volume capacity referred to 20°C and 0.1013 MPa, mil m <sup>3</sup> /day	5.25	4.3	5.25	4.3	7.87	4.43	32
Volume capacity referred to the initial conditions, m <sup>3</sup> /min.	150	123	150	123	151	96.1	385
Final gas pressure at the compressor outlet, MPa, abs.	3.74	3.74	3.74	3.74	4.62	4.83	7.45
Pressure ratio	1.7	1.7	1.7	1.7	1.4	1.65	1.44
Polytropic efficiency, no less than	0.82	0.84	0.82	0.84	0.84	0.82	0.85
Power consumed by the compressor, MW	3900	3400	3900	3400	3750	3250	15.2
Gas pressure at the compressor inlet, MPa	2.2	2.2	2.2	2.2	3.3	2.93	5.174
Gas temperature at the compressor inlet, °C	2	2	2	2	10	8.5	15
Gas density referred to 20°C and 0.1013 MPa, kg/m <sup>3</sup>	0.681	0.681	0.681	0.681	0.6913	0.6913	0.682
Nominal rotor speed, min <sup>-1</sup>	10300	10400	10300	10400	10200	10300	5050
Overall dimensions of the compressor unit, mm.: Length Width Height	2230	2230	2230	2230	2037	2037	2900
	1590	1590	1590	1590	1590	1590	2530
	1435	1435	1435	1435	1435	1435	3150
Mass of the heaviest parts, kg Unit casing package							26800
							12200
							9900
Hoisting height of the crane hook from the floor level of the machine room for package disassembly, mm	2200	2200	2200	2200	1500	1500	
Mass of the heaviest parts, kg for mounting (inside the container) For operation (outside the container)	9550	9740	9550	9740	8500	8500	24600
	1000	1000	1000	1000	1000	1000	8800



REP Holding designs and manufactures centrifugal compressors of new generation with highly efficient flow passages for electrically-driven and gas-turbine-driven gas-pumping units rated within the power range from 4.0 to 32.0 MW.

Due to its design experience REP Holding can design highly-efficient flow passages for the centrifugal compressors with wide operating ranges. New models have some advantages over the centrifugal compressors of the previous generation, such as, first of all, polytropic efficiency, and standardization and unification of the compressor's flow passage components and assemblies.

Pattern stages with 3D-blade impellers sufficiently increase effectiveness of the centrifugal compressors' flow passage. REP Holding uses the advanced technologies of the local machine-building industry in designing of the centrifugal compressors, and thus can provide high efficiency values of the flow passages due to increase in polytropic efficiency.

REP Holding has its own production facilities for manufacturing of the magnetic bearings (under the license of SKF). Active magnetic bearing system is successfully applied not only in the electrically-driven gas-pumping units, but also in the centrifugal compressors that

are the part of the gas-pumping units of the main gas transfer pipelines, and in the booster compressor stations.

### Advantages of REP Holding compressors:

- Decrease of operation cost;
- Twice longer life of the bearings as compared to life of the oil bearings;
- Increase of the efficiency due to absence of the mechanical losses;
- Reduced number of additional equipment;
- Increase of reliability;
- Improved environmental characteristics.

According to GPA Standardization Program (OAO Gazprom) REP Holding designed and manufactured the 16 MW standardized centrifugal compressor with the polytropic efficiency of 87 - 88%.

Standardization of the centrifugal compressors implies designing of the standard elements of the flow passage, sealing and bearings. The benefit from standardized centrifugal compressors is decreasing of the manufacturing period and manufacturing cost.



Pattern Axial-Radial Impellers with 3D Blades



## Centrifugal compressor 405-21-1C

Centrifugal compressor 405-21-1C is purposed to transfer gas via the main gas transfer pipelines, and has a vertically split casing, equipped with the dry gas seals and oil plain bearings. The compressor's casing allows to use the replaceable flow passages with the pressure ratio 1,35, 1,44(1,5) and 1,7 for the absolute outlet pressure of 9.91MPa (101 kgf/cm<sup>2</sup>).

The main advantages of the compressor 405-21-1C:

- standardization of the flow passage assemblies and components;
- high efficiency;
- capability of use with various types of GTU.

REP Holding has designed a range of standardized compressors for various power classes.



Standardized Centrifugal Compressor  
405-21-1C

Parameter	Unit of Measurement	16 MW	25-32 MW	4-6.3 MW	
		type 405-21-1C	type 400-21-1C	type 220-11-1*	type 200-21-1*
Capacity at 20°C and 0.1013 MPa	mIn. nm <sup>3</sup> /day	33.0	78.6	12.5	12
Capacity at the input conditions	m <sup>3</sup> /min	400	505	220	202
Outlet gas pressure absolute at the exit from the discharge pipe branch	MPa	7.45	11.86	4.41	5.49
Pressure ratio	-	1.44	1.4	1.26	1.44
Polytropic efficiency	-	0.875	0.85	0.85	0.85
Power consumed by compressor	MW	15.50	30.4	3.8	6
Input Conditions					
Absolute gas pressure, at the inlet of the suction pipe branch of the compressor	MPa	5.17	8.45	3.5	3.8
Gas temperature at the inlet of the suction pipe branch of the compressor	°C	15	5	15	15
Gas density at 20°C and 0.1013 MPa	kg/m <sup>3</sup>	0.676	0.689	0.682	0.682
Frequency of rotation of the compressor rotor	rpm	5200	5550	8200	8200

\* Magnetic Bearing System with dry seals and magnetic bearing



## Centrifugal compressors. New technologies

### Integrally-Machined Axial – Radial Impellers with 3D Blades for Centrifugal Compressors

Integrally-machined axial – radial impellers with 3D blades are innovative high-technology flow path elements shaped to significantly increase compressor polytrophic efficiency and reliability. The impellers are produced on a special machining center from a solid stock, with no welding and riveting operations being applied which leads to

overall impellers' and compressors' reliability growth.

The axial – radial impellers were designed for centrifugal compressors applied on the gas trunk lines and booster compressor stations.

Centrifugal compressor 910-41-1 CMП is the first unit with 3D blade integrally-machined axial – radial impellers developed by REP Holding specialists. The compressor is designed for associated gas compression and transportation. It is applied in assembly with gas-pumping units at gas producing industry booster compressor stations.

#### Technical characteristics:

Value description	UOM	Nominal mode	Additional mode
Capacity referred to 20°C and 0.1013 MPa	MMNCMD	13.0	16.4
Capacity referred to initial conditions	m <sup>3</sup> /min	910	1015
Final gas pressure, abs., at the discharge branch pipe outlet	MPa	2.058	2.058
Pressure ratio	-	2.2	1.96
Power consumed by compressor	MW	15.2	18.4
Compressor rotor speed	rpm	5150	5150
Polytrophic efficiency, no less than		0.820	0.725

In order to manufacture integrally-machined axial – radial impellers with 3D blades “Nevsky Zavod” re-designed its production lines and purchased the up-to-date turning-and-milling machining center with five-axis machining capability (“OKUMA VTM-YB”).

The reduced production cycle time and extended machining accuracy is the current (working) center major advantage.

#### Main advantages:

- Efficiency increase by 5%
- Improved reliability
- Expanded range of capacity and head characteristics
- Reduced mass and overall dimensions of the design
- Reduced operational life

REP Holding is a Russian power engineering Company, a designer, manufacturer and supplier of new generation power equipment. REP Holding provides engineering de-

sign, manufacturing and package supply of power and electrical equipment for oil & gas, metallurgical and chemical industry, power generation and integrated power grid.

REP Holding incorporates production, research-engineering and service enterprises such as “Nevsky Zavod” and “Electropult”, two of the largest St. Petersburg facilities, and Power Machine Building and Electrotechnics R&D Institute.

Vast design experience, modern production facilities and in-house R&D base enables REP Holding to develop wide range of new generation compressor equipment with extended field of application in Oil&Gas, chemical and metallurgical industries, as well as within comprehensive upgrading programs implementation.

The equipment features up to 89% polytrophic efficiency, reliability and improved environmental performance.



Integrally-machined axial-radial impellers with 3D blades



## New-Generation Centrifugal Compressor 285-61-1СМП with Active Magnetic Bearing and Extended Operational Life

Centrifugal Compressor 285-61-1СМП is one of the recent REP Holding developments. The compressor design employs the active magnetic bearing system and dry gas dynamic seals. The active magnetic bearing provides rotor contactless rotation in the controlled magnetic field. Absence of friction and oil elements increases the life time of the bearing parts, the unit efficiency, reduces operating costs. Rep Holding established in-house production of electric drives and magnetic bearings under S2M (SKF) licenses.

### Compressor 285-61-1СМП configuration:

- barrel type casing;
- six compression stages;
- volute outlet chamber;
- dry gas dynamic seals;
- active magnetic bearing.

Compressor 285-61-1СМП is designed for compression and transportation of natural gas. It is applied in assembly with gas-pumping units at booster compressor stations of the gas producing industry.

### Compressor 285-61-1СМП main advantages:

- “dry” version (dry gas dynamic seals and active magnetic bearing system)
- twofold operational life increase
- higher efficiency due to no mechanical losses
- assemblies and parts commonality (up to 80% elements substitutability)
- universal compression casing accommodating replaceable flow passages with pressure ratio from 1.5 to 4.0
- reduced operational costs
- improved reliability of the design
- reduced amount of additional equipment
- Russian components

- Energy losses reduction by 200 kW
- Higher efficiency

- Improved environmental performance



Centrifugal Compressor 285-61-1СМП

### Compressor 285-61-1СМП technical characteristics:

Value description	UOM	Nominal mode	Second warranted operating mode
Capacity referred to 20°C and 0.1013 MPa	MMNCMD	21.30	26.93
Capacity referred to initial conditions	m <sup>3</sup> /min	283.0	318.0
Final gas pressure, abs., at the discharge branch pipe outlet	MPa	10.35	10.35
Pressure ratio	-	2.2	1.953
Power consumed by compressor	MW	23.75	26.70
Compressor rotor speed	rpm	4900	
Polytropic efficiency, no less than	-	0.825	0.780
Gas density referred to 20°C and 0.1013 MPa	kg/m <sup>3</sup>		0.763



## New-Generation Centrifugal Compressor 910-41-1СМП with Active Magnetic Bearing and Integrally-Machined Axial – Radial Impellers with 3D Blades

Centrifugal Compressor 910-41-1СМП is one of the recent REP Holding developments featuring higher capacity and efficiency. The compressor design employs integrally-machined axial – radial impellers with 3D blades, the active magnetic bearing system and dry gas dynamic seals. Rep Holding established in-house production of electric drives and magnetic bearings under S2M (SKF) licenses.

### Technical characteristics:

Value description	UOM	Nominal mode	Additional mode
Capacity referred to 20°C and 0.1013 MPa	MMNCMD	13.0	16.4
Capacity referred to initial conditions	m <sup>3</sup> /min	910	1015
Final gas pressure, abs., at the discharge branch pipe outlet	MPa	2.058	2.058
Pressure ratio	-	2.2	1.96
Power consumed by compressor	MW	15.2	18.4
Compressor rotor speed	rpm	5150	5150
Polytropic efficiency, no less than		0.820	0.725

### Configuration:

- barrel type casing
- 4 compression stages (3 out of them with axial – radial impellers)
- volute outlet chamber
- dry gas dynamic seals
- active magnetic bearing

Integrally-machined axial – radial impellers with 3D blades are innovative high-technology flow path elements shaped to significantly increase compressor efficiency (by 5%), reliability and operational life. Integrally-machined axial – radial impellers also provide an expanded range of capacity and head characteristics, as well as reduced mass and overall dimensions of the design.

### Main advantages:

- active magnetic bearing system and dry gas dynamic seals
- standardized assemblies and parts
- reduced operational costs and the amount of additional equipment
- improved reliability of the design
- twofold operational life increase
- higher efficiency due to no mechanical losses
- unique capacity in the 16 MW power rating with final pressure no less than 3.0 MPa

Compressor 910-41-1 СМП is designed for compression and transportation of associated gas. It is applied in assembly with gas-pumping units at booster compressor stations of the gas producing industry.

- Russian components
- Energy losses reduction by 200 kW
- Up to 80% elements substitutability
- Improved environmental performance



Centrifugal Compressor 910-41-1СМП



## The mixed refrigerant centrifugal compressor K905-71-1C

The first in Russia compressor K905-71-1C was manufactured at Nevskiy Zavod in 2017 and is used during the technological process of natural-gas liquefaction. The compressor includes high-tech elements of the bundle - integrally-milled axialradial impellers with spatial blades. "REP Holding" is the only company in Russia which mastered the production technology of such elements and uses them in innovative developments.

### Compressor K905-71-1C configuration

- Two sections compressor with "barrel" type casing
- 7 compression stages: 4 – for the first section, 3 – for the second
- Dry gas dynamic seals
- Roll-out device, set of the special tools

The mixed refrigerant compressor was successfully tested at Nevskiy plant, confirmed the technical characteristics, mentioned in the project. "REP Holding" became the first in Russia and the third in

the world manufacturer of compressor equipment of this type.

Mastered by «REP Holding» the production of mixed refrigerant compressors in future helps to create Russian technology for natural-gas liquefaction, increase the share of high-tech domestic equipment, used for large-tonnage plants construction, and also reduce the dependence on service programs of foreign manufacturers.

### Compressor K905-71-1C main advantages

- Reduced operational costs and quantity of additional equipment

- Operational life increase and unit improved reliability by using the part made from a single blank (without welding and clapping);
- Stage efficiency increasing up to 2-4% by 3D spatial forming of the bundle;
- Standardized assemblies and parts;
- Expansion of productivity and pressure loads range;
- Weight and dimension parameters decrease.
- Russian solutions and materials
- Up to 80% elements substitutability
- Independence from foreign service
- High level of polytropical efficiency

### Compressor K905-71-1C technical characteristics:

Value description	The first section	The second section
Volume efficiency, related to 0° and 0,1013 MP, ths. nm <sup>3</sup> /h	147,000	134,492
Volume efficiency, related to the initial conditions, m <sup>3</sup> /h	54146	8077
Initial gas pressure (abs.), on the inlet, bar	3,0	17,7
Final gas pressure (abs.), on the exhaust, bar	18,2	51,0
Pressure index	6,067	2,881
Inlet gas temperature, °C	33,0	35,0
Polytropic efficiency, not less than	0,825	0,805
Power, consumed on the turbine coupling, MW		17,230
Rotor speed, rpm		6200



Mixed refrigerant centrifugal compressor K905-71-1C





## Units for Underground Gas Storage

### 47-71-1C Compressor for Compressor Stations of Underground Gas Storage

#### Purpose

The 47-71-1S (47-71-1) compressor is included in GPU-4RM as part of GPU-4RM-02 and is designed for gas injection into the underground storage facility.

#### The main components of the compressor:

- compressor casing;
- compressor package;
- journal and thrust bearings;
- ACS system;
- lubrication system;
- dry gas seals system;
- compressor rotor.

#### Design features

The compressor is driven by the gas turbine produced by JSC "NPO "Saturn".

The GTU power is 4MW, nominal rotor speed is 10 200 rpm.

The compressor is driven directly from the turbine, without a gear box.

The flow passage of the compressor is designed with vaneless diffusers to provide a wide range of steady operation. The branch pipes are arranged on one side. Inside the casing boring inserted is the package consisting of two covers, suction chamber and diaphragms connected with each other by elastic ties. The suction chamber and diaphragms are horizontally split.

#### Technical characteristics

Parameters	Type of compressor	
	47-71-1C	47С СПЧ 2,5/116
Volume capacity referred to 20°C and 0.1013 MPa, mil m <sup>3</sup> /day	3.44	2.51
Volume capacity referred to the initial conditions, m <sup>3</sup> /min.	45	44
Final gas pressure at the compressor outlet, MPa abs.	9.5	8.25
Pressure ratio	1.98	2.34
Polytropic efficiency, no less than	0.8	0.805
Power consumed by the compressor, kW	3650	3300
Gas pressure at the compressor inlet, MPa	4.8	3.53
Gas temperature at the compressor inlet, °C	15	6
Gas density referred to 20°C. 0.1013 MPa, kg/m <sup>3</sup>	0.682	0.682
Nominal rotor speed, min <sup>-1</sup>	10290	10350



## Replaceable Flow Paths (RFP) for Modernization of Serial Natural Gas Compressors

The replaceable flow paths (RFP) are designed for modernization of the of the life-expired and obsolete gas-pumping unit compressors, as well as in case of changes in the compressor station operating conditions.

### Complete set of the unit

The package consists of the rotor, stator elements and seals of the flow path, bearings and high pressure end face seals, the joint with the drive and overhead main oil pump that supplies oil both to the high pressure system and to the lubrication system of the modernized compressor. During operation the compressor becomes completely independent of the external power supply. The stator elements of the flow path are made without a horizontal split. The rotors of all the flow paths are made two-point.

The replaceable flow passage can apply the system of magnetic bearings. The magnetic bearing system is manufactured at the facilities of Nevskiy zavod under the licensed technology of S2M.

### The Main Parameters of the replaceable flow paths for Modernization of Serial Natural Gas Compressors

Name of parameter	Type of Replaceable Flow Path									
	235-26-1	235 СПЧ 1,32/76 -5000 ЭГПА	235-28-1	295ГЦ2-500/26-45М	235 СПЧ 1,4/76-5300-АЛ -31СТ	370 СПЧ 1,4/7,45 -9000	370 СПЧ 1,4/76 -6500 -ПС90	СПЧ-295-16/30-3.0 СМ	155 СПЧ 10/76-2.2С	СМЧ 16_76
Volume capacity referred to 20 °C and 0,1013 MPa, mln m <sup>3</sup> /day	28	30,4	35	11,4	39	18,16	23,45	8,58	7,67	38
Mass capacity, kg/s	221	240	276,2	90,5	244,3	143,3	185			
Volume capacity referred to the initial conditions, m <sup>3</sup> /min.	312	332,8	408	441,4	377	212	248	485	156	460
Final gas pressure at the compressor outlet, MPa abs.	7,45	7,45	7,45	4,02	7,45	7,45	7,45	3,5	7,45	7,083
Pressure ratio	1,35	1,32	1,4	2,2	1,45	1,4	1,45	3,0	2,2	1,37
Polytropic efficiency, no less than	0,83	0,83	0,82	0,80	0,81	0,81	0,83	0,81	0,82	0,835
Power consumed by the compressor, MW	11,5	11,5	15,95	15,2	16,0	8,5	13,2	15,0	9,5	15,80
Initial conditions: gas pressure at the compressor inlet, MPa, abs.	5,52	5,64	5,32	1,83	5,14	5,32	5,14	1,167	3,39	5,17
Gas temperature at the compressor inlet, °C	15	15	15	30	15	15	15	8	35	15
Gas density referred to 20 °C and 0,1013 MPa, kg/m <sup>3</sup>	0,682	0,682	0,682	0,686	0,682	0,682	0,682	0,686	0,766	0,682
Nominal speed of the rotor, min <sup>-1</sup>	5000	5000	5200	5300	5300	4800	6500	5150	8800	5150
Compressor drive	СТД-12500	СТД-12500	ДЖ-59 или ДГ-90	ПС-90	АЛ-31 СТ	ГТК-10-4	ПС-90	295ГЦ2-500/26-45М	НЦ10 ДКС-01	НЦ-16/76-1.44
Type of the package	I	I	I		I	I	I			



Name of parameter	Type of Replaceable Flow Path					
	370-21-2	370 СПЧ 1,23-6500 ПС	370 СПЧ 1,5/76-ЭГПА-Р	520-21-1	650-23-1	650 СПЧ 1, 37/76-5000-НК36СТ
Volume capacity referred to 20 °C and 0,1013 MPa, mln m <sup>3</sup> /day	25,4	32,6	20,75	32,0	36,9	54,0
Mass capacity, kg/s	200,5	251,5	162,8	252,6	291,5	426,2
Volume capacity referred to the initial conditions, m <sup>3</sup> /min.	300	430	260,6	528	420	610
Final gas pressure at the compressor outlet, MPa abs.	7,45	7,11 (at the output of 2nd compressor)	7,45	5,49	7,45	7,45
Pressure ratio	1,42	1,54	1,5	1,42	1,37	1,37
Polytropic efficiency, no less than	0,81	0,83	0,84	0,81	0,83	0,835
Power consumed by the compressor, MW	12,4	10,5 (on the socket of the 2nd compressor)	11,4	15,9	15,85	23,2
Initial conditions: gas pressure at the compressor inlet, MPa, abs.	5,546	4,61 (of the 1st compressor)	4,97	3,866	5,44	5,44
Gas temperature at the compressor inlet, °C	15	10 (at the input of the 1st compressor)	15	15	15	15
Gas density referred to 20 °C and 0,1013 MPa, kg/m <sup>3</sup>	0,682	0,682	0,6783	0,682	0,682	0,682
Nominal speed of the rotor, min <sup>-1</sup>	4800	6500	4800	5200	5200	5000
Compressor drive	СДГ-12,5-2	ПС-90	СДГ-12,5-2	ГТНР-16	ДЖ 59 ЛГ или ДГ-90	НК-36 СТ
Type of the package	II		II	II	II	II



Replaceable Flow Paths produced by REP Holding at the booster compressor station of the West Tarkosalinskiy gas field



Replaceable Flow Path at the test bed of the production site Nevskiy Zavod

## The supply objects

REP Holding performs packaged supply of up-to-date gas-pumping units to the compressor stations of the gas-main pipelines and for Gazprom reconstruction and new construction projects.



## Equipment for Gas Industry



Replaceable Flow Passage 155-1076-2.2C for the booster compressor station of OOO Gazprom Dobycha Urengoy



295 Replaceable Flow Passage at the booster compressor station of Zapadno-Tarkosalin gas field of OOO Gazprom Dobycha Noyabrsk



GPU-32 "Ladoga" to CS "Russkaya"



295 Replaceable Flow Passage on the test bench



Rotor 155 of the replaceable flow passage on the balancing machine Shenk



EGPA 4.0 MW on CS "Volodino" of the main gas transfer pipeline "Parabel-Kuzbass"



## Equipment for Oil Industry

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## Units for compression of oil gas

REP Holding performs packaged supply of equipment for the oil industry. These units are made as stationary, various sizes, featuring long service life and satisfactory repairability.

### Compressors for oil-associated gas

#### Purpose and application

The centrifugal compressor machines of this group are designed to compress raw oil gas and to supply it to the place of its utilization. These units are used at electric and thermal power stations, gas-processing plants, underground storage and other sites.

The machines are made as one- and two-cylinder explosion-proof versions. The units feature high mounting availability and are supplied fully completed, in pre-assembled modules, equipped with modern hardware making it possible to fully automate the unit control process.

#### The unit components

The unit includes a drive el. motor and the compressor unit with the ASKU automatic control system developed by CJSC REP Holding.

#### Standard completeness of the unit

The scope of supply includes compressor, electric motor, instrumentation and ASKU ACS. The compressors consist of cylinders with rotors, foundation plates and frames, anchor bolts, intermediate air cooler with supports and connecting air ducts, couplings, step-up gears, lubrication system (including the oil tank, filter unit and pumping unit), anti-surge control and protection system. Together with the compressor supplied is a complete set of appliances to lift the upper part of the compressor cylinders and rotors, for alignment of the compressor and drive rotors; wrenches and tools for technical maintenance; replacement spare parts and operational documentation.

#### Design features of the units

##### K890-122-1 compressor

The K890-122-1 compressor is designed to compress raw oil gas at gas-processing plants and field compressor stations and to supply it to the common collector.

The compressor represents a two-cylinder twelve-staged machine. Each cylinder includes six stages. The rotor of each cylinder has its

own optimum speed. The step-up gears are installed between the L.P. cylinder and el. motor drive, as well as between the cylinders. The tightness of the compressor cylinders is provided by the end face seals.

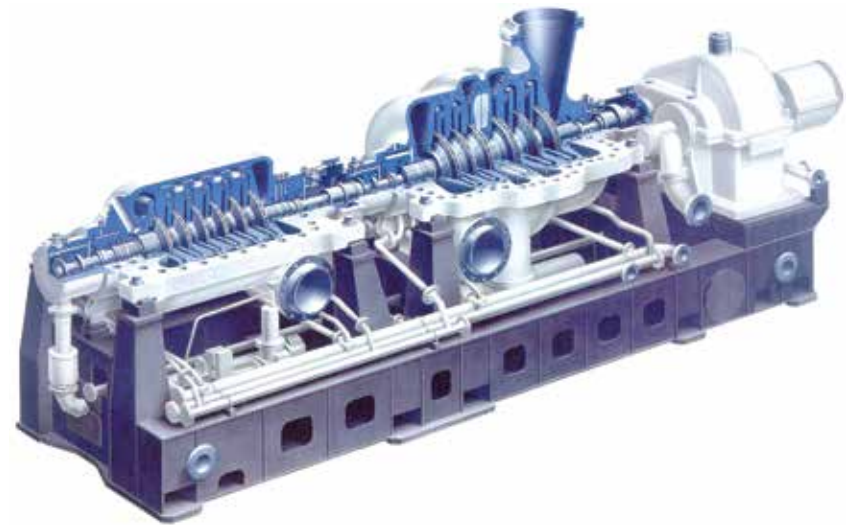
Gas and oil are cooled in the air coolers.

##### K411-122-1 compressor

The K411-122-1 compressor is designed to compress raw oil gas with a density of 0.824 to 1.12 kg/m<sup>3</sup> at gas-processing plants and field compressor stations and to

supply it to the common collector. The compressor proper represents a two-cylinder three-section twelve-staged machine with vaneless diffusers. The L.P. cylinder sections feature opposite direction of the compressed air flow, which reduces leakages through the balance piston. The cylinder casings are horizontally split. The compressor is equipped with anti-surge protection and a bleed-off valve allowing for operation in the partial load conditions.

The tightness of the compressor cylinders is provided the end face seals.



K 411-122-1 compressor



## Equipment for Oil Industry

### Main technical characteristics of the units

Parameters	K890-122-1	K411-122-1	K410-121-1	K410-121-2	415-61-1	K354-101-1	K380-103-1	K320-131-1	340-81-5
Mass capacity, kg/f	19,4 (18,25)	8,93	8,93	10,1	11,72	9,53 (9,73)	9,73	10,086	13,5
Volume capacity at suction conditions, m <sup>3</sup> /min	760 (820)	372	372	395	372	355 (345)	345	320	300
Final gas pressure, MPa, abs.**	3,63	3,53	3,7	3,7	1,57	3,82	3,82	3,1	1,3
Gas density, kg/m <sup>3</sup>	0,98 (0,957)	0,91*	0,91*	1,12**	0,91*	0,83 (0,913)	0,98	0,75	1,42
Initial gas parameters									
Temperature, °C	15	15	15	30	15	15	15	15	35
Pressure, MPa, abs.	0,157	0,157	0,157	0,147	0,206	0,186	0,186	0,25	0,1275
Nominal rotor speed (L.P. cylinder/ H.P. cylinder), min <sup>-1</sup>	5240 HPC 9270 HPC	11129	10345	9677	10345	8559 HPC 18419 HPC	8100/ 17445	10800	4800/ 9370
Power consumed by the rotor, MW	10,0 (11,2)	4,95	5,17	4,95	4,243	5,2 (5,3)	5,3	5,3	3,0
Overall dimensions, m:									
Foundation length	16,3	11	11	11	8,2	12,2	12,2	12,2	7,0
Foundation width	4,5	2,9	2,9	2,9	2,9	4,0	4,0	4,0	2,8
Height	2,6	2,0	2,0	2,0	4,0	4,8	4,8	4,8	2,0
Hoisting height of the crane hook over the floor level of the machine room	5,0	4,9	4,9	4,9	4,2	3,5	3,5	3,5	4,2
Design mass, t:									
Compressor in the scope of supply (without el. motor drive)	77,3	38,89	37,65	37,65	26,23	34,8	35,0	35,0	29,0
The heaviest part for:									
Mounting	36 (L.P.C. unit)	24 (compressor unit)	22,4 (compressor unit)	22,4 (compressor unit)	14,5 (compressor unit)	10,2 (el.motor stator)	10,2 (el.motor stator)	25 (compressor unit)	7,15 (main el.motor)
Operation	10 (upper part of the L.P.C. casing)	4,3 (el.motor rotor)	4,3 (el.motor rotor)	4,3 (el.motor rotor)	3,17 (el.motor rotor)	3,5 (upper part of the L.P.C. casing in assy)	3,5 (upper part of the L.P.C. casing in assy)	5,2 (HPC package)	2,5 (upper part of the L.P.C. casing in assy)

\* Operation on gas with density of 0.824; 1.02; 1.12 kg/m<sup>3</sup> is also available alongside with the above-mentioned values .

\*\* Operation on gas with density of 1.22; 1.35 kg/m<sup>3</sup> is also available alongside with the above-mentioned values.



### 415-61-1 compressor

The 415-61-1 compressor is designed to compress raw oil gas with a density of 0.824 to 1.12 kg/m<sup>3</sup> at field compressor stations and to supply it to the common collector.

The compressor represents a one-cylinder six-staged centrifugal compressor machine and is provided with hermetical end face seals. The compressor is supplied with two gear pairs of the step-up gear designed for operation on gas with the following density values, kg/m<sup>3</sup>: 0.824; 0.91; 1.02; 1.12. Operation on gas with other density values is provided by installation of replacement gear pairs. The compressor casing is horizontally split.

### K 354-101-1 compressor

The K 354-101-1 compressor is designed to compress oil gas at gas-processing plants.

The compressor and all the completing equipment are explosion-proof and can be operated in the explosive room of B-1A class, with 2T-2 explosive mixture category and group.

The compressor is two-cylinder, two-section, ten-staged. The tightness of the compressor cylinders is provided by means of oil end seals.

The el. motor and the exciter are explosion-proof, blown through under gage pressure in the closed ventilation cycle.

The compressor unit is equipped with the systems of control, protection, monitoring and signalling, protection against backflow of gas from the network to the compressor, against surge, axial displacement of rotors of all the cylinders, against temperature rise of the unit bearing shells, as well as against oil pressure reduction in the lubrication system.



K354-101-1 compressor





### Upgraded Unit Based on K320 Compressor

The K320-131-1 centrifugal compressor is designed to compress oil gas at gas-processing plants.

The compressor and all the completing equipment are explosion-proof and can be operated in the explosive room of B-1A class, with 2T-2 explosive mixture category and group.

The compressor is two-cylinder, two-section, thirteen-staged. The tightness of the compressor cylinders is provided by means of oil end seals. The LP cylinder has a cast casing horizontally split. The HP cylinder has a forged barrel type casing with an end cover.



K320-131-1 centrifugal compressor at the Severo-Danilovskoye field TPP compressor station

The el. motor and the exciter are explosion-proof, blown through under gage pressure in the closed ventilation cycle.

The K320-131-1 compressor has been designed for the foundation dimensions of the K380-103-1 and K354-101-1 units, which makes it possible to replace the outdated equipment at minimum costs.

### Unit driven by the high-speed variable speed electric motor with K-230 compressor

The K-230 compressor is incorporated into the electrically-driven gas-pumping unit EGPU-4,0/14000 and is designed for compression and transmission of oil gas.

### The unit components:

- K230-81-1 SMP compressor;
- high-speed el. motor;
- semiconductor frequency converters;
- automatic control and governing system of the unit.

### Description of the K230-81-1 SMP compressor

The compressor is made one-cylinder, two-section, eight-staged. The compressor casing is forged, with a welded discharge branch pipe and a bolted suction branch pipe.

The compressor rotor is equipped with a magnetic bearing of the rotor, the digital control system of which is connected with the unit control and governing system of EMCM 4000/14 000 type. The nominal compressor shaft speed is 14 000 rpm, the drive power is 4.0 MW.

The tightness of the compressor is provided by dry gas dynamic seals. To prevent damage to the stator and rotor parts of the magnetic bearings after switching off the power and in case of emergency installed are auxiliary bearings that provide the emergency run-down of the rotor. The confusor and a set of transducers to measure gas parameters provide operation of the compressor anti-surge protection.

### Scope of supply:

- compressor unit;
- dry gas seals system;
- magnetic bearing system of the rotor, including the control cabinet with the UPS batteries (energy consumption of the magnetic bearing system  $\approx 5$  kW) and cables;
- restriction device set for the anti-surge protection system;
- a set of transition discharge branch pipe;
- foundation frame with fasteners;
- intermediate shaft guard up to the fire-proof partition;
- counter-flanges of the magnetic bearing system, dry gas seals system with sealing and fastening elements on the side of the compressor;
- complete set of plugs for pressure test of the gas loop;
- intermediate gas cooler;
- complete set of special tools;
- appliances for assembly and disassembly of the compressor and its component parts;
- complete set of replacement parts;
- complete set of replacement parts for mounting, pre-commissioning and acceptance tests;
- complete set of transport boxes;
- piping to supply and remove gas and air flows from the dry gas seals system instrumentation to the seal.



## Technical characteristics of the compressor

Name of parameter	UOM	Value
Nominal mechanical power consumed by the compressor on the el. motor intermediate shaft	kW	3800
Volume capacity referred to 20 °C and 0.1013 MPa	Ths m <sup>3</sup> /day	855
Volume capacity referred to the initial conditions	m <sup>3</sup> /min	235
Final gas pressure at the compressor outlet, abs.	MPa	3,5
Initial gas pressure at the compressor inlet, abs.	MPa	0,25
Gas temperature at the compressor inlet	°C	15
Nominal rotor speed	rpm	14000
Sense of the rotor rotation (clockwise, if the compressor is viewed from the drive side)	-	Right-hand

## The high speed electric motor

The high speed el. motor is designed to drive the K230-81-1 SMP centrifugal compressor having squared relationship between the torque on the shaft and speed. The torque of the electric motor is transmitted directly to the compressor shaft by means of an intermediate shaft. The electric motor operates as part of the frequency variable electric drive with power supply from the frequency converter and with the variation of the current frequency from 0 to 250 Hz and that of voltage from 0 to 3300 V.

The el. motor is equipped with the rotor magnetic bearing system manufactured by REP Holding under the license of S2M.

## Components of the complete set of magnetic bearings:

- magnetic bearing control cabinet providing digital control of the magnetic bearings;
- two radial magnetic bearings, including radial electro-magnetic supports with two units of radial-axial position transducers each;
- auxiliary bearings providing emergency rundown of the rotor to prevent damage to the surfaces of the stator and rotor parts of the magnetic bearings after switching off the power and in case of emergency.

The magnetic bearings are of modular design, convenient for assembly and disassembly of the el. motor.



High-speed electric motor



## Technical characteristics of the electric motor

Name of parameter	UOM	Value
Supply voltage at all operating conditions	V	3300
El. motor power rating	kW	4000
Maximum continuous power	kW	4200
Nominal efficiency	p.u.	0,958
Nominal torque	Nm	4658
Nominal current	A	970
Maximum continuous current	A	1020
Rotor moment of inertia	kg·m <sup>2</sup>	48
Mass	Kg	15500
Protection degree as per GOST 14254	-	IP22
Cooling system	-	air
Maximum allowable axial displacement of the rotor	mm	±2,5
El. motor mounting version	-	IM1001

## Electric motor protection

Type of protection	Protection implementation	Location
Current protection against external multi-phase shorting	Current cutoff without time delay	Frequency converter
Current protection against single-phase ground short circuit	Current protection without time delay, operating for trip	Frequency converter
Protection against overload	Current overload 123 % — warning is generated, current overload 126 % — emergency trip	Frequency converter
Current protection against phase failure	Operates for trip without time delay	Frequency converter
Protection against excessive rotor vibration		Magnetic bearings CS
Protection against magnetic bearings overheating	Two – level protection: - warning; - operates for trip without time delay	Magnetic bearings CS
Protection against excessive temperature or cooling system failure		ACS



## Semiconductor frequency converters

### Technical characteristics

Name of parameter	UOM	Value
Total output power, no lower than	kVA	5200
Nominal output current	A	910
Efficiency in the nominal conditions (without transformers)	p.u.	0,985
Nominal power factor	p.u.	0,96
Nominal output voltage, Un	V	3300
Output voltage range	V	0...Un
Nominal frequency of output voltage, fn	Hz	233
Smooth start by underfrequency relay from 0 to the preset working frequency		0...1.05xfn
Cooling system	-	air
Protection degree as per GOST 14254	-	IP22

### The supply objects

The equipment is supplied for the projects of CJSC "Gazprom Neft", OJSC LUKOIL, OJSC "NK "Rosneft", OJSC "NK" RussNeft", JSC "SIBUR Holding", OJSC "Surgutneftegaz", OJSC "TATNEFT", TNK-BP International Ltd., JSC "Transneft" JSC, NC «KazMunayGas» and other.



## Equipment for Chemical Industry

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## Centrifugal Compressor Machines (CCM) for production purpose

The equipment for chemical industry takes up a weighty portion in the products range of REP Holding. These units are designed to compress various gases in the production of nitrogen fertilizers, ethylene, propylene, as part of the facilities for isothermal storage of ethylene and propylene, to supply natural gas to the combustion chambers of gas turbine units, for the production of sulfuric and nitric acids and in other industries.

### K104-101-1 compressor

#### Purpose

The compressor is designed to compress ethylene and propylene vapor as part of the facilities for isothermal storage of ethylene and propylene.

#### The unit components:

- centrifugal compressor made two-cylinder;
- step-up gear;
- el. motor drive;
- oil supply system;
- governing system;
- hardware for monitoring, control, protection and signaling;
- intermediate and by-pass gas coolers.

#### Design features

The compressor represents a two-cylinder two-section machine with gas being cooled between the cylinders. The compressor cylinders are horizontally split; the suction and discharge branch pipes are directed downwards.

The compressor is driven by an induction el. motor.

The oil system of the unit provides forced lubrication of the unit, as well as oil supply to the step-up gear gearing, toothed couplings, end face seals. The oil accumulators allow for trouble-free shutdown of the unit in case of power failure.

The governing system provides maintenance of constant pressure at compressor suction by way of gas bypass.

The compressor is equipped with anti-surge protection.

The hardware is designed to control the compressor and allows for complete automation of the compressor control both during start, shutdown, and during operation.

### K270-61-1 compressor

#### Purpose

The compressor is designed to compress hydric gas in the hydrocracking processing lines.

#### The unit components:

- compressor;
- step-up gear;
- el. motor drive;
- oil supply system;
- governing system;
- hardware for monitoring, control, protection and signaling;
- intermediate and by-pass gas coolers.

The compressor is supplied in pre-assembled units: the compressor unit and oil supply unit. The rest of the equipment is supplied as separate assembly units.

The compressor unit includes the compressor cylinder and step-up gear mounted on a common foundation frame. On the frame mounted are some pipes of the oil pipeline and gas pipeline of leakages.

The compressor proper presents a one-cylinder, two-section, six-staged machine.

The compressor sections feature opposite direction of the compressed gas flow.

The tightness of the compressor cylinder is provided by end face seals.

Between the compressor and drive el. motor installed is the step-up gear.

The compressor is driven by an asynchronous electric motor.

Gas is cooled between the sections and after the compressor in the intermediate and end gas

coolers of the shell-and-tube type. The oil accumulators allow for trouble-free shutdown of the unit in case of power supply failure.

The governing system provides maintenance of constant pressure at the compressor suction by means of bypassing gas from the compressor to the suction.

The compressor is provided with anti-surge protection and the hardware allowing for the compressor operation without permanent presence of the attending personnel on site.

### 3300-11-1 and 3300-12-1 compressors

#### Purpose

The compressors are designed to compress and supply dry sulphur dioxide in the production of sulphuric acid, as well as to compress and supply atmospheric air and other noncorrosive gases close to air in their thermodynamic parameters.

#### The unit components:

- centrifugal compressor;
- electric motor drive;
- oil system;
- throttle valve with an electric actuator;
- the system of control, monitoring, protection and signaling.



### Design features

The compressor is one-cylinder, one-staged, with an impeller of two-side suction.

The compressor casing is cast, with a horizontal split. The end shaft seals of the compressor provide its tightness due to supply of inert gas to the seals when operating on sulphur dioxide.

The compressor is driven by an asynchronous electric motor.

The system of control, protection, monitoring and signaling performs:

- the compressor start and stop from the remote board or locally;
- protection and emergency shutdown of the compressor in the emergency conditions;
- monitoring of the compressor process variables;
- light and audible signaling in case of deviation of the variables from the norm (warning signaling);
- signaling the protection facilities actuation (emergency signaling);
- light process signaling;
- electrical interlock for switching on and off the auxiliary electrical devices of the compressor.

The oil accumulator provides trouble-free shutdown of the compressor in case of power supply failure.

### 95-81-1 compressor

#### Purpose

The compressor is designed to compress natural gas in the production of nitrogen fertilizers.

#### The unit components:

- centrifugal compressor made two-cylinder;
- the system for oil supply to the seals;
- governing system;
- anti-surge protection system;
- the system of control, monitoring, protection and signaling.

#### Design features

The compressor cylinders are installed on a common foundation frame. There are four stages in each cylinder. The cylinder casings are made of steel, with a horizontal split.

The compressor is provided with hermetical end face seals. Oil is supplied to the end face seals by a screw pump. The pressure differential regulator maintains constant pressure differential of oil-gas.

The compressor is driven by the C-4,3-40,8 condensing turbine.

### 133-21-1 compressor

#### Purpose

The compressor is designed to compress the propylene fraction when operating individually for the consumer.

#### The unit components:

- centrifugal compressor and a step-up gear mounted on a common frame.

#### Design features

The compressor is a two-staged unit with radial and tangential arrangement of the respective inlet and outlet branch pipes cast integral with the compressor casing. The compressor cover is made of forge steel and is provided with an elastic diaphragm relieving the compressor from the axial forces during its operation.

The end face seals mounted in the borings of the casing, as well as the rings on the shaft prevent gas penetration into the machine room. Rotor speed increase is provided by means of the step-up gear.

The unit is controlled automatically via microprocessor-based hardware.

The compressor is driven by an asynchronous electric motor.

### 175-21-1 compressor

#### Purpose

The compressor is designed to compress contact gas in the production of ethylene oxide and is intended to replace the compressors that have exhausted their life time.

#### The unit components:

- centrifugal compressor and a step-up gear mounted on a common frame.

#### Design features

The compressor represents a one-cylinder two-staged modular centrifugal compressor machine. The compressor is provided with the systems of automatic governing and protection, as well as with the control and monitoring facilities.

The compressor is driven by an electric motor. The electric motor is connected with the compressor through a step-up gear by means of toothed couplings.

### 540-41-1 compressor

#### Purpose

The compressor is designed to compress nitrous gas in the production of weak nitric acid.



### The unit components:

- compressor with a built-in turbo-expander;
- speed increaser;
- el. motor drive;
- electrical lubrication system;
- thermo-technical monitoring, control, protection and signaling system.

### 540-41-1 compressor

#### Purpose

The compressor is designed to compress nitrous gas in the production of weak nitric acid.

### The unit components:

- compressor with a built-in turbo-expander;
- speed increaser;
- el. motor drive;
- electrical lubrication system;
- thermo-technical monitoring, control, protection and signaling system.

#### Design features

The compressor is a one-cylinder, four-staged machine with one-side suction.

The turbo-expander presents a two-staged impulse turbine and serves to reduce power consumption for compression of nitrous

gas in the compressor. The turbo-expander utilizes the energy of waste gas in the production of weak nitric acid.

The compressor and turbo-expander components are made of special alloyed steels providing their corrosion resistance.

The compressor is driven by asynchronous electric motor 2AZMP-1600/6000 with a squirrel-cage rotor (rated at 1600 kW, 6000 V, 2980 rpm).

The centrifugal compressor, having constant operating conditions, is not equipped with automatic governing facilities. The compressor capacity is maintained constant by varying the nitrous gases to make up air ratio.

The system of thermo-technical monitoring, control, protection and signaling consists of the board on which mounted are:

- facilities for the unit start and stop;
- instrumentation for remote measurement of the performance parameters of the centrifugal compressor;
- emergency and warning signaling devices;
- protection devices against the rotor axial displacement, against oil pressure drop in the lubrication system and gas pressure drop in the suction, as well as against higher temperatures in bearings of centrifugal compressor.



540-41-1 compressor



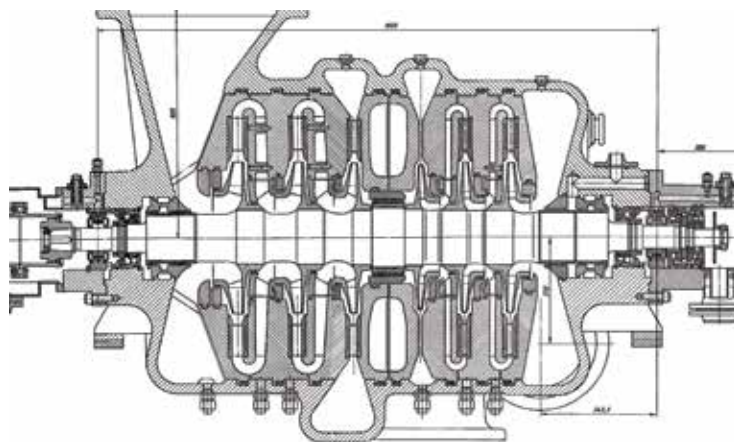
540-41-1 casing





## The main characteristics of the CCM for production purpose

Name of parameter	Type of Centrifugal Compressor Machine		
	45-21-4	K88-101-1	
Compressed gas		Propylene	Ethylene
Volume capacity referred to 20 °C and 0.1013 MPa, Nm <sup>3</sup> /s	Mode 1 8.95	Mode 2 10.73	1.56
Mass capacity, kg/s	15.6	18.7	1.817
Volume capacity referred to the initial conditions, m <sup>3</sup> /min	45.5	45.5	81
Final gas pressure at the discharge branch pipe outlet, MPa, abs.	1.86	2.35	2.0
Power consumed, MW	0.63	0.82	0.75
<b>Initial conditions</b>			
Initial gas pressure at the suction branch pipe inlet, MPa, abs	1.0	1.275	0.102
Initial gas temperature at the suction branch pipe inlet, °C	21	40	-15
Dry gas density referred to 20 °C and 0.1013 MPa, kg/m <sup>3</sup>		1.747	1.167
Rotor speed, min <sup>-1</sup>		9370	16122

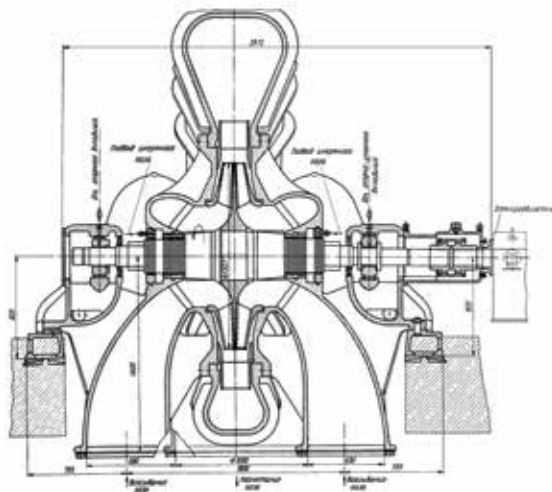


Longitudinal section of K270-61-1 compressor



## The main characteristics of the CCM for production purpose

Name of parameter	Type of Centrifugal Compressor Machine				
	95-81-1	81-81-1	K104-101-1		175-21-1
Compressed gas	Natural gas		Ethylene	Propylene	Contact gas
Volume capacity referred to 20 °C and 0.1013 MPa, Nm <sup>3</sup> /s	14.7	16.94	1.67	1.314	22.4
Mass capacity, kg/s	10.55	11.43	1.945	2.33	27.6
Volume capacity referred to the initial conditions, m <sup>3</sup> /min	90	90	92	72	175
Final gas pressure at the discharge branch pipe outlet, MPa, abs.	4.51	4.18	1.96	1.96	1.57
Power consumed, MW	3.6	3.5	0.9	0.68	2.2
Polytropic efficiency, no less than	0,805				0,82
<b>Initial conditions</b>					
Initial gas pressure at the suction branch pipe inlet, MPa, abs	0.981	1.1	0.1	0.1	0.834
Initial gas temperature at the suction branch pipe inlet, °C	25	15	-5	-5	40
Relative gas moisture, %	100	100			100
Dry gas density referred to 20 °C and 0.1013 MPa, kg/m <sup>3</sup>	0.718	0.675	1.167	1.773	1.232
Rotor speed, min <sup>-1</sup>	11700	12358	16180	11326	10115

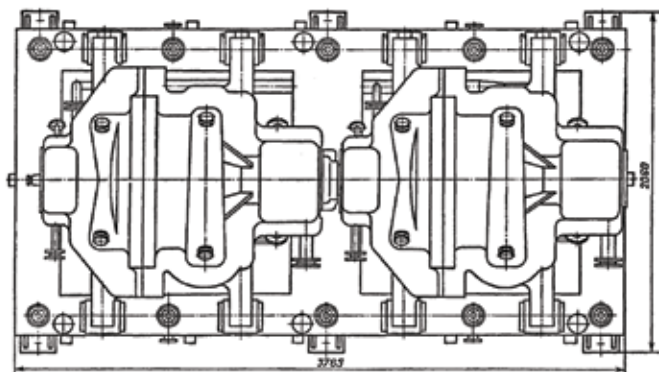


Longitudinal section of 3300-11-1 and 3300-12-1 compressors



## The main characteristics of the CCM for production purpose

Name of parameter	Type of Centrifugal Compressor Machine			
	133-21-1	K605-181-1	K270-61-1	
Compressed gas	Propylene	Natural gas	water-containing	
Volume capacity referred to 20 °C and 0.1013 MPa, Nm <sup>3</sup> /s	26.9	12.76	5.4	6.05
Mass capacity, kg/s	47	4.33	5.5	
Volume capacity referred to the initial conditions, m <sup>3</sup> /min	133	610	268	300
Final gas pressure at the discharge branch pipe outlet, MPa, abs.	1.96	3.92	0.883	0.883
Power consumed, MW	2.15	7	1.78	2.05
Polytropic efficiency, no less than	0.67 (isothermal)			
<b>Initial conditions</b>				
Initial gas pressure at the suction branch pipe inlet, MPa abs	1.0	0.13	0.1275	0.1275
Initial gas temperature at the suction branch pipe inlet, °C	20	35	33	33
Relative gas moisture, %	100	100	100	100
Dry gas density referred to 20 °C and 0.1013 MPa, kg/m <sup>3</sup>	1.75	0.68	0.803	0.909
Rotor speed, min <sup>-1</sup>	7500	7240-L.P. Cyl. and M.P. Cyl4020-H.P.Cyl.	11514	11514

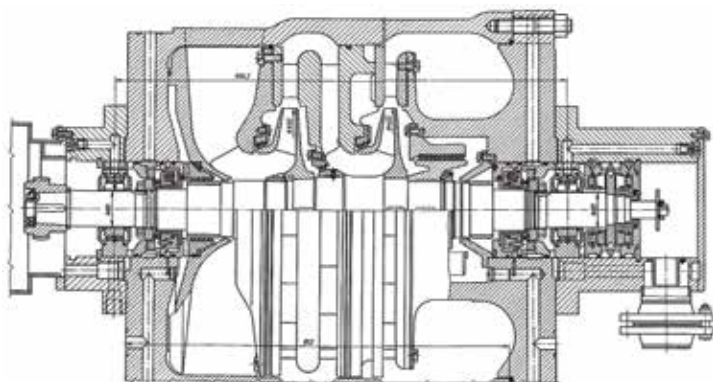


95-81-1 compressor unit



## The main characteristics of the CCM for production purpose

Name of parameter	Type of Centrifugal Compressor Machine				
	K210-62-1			3300-11-1	
Compressed gas	Propylene 1st section	Propylene 2nd section	Propylene 3rd section	Sulphur dioxide	Atmospheric air
Volume capacity referred to 20 °C and 0.1013 MPa, Nm <sup>3</sup> /s	10.74	22.8	28.3	47.3	48.8
Mass capacity, kg/s	18.7	21	9.5	64.35	58.77
Volume capacity referred to the initial conditions, m <sup>3</sup> /min	318	354	217	3300	3300
Final gas pressure at the discharge branch pipe outlet, MPa abs.	0.32	0.72	1.71	0.1322	0.1341
Power consumed, MW	6.0	6.0	6.0	2470	2300
Polytropic efficiency, no less than	0.79	0.79	0.8	0.81	0.81
<b>Initial conditions</b>					
Initial gas pressure at the suction branch pipe inlet, MPa abs	0.16	0.32	0.72	0.0932	0.0981
Initial gas temperature at the suction branch pipe inlet, °C	-37	-18	6	40	40
Relative gas moisture, %				0.01	75
Dry gas density referred to 20°C and 0.1013 MPa, kg/m <sup>3</sup>	1.745	1.745	1.745	1.36	1.205
Rotor speed, min <sup>-1</sup>	6970	6970	6970	3000	3000
Cooling water flow, m <sup>3</sup> /h	124	124	124		62

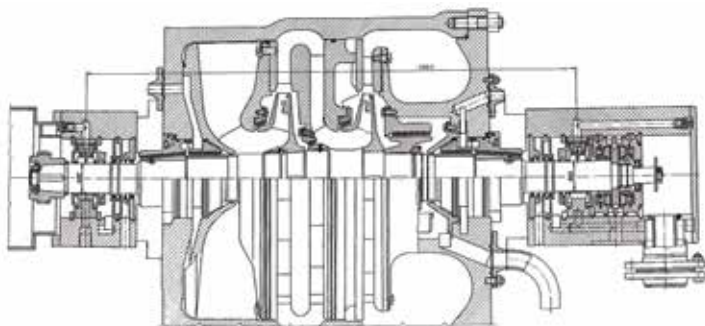


Longitudinal section of 133-21-1 compressor



## The main characteristics of the CCM for production purpose

Name of parameter	Type of Centrifugal Compressor Machine			
	3300-12-1	540-41-1	K160-131-1	
Compressed gas	Sulphur dioxide	Atmospheric air	Nitrous gas	Converted gas
Volume capacity referred to 20 °C and 0.1013 MPa, Nm <sup>3</sup> /s	50.2	51.7	7.35	19.67
Mass capacity, kg/s	68.25	62.33	8.8	9.44
Volume capacity referred to the initial conditions, m <sup>3</sup> /min	3500	3500	540	163.2
Final gas pressure at the discharge branch pipe outlet, MPa abs.	0.1412	0.1421	0.412	4.51
Power consumed, MW	3050	2850	2150/930	5.7
Polytropic efficiency, no less than	0.81	0.81	0.795	0.65 (isothermal)
<b>Initial conditions</b>				
Initial gas pressure at the suction branch pipe inlet, MPa abs	0.0932	0.0981	0.094	0.78
Initial gas temperature at the suction branch pipe inlet, °C	40	40	50	40
Relative gas moisture, %	0.01	75	60	100
Dry gas density referred to 20°C and 0.1013 MPa, kg/m <sup>3</sup>	1.36	1.205	1.2	0.48
Rotor speed, min <sup>-1</sup>		3000	8455	8020-LPC 14526-HPC



Longitudinal section of 175-21-1 compressor



## The main characteristics of the CCM for production purpose

Name of parameter	Type of Centrifugal Compressor Machine			
	K65-101-2	K70-81-1		
Compressed gas	Propylene	Ethylene fraction		
Volume capacity referred to 20°C and 0.1013 MPa, Nm <sup>3</sup> /s	1.25	1st section 1,61	2nd section 4,46	3rd section 9,9
Mass capacity, kg/s	2.183	1.877	5.2	11.55
Volume capacity referred to the initial conditions, m <sup>3</sup> /min	64	69	46.8	57
Final gas pressure at the discharge branch pipe outlet, MPa abs.	1.96	0.5	0.872	2.45
Power consumed, MW	0.54	2.1	2.1	2.1
Polytropic efficiency, no less than	0.65 (isothermal)			
<b>Initial conditions</b>				
Initial gas pressure at the suction branch pipe inlet, MPa abs	0.102	0.103	0.5	0.872
Initial gas temperature at the suction branch pipe inlet, °C	-15	-58	-66	-50
Dry gas density referred to 20°C and 0.1013 MPa, kg/m <sup>3</sup>	1.747	1.167	1.167	1.167
Rotor speed, min <sup>-1</sup>	12357	12465	12465	12465



## The main characteristics of the CCM for production purpose

Name of parameter	Type of Centrifugal Compressor Machine			
	50-32-1	K60-82-1		
Compressed gas	Ethylene			
Volume capacity referred to 20 °C and 0.1013 MPa, Nm <sup>3</sup> /s	14.56	1st section 1.61	2nd section 4.28	3rd section 8.67
Mass capacity, kg/s	17.1	1.89	3.13	5.15
Volume capacity referred to the initial conditions, m <sup>3</sup> /min	70	62	44	52
Final gas pressure at the discharge branch pipe outlet, MPa abs.	2.16	0.5	0.84	2.16
Power consumed, MW	1.39	1.68	1.68	1.68
Polytropic efficiency, no less than	0.895			
<b>Initial conditions</b>				
Initial gas pressure at the suction branch pipe inlet, MPa abs	0.83	0.113	0.5	0.84
Initial gas temperature at the suction branch pipe inlet, °C	-56	-61	-17	-16
Dry gas density referred to 20°C and 0.1013 MPa, kg/m <sup>3</sup>	1.174	1.174	1.174	1.174
Rotor speed, min <sup>-1</sup>	11340	12570	12570	12570

## The supply objects

The equipment of JSC REP Holding is installed on the chemical industry sites, United Chemical Company "Shchekinoazot", Acron, OJSC "Kirovo-Chepetsky Chemical Integrated Plant", JSC "Grodno Azot", OJSC "Naftan", OJSC "Nizhnekamskneftekhim", "Kazanorgsintez" OJSC, "Ufaorgsintez", JSC "EVROKHIM", JSC "FOSAGRO", JSC "Minudobreniya", OAO Gazprom Neftekhim Salavat, and other being among them.



## Equipment for Power-Generating Industry

Electro technical products.....79

Generation.....99

Gas turbine electric station with  
the power 32 MW.....100

Gas turbine electric station with  
the power 22/25 MW.....101

Gas turbine electric station with  
the power 16 MW.....103

Steam gas electric station with  
the power 42 MW.....105

Steam gas electric station with  
the power 84 MW.....107





## Electro technical products

REP Holding manufacturers and supplies the power and electro technical equipment for nuclear-power branch, the generating companies and enterprises of power supply network.

### Mosaic diagram

#### Application

Service for displaying the mnemonic information of status and processes controlling in real-time basis.

#### Design advantages of Boards based on the mosaic system:

- creation of boards practically of any dimensions;
- different dimensions of mosaic board elements: 25x25, 50x25, 50x50 mm;
- creation of arched support structure.

#### Operational advantages of boards based on the mosaic system:

- operational introducing of changes on the front panels due to Mosaic system;
- mosaic system construction as on passive elements (With pictures and figures) and in active (with hardware and instrumentation).

### Full-Scope Simulator for NPP

#### Application

The simulator is designed for joint professional training of operators of NPP modular control panel (MCP) and NPP back-up control panel (BCP) by using the full-scale model of the actual MCP and BCP, and of the complex all-mode mathematical model of the power unit operating in real-time.

#### Design

The design of MCP and BCP simulator's panels and desks is in accordance with the power unit prototype.



Mosaic diagram



Mosaic diagram



Modular Control Board of the 2nd power unit of Kurskaya NPP



Full-Scope Simulator of NPP



Full-Scope Simulator of Leningrad NPP



## Automatic control systems (ACS TP)

### Application:

- ACS of electrical part of electrical station (CMS EP);
- ACS of industrial objects;
- ACS TP of gas turbine electric station;
- ACS TP of distribution sub-stations;
- the complex of high voltage relay protection and automatic equipment;
- the cabinets of central signaling system of the switchgears.

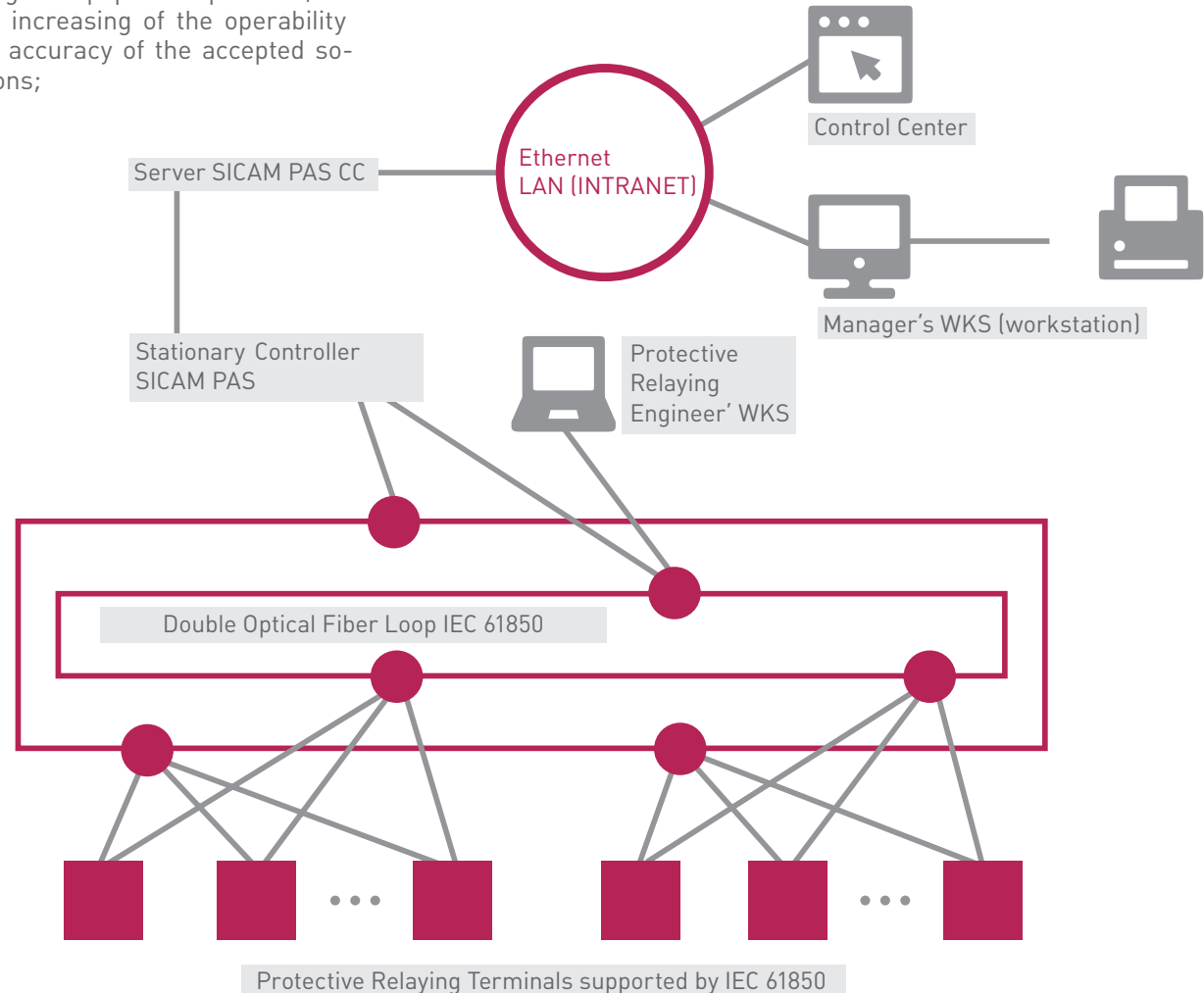
### Complex of services

The creation of the automatic control systems includes:

- draft design investigations at a site;
- development of Technical Assignments for creation of ACS taking into account individual requirements of Purchaser;
- draft design development based on the Engineering;
- development of construction project drawings and specifications;
- software engineering, realizing control algorithm of production equipment (Low level of controlling) and sequences of information collection and processing (Upper level of controlling);
- manufacture and delivery of equipment according to specifications;
- installation and commissioning;
- warranty and post services;
- customer personnel training.

### The benefits:

- the automatic control process of technological equipment;
- the increasing of stability, reliability and efficiency of the technological equipment operation;
- the increasing of the operability and accuracy of the accepted solutions;
- the decreasing of the operating costs;
- the improvement of employees working conditions;
- the creation of the operation modes library.





## The Low-voltage package module

### Application

The Low-voltage package modules are intended for receiving and distribution of electric power between auxiliaries consumers at the heat electric generation plant, regional power station and NPP, industrial enterprises and etc.

Control cabinets are designed for control of the power generating equipment of the electric power plants and substations. The panels are used to form control, protection, indicator boards, and real-time process control loops of thermal, nuclear, and hydraulic power plants.



DC boards (ЩПТ-24 В, ЩПТ-48 В, ЩПТ-60 В, ЩПТ-110 В, ЩПТ-220 В, ЩПТ-20 В)

Such boards are designed to receive and distribute DC power to power-consuming units (consumers) of the 1 category and of the special group of 1 category, as defined by Rules on design of power electric installations, in various industries.



The special control panels (ПС-5, ПС-6, ПС-7, ПС-8)



Distribution boards (PT30-88M)



The control cabinets (ЩО-3, ЩД-3)



The panels of radial and straight types (ПРП, ПРП)

These desks are designed to form the real-time control loops of the thermal and nuclear power plants.



## Equipment for Power-Generating Industry



Cabinets of power protection and automatics in a container unit



Suspended boxes/cabinets

These boxes/cabinets are intended for the control cables to be connected during installation of the control-circuit devices and of the industrial lighting circuits rated to the voltage of 380V AC and up to 200V DC.



Protection Relay and Control Cabinets

Protection Relays and Controls designed by Rittal are based on the micro-processor Protection Relays and Controls Terminals of the leading Russian and world manufacturers: Siprotec (by Siemens), Sepam (by Schneider Electric), Sirius (CJSC "Radius Avtomatika"), etc. Nomenclature of the Protection Relays and Controls Cabinets manufactured by REP Holding includes a full list of cabinets for protection of equipment ПС 35-110/6(10) kV. Dimensions of a standard cabinet: 800x600x2200.



Valve Actuator Module B33

These modules are designed for installation of the secondary electrical circuits for control of the starting and control valves' actuators and for local control of the process gate valves of power plants.



## Low-Voltage Switchgear "Sphere-N"

The universal low voltage packaged device "Sphere – N" is designed to receive and distribute three-phase AC el. power with voltage of 220/380/660 V, 50 Hz. It performs protection functions in case of excess voltage and short-



External view of "Sphere – N"

circuits, as well as the functions of guaranteed power supply of critical power consumers.

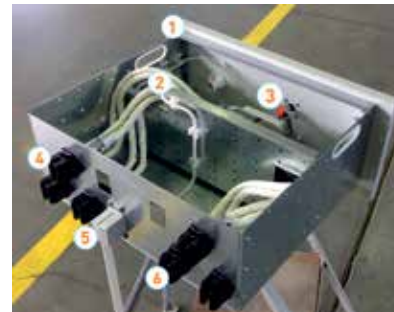
Depending on its applicability, low-voltage packaged devices are produced as per TU 3433-003-71439231-2005 "Low-Voltage Packaged Devices. Control and distribution. Technical Specifications" or, if included into a Packaged Transformer Substation, as per TU3412-018-05758859-2004 "Packaged Transformer Substations ranging from 25 to 2500 kVA. Technical Specifications".

"Sphere – N" low-voltage packaged devices cabinets are available in home-made metal casings.

### The main advantages

- versatility;
- a possibility to use component parts of both domestic and import suppliers;
- the construct is used based on both plug-in, draw-out and stationary modules and on the equipment installed on mounting panels.

In accordance with implementation of the State program on import substitution "Sphere-N" is manufactured from the materials produced on the territory of the Russian Federation (metal sheet, glass sheet, copper, aluminum, etc.), as well as is oriented on the components and devices made by domestic companies.



1. Draw-out module base;
2. Unit holder;
3. Actuating mechanism;
4. Output pins;
5. Control circuit connector;
6. Power supply contacts



Stationary cabinet cell



Draw-out module

Besides draw-out modules, the equipment in the outgoing lines cabinets can be placed in stationary cells wherein switching units, stationary, plug-in and draw-out, are arranged.

### Technical characteristics

- Nominal current  $I_n$  up to 630 A
- 3- and 4- pole
- Manual or motor actuator
- Actuator on the door or behind the door
- Wire-circuit boards for auxiliary units

### Standard draw-out modules

Height of draw-out module, mm	0.4kV / direct start	0.4kV / cable
150	40 kW	100 A
200	64 kW	160 A
250	100 kW	250 A
300	-	400 A
400	160 kW	630 A
600	250 kW	-

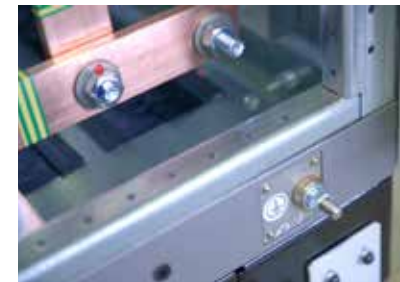


Low voltage packaged device “Sphere – N” with outgoing lines cabinet modules

### Types of cabinets by their functionality

- Entrance (including emergency entrance) – with stationary or draw-out switching units;
- Outgoing lines - with stationary, plug-in or draw-out switching units, as well as with with drawables cells. The maximum number of outgoing lines in the cabinets with drawables cells is 36;
- Sectional - with stationary or draw-out switching units;
- Reactive power compensation;
- Control panels;
- Electric power metering – with power consumption metering and control instruments installed;
- Combined – one cabinet contains units of different functionality. For example, entrance and outgoing line.

Each cabinet is completed with additional elements on the face side to provide visible earthing by a conductor to the room earthing loop.



The element providing visible earthing

### The main characteristics

- The product cabinets can be both for one-side and two-side service;
- Cabinet width, mm: 400-1400 (in increments of 100);
- Cabinet depth, mm: 400-1200 (in increments of 200);
- Cabinet height, mm: 1400-2000 (in increments of 200);
- Protection level – up to Ip54\*.

\* There are design restrictions

An important feature of the “Sphere – N” construct is a possibility to use draw-out modules.

Draw-out modules are equipped with mechanical interlocks and fixed positions. There are three fixed positions at all: “Connected”, “Test” and “Disconnected”. The modules are completed with actuating mechanisms preventing the module movement under load.



## Factory-assembled switchgear

### Application

Factory-assembled switchgear is designed for accepting and distribution of electrical power of three-phase AC current at a frequency of 50 & 60 Hz to rated voltage of 6, 10 and 35 kV, are applicable for all

types of power plant and substations, nuclear power facility, electric-power supply for enterprises of all industrial branches, transport & utilities system, and also for nuclear power generation industry.

### The features of equipment

REP Holding manufactures the switchgears of different modifications.

#### K-204 EP

It is used on all industrial enterprises and electric power plants, where the nominal current of the main circuit is not more than 1600 A. The low arrangement of bus bars, two-way service.



K-204 EP

#### K-205 EP

K-205 EP is utilized together with switchgear K-204 EP for income and sectioning or electric-power supply for powerful consumers at a rated current up to 3150 Amps. Lower arrangement of bus-bars, two-way services.



K-205 EP

The switchgear cabinets can be used to expand the operated switchgears of other manufacturers and connected with them using fitting cabinets. It depends on the maintenance conditions switchgear cabinets can be installed in one-row, two rows or duplex way.

#### K-206 EP

It was developed in accordance with requirements of the metallurgical industry, has the increment air isolation gaps, that is increase reliability and procure conformability for installation of cable connections, at a rated current up to 1600 Amps. The upper arrangement of bus-bars, two-way services.



K-206 EP

#### K-207 EP

The design of switchgear has smaller overall dimensions, i.e. the cabinet depth is 1400 mm, which allows installing the switchgear of K-207 EP series inside the buildings with small area. The switchgear cabinets can be serviced from front panel side (single-sided design), and from other side as well (double-sided design). Collecting bus bars rated at less than 3150 A is on top. The cabinet can be of different width: 650 mm at the rated current in the mains less than 1250A, 800 mm at the rated current in the mains less than 1600 mm, 1000mm at the rated current in the mains less than 3150 A. The switchgear cabinets can be equipped with different power circuit breakers. The circuit breakers are arranged in the middle and can be drawn out to the service trolley.



K-207 EP



## Equipment for Power-Generating Industry

### The package transformer substations with the power 25-2500 kV (6(10)/0,4 rV)

#### Application

It is intended for reception, converting and distribution of the electric power of the three-phase AC with the frequency 50Hz and voltage 0.4 kV. The package trans-

former substations are used in the industrial enterprises, on the nuclear power generation industry objects and on the objects of all industry branches.

#### Constructional features

The package transformer substations are manufactured using the low voltage distribution devices

(PYHH- 0,4 kV) on the base of the cabinets of manufacturer RITTAL the construction TS8, enterprise Siemens the construction SIVACON 8PT. The cabinets construction is foreseen the installation of full complex of electric equipment and apparatus, control devices, protection, automatic and signaling.



PTS (under the license of RITTAL)



PTS in the construction of SIVACON





### The Low-voltage package modules SIVACON 8PT (6(10)/0,4 kV)

#### The application

The Low-voltage package modules are intended for receiving and distribution of the electric energy of three phases AC with the frequency 50Hz for nominal voltage up to 690 V are used for all types of electric power plants and substations, for power supply of all industrial enterprises. The Low-voltage package modules can be used as the following equipment:

- the main and auxiliary distribution boards;
- the station control boards for electric motors;
- the entry and distribution device;
- the low voltage distribution device (LVDD) for Packaged Transformer Substation.

#### The benefits:

- quick change or modernization of the modules inside the cabinets to realize all the customers' requirements;
- the using of high quality apparatus Siemens, which can provide the long operation period and reliable control;
- the consonant testing of the accessory equipment, provides the maximum reliability and safety of the operational personnel;

- the high level of comfort operation because of the using of pull out/in principals of apparatus construction;
- the high density of the assembling can provide the connection up to the 11 feeders inside one cabinet of output lines;
- the possibility of the independent combining and quick re-equipment of the cable feeder inside one cabinet, because of the multi-purpose side busbar system;
- the installation opportunity of the automatic switches to the pull in bases;
- the optimal conditions for cable connection inside the cable compartment
- the division grade up to 4b.



The Low-voltage package modules SIVACON 8PT

### Container

The container is designed for installation of various electrical equipment: transformer substations, frequency converters, diesel generator stations, 6, 35 kW cubicle, MCC board and many other devices of various functions and overall sizes.

Each container is equipped with lighting, ventilation, heating, fire alarm systems which ensure required operating conditions for the electrical equipment.

Design of the container is such that it allows to stably, safely and comfortably operate the equip-

ment, and to transport the equipment by road and rail transport, and to transfer the equipment by means of the lifting equipment.

Basis of the container is a light and strong steel-tube framework. The walls and the top of the container are covered up with a heat-insulation material, such as sandwich-panels.

The basis is a one-piece welded structure and due to this it is sufficiently hard and strong. The basis has embedded items for installation of the floor equipment, and the cable glands for installation of cables.



Factory-assembled switchgear in a container unit



## Equipment for Power-Generating Industry

Heat-insulating filler of the basis is a heat-insulating material URSA type or ROCKWOOL LIGHT BATTS panels.

Due to its heat insulation, the container can be used at the ambient temperatures from  $-60^{\circ}\text{C}$  to  $+40^{\circ}\text{C}$ .

The container design allows to make separate rooms, air-lock chambers, work areas, recreational areas, etc. Also the container can be designed to be covered up with corrugated metal sheets.

Various container top solutions allow to fit the equipment of non-standard height inside the con-

tainer. Due to the load-bearing frame of the container, additional equipment can be installed on its top.

### Advantages of the containers:

- high heat-insulating ability of the container covered up by the sandwich-panels (rockwool, polyisocyanurate foam, etc.);
- relatively small weight;
- modular and demountable nature of the structure makes it possible to move the container many times over its entire lifetime;
- ability to implement its various configurations.

REP Holding designed the containers for the main pipeline network "Bovanenkovo-Ukhta", GPA-32 Ladoga, CS "Gryazovets-Vyborg", LLC "Orenburgenergoneft", LLC "RUSAL", LLC "RN-Yuganskneftegaz", the gas pipeline Southern stream CS "Kazachya", CJSC "Gazprombank Leasing", etc.



Docking Container for LLC "Orenburgenergoneft"



Control Rooms at CS-8 "Chikshinskaya"



Containers Covered Up With Corrugated Metal Sheets



Containers on the Site



## Equipment for Power-Generating Industry

### The New Construct for Distribution Units and Power Boards of Low Voltage Control SIVACON S8

#### Innovations:

- saves space by a combination of different types of modules in a single cabinet;
- patented connection terminals and internal separation provides a simple separation of the functional compartments;
- varied position of the main bus system: on top or from behind on top and/or from below;
- different height of the cabinets – 2000 mm or 2200 mm allows to implement any requirements of the Customer;

- reactive power compensation up to 600 kvar per cabinet saves space in the room;
- uniform marking system;
- locking system for an individual or central locking;
- the capability to quickly self-change the direction of opening through the use of universal hinges and locks;
- fast-acting locks provide an easy and quick installation of covers;
- application of the rotary covers increases the ease of the equipment operation.

#### Advantages in the design, installation and operation:

- flexibility to choose the form of internal separation in accordance with the requirements;
- saves space in the room thanks to the small size: the section, starting from 400 x 500 mm;
- varied position of the main bus system on top/from behind for easy and flexible implementation of various requirements;
- different ways for connection to the vertical bus for cable, buses, without the need for drilling or punching holes;
- quick-removable cover;
- efficient installation due to a combination of different systems;

- maximum safety due to low voltage package units that have passed standard tests;
- maximum safety for personnel due to the system of locks resistant to fault arc;
- high-quality industrial design for use in modern buildings;
- the disconnected position with the cabinet doors closed, secure transfer of withdrawable modules from one position to another;
- safe operation thanks to the unified protection during operation;
- quick access to devices for adjustment of pickup settings;
- easy to change the direction of the doors opening;
- highly efficient ventilation system with easy maintenance.



New Construct SIVACON S8



### Electrical Equipment for Shipbuilding

#### Marine type LV electric switchboard equipment

##### Purpose

The marine LV electric switchboard equipment is designed to receive the generated power, to distribute it among the vessel consumers and to protect the outgoing lines.

##### Field of application:

Marine and river vessels of different purpose, offshore fixed platforms and drilling units, coastal facilities of the water transport.

##### Component parts

Depending on their functionality, the distributing switchboards are classified as:

- main switchgear;
- main distributing switchgear (MDS);
- emergency switchboard board (ESB);
- secondary switchboards.

##### A standard Main Switchgear comprises:

- generation section (GS);
- distribution section (DS);
- control section (CS).

##### Technical specifications:

- collecting busbars rated current up to 7010 A;
- rated operating voltage up to 690 V;
- rated feeder current up to 6300 A;
- rated short time electrodynamic current up to 150 kA;
- protection level of the equipment — up to IP54;
- climatic version of the equipment — OM3, OM4.

##### Advantages:

- wide range of standard sizes;
- up to 40 load feeders per one cabinet;
- possibility of bus-bars arrangement on top or from behind;
- possibility of cable connections from bottom, from top, from behind;
- TEST and OFF position of switchers when the doors are closed.



Ice-Resistant Stationary Platform ISP-1



### Integrated control systems of the onboard technical equipment

#### Purpose

The integrated control systems of the onboard equipment are designed to provide the centralized access to information and remote automatic control of the vessel technical equipment.

The integrated control systems of the onboard equipment ensure interaction of the system with other control systems of the vessel.

#### Field of application:

Marine and river vessels of different purpose, offshore fixed platforms and drilling units, coastal facilities of the water transport.

#### Structure

The communications networks of the integrated control systems of the onboard equipment form the terminal, system and field busbars. All busbars have optical channels with glass fiber — optic cables as the data transmission media.

The basic and back-up optical rings of each busbar (system and field ones) are laid in the vessel rooms along different routes and are not physically connected with each other.

#### Component parts:

- control subsystem;
- indication subsystem;
- emergency warning subsystem.

#### Technical specifications:

- power-supply voltage — 24 V DC, 220 and 380 V AC;
- protection level of the equipment — up to IP56;
- climatic version of the equipment — OM3, OM4.

#### Advantages:

- wide functional capabilities;
- high reliability;
- friendly HMI;
- standardized hardware and software using the concept of modular design as much as possible;
- upgradability, a possibility to increase the number of signals and to expand the realized functions during the whole service life.



Integrated Control System of the Vessel Technical Equipment



Jack-up Drilling Rig "Arkticheskaya"



### Substations of 110, 35, 6(10) kV

#### Component parts:

#### ОРУ-110 кВ

Units of 110 kV:

- switch unit;
  - breaker unit;
  - voltage transformer unit;
  - voltage limiter unit;
  - receiver unit for the high-frequency equipment line;
  - support insulator unit
- Power transformer;
- Portals.

#### Equipment of the 110 kV.

- dead-tank circuit breakers: ВЭБ-110, ЗАР1DT-145, 145PM;
- column circuit breakers: ВГП-110, WCB LTB 170, ЗАР1FG-145, ВГТ-110;
- disconnect switches: РГ(П)-110, РПД-110, РГП-110;
- voltage transformers: НАМИ-110, НДКМ-110, SPB;
- current transformers: ТБМО-110, ТГМ-110;
- cells: PASS M0;
- Power transformer.

#### ОРУ-35 кВ

35 kV units:

- switch unit with an overvoltage limiter (for a double-winding transformer);
- line breaker unit (with a side-mounted current transformer);
- switch unit with an overvoltage limiter (for a three-winding transformer);
- line breaker unit with an overvoltage limiter and voltage transformer (with a side-mounted current transformer);
- jumper unit;

- voltage transformer unit;
- receiver unit for the high-frequency equipment line;
- Power transformer;
- Portals.

#### Equipment of the 35 kV Units

- dead-tank circuit breakers: ВГБ-35, 48PM, VOX;
- column circuit breakers: ВГТ-35, ОНВ 40, HPL 72, ВВСТ 35, ВВН-СЭЩ-Э-35 ;
- disconnect switches: РГ-35, РГП-35, РГП-СЭЩ-35;
- voltage transformers: НАМИ-35, SPB;

- current transformers: ТГМ-35;
- Power transformer.

#### КРУ 6(10) кВ

Factory-Assembled Switchgear КРУ-6 (10) kV based on the К-207 ЭП, К-204 ЭП, К-205 ЭП cells produced by REP Holding.



Outdoor switchgear-ОРУ 110 kV



# Equipment for Power-Generating Industry

## Auxiliary power and operational power supply system:

- 2КТП 6(10)/0,4;
- operational current system.

## Relay protection and automatics (RPA) cabinets made by REP Holding

The relay protection and automatics cabinets in the Rittal construct based on RPA microprocessing terminals from the leading Russian and world producers: Siprotec (Siemens), Sepam (Schneider Electric), Sirius (ZAO "Radius Avtomatika") and other.

The product range of RPA cabinets made by Close Co. REP Holding includes a complete list of cabinets for protection of the equipment ПС 35-110/ 6 (10) kV:

- transformer protection cabinet 35-110 kV;

- protection and automatics cabinet CB 35-110 kV;
- transformer voltage regulation cabinet 35-110 kV;
- cabinet for differential protection of the line 110 kV;
- cabinet for remote protection of the line 110 kV;
- cabinet for remote protection of the line 110 kV with high-frequency interlocking;
- control cabinets and other.

## Communication system

Implemented via fiber-optics communication lines (based on the Cisco ONS 15305 multiplexed platform hardware or similar) or using a high-frequency channel on the power transmission line (based on the hardware of AKST "Linia-Ts", "Shadrinsky Telephone Plant", ETL 600, ABB, or similar).

## Telemechanics system

- ASCAPC (automatic system for commercial accounting of power consumption);
- ADCSPS (automated dispatch control system of power supply);
- ASEPTRK (automated system of electric power technical record-keeping).



Modular mobile substation (MMS)



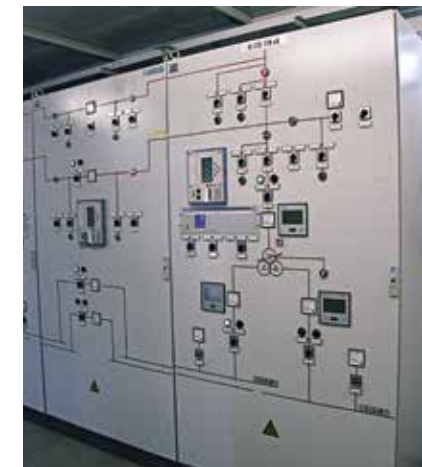
JSC Lenenergo Substation № 124

## Modular mobile substation (MMS) (110/35/10 kV)

MMS — mobile container (trailer, platform or pallet), in which one are arranged: power transformer module, HV and MV module.

## Purpose of substation:

- operative power supply at emergency shutdown of main substation (MS);
- emergency avoidance, at maintenance procedures;
- operative electrical power supply to new sites;
- mains supply procurement for those sites, where building of stations is unremunerative;
- temper growth of site power at peak load mode.



RPA cabinets based on Siemens microprocessor protection

NAME OF PARAMETER	PARAMETER VALUE
Nominal voltage, kV	6,0 (10,0)
Maximum working voltage, kV	7,2 (12)
Nominal current of the main circuits, A	to 3150
Conventional thermal current, кА	to 40
Breaker type	BB/TEL, LF, Evolis, VD4 и др.
Type of the relay protection and automatics unit	Siprotec, Sepam, Сириус, БМРЗ.
Protection degree of the casing	IP42



## Containerized Automated Diesel Power Plants

The containerized power plants are designed to be used as a backup (emergency) or main power source.

The substation is designed to be used for:

- Quick power backup in case of emergency shutdown of the main substation;
- Avoiding emergency during repair;
- Quick power supply to new sites;
- Power supply in the places where use of stationary substations is not profitable;
- Short-time boosting of power on the existing site at peak loading.



## Technical characteristics

Name of parameter	Value
Climatic version of the power plant	ХЛ1, УХЛ1, У1
Air temperature during operation	213 to 313 °K (minus 60 to plus 40 °C)
Automation degree of the power plant as per GOST R 50783-95	3 <sup>rd</sup>
Power (Prime), kVA	500÷1500
Nominal voltage, V	400, 6300, 10500
Nominal frequency, Hz	50
Power factor (inductive)	0,8
Starting system	Electric starter
Capacity of the fuel consumed tank	1000 l
Capacity of the oil consumed tank	250 l
Remote control	Available
Operation in parallel with another diesel power plant and the electric power system network	Available
Fire safety	Automatic gas fire-fighting system (CO <sub>2</sub> , aerosol)





## Technical parameters of the containerized diesel power plant

	Electro-Д400/0,4KH30	Electro -Д512/0,4KH30	Electro -Д600/0,4KH30	Electro -Д656/0,4KH30
Nominal power $P_{nom.}$ (Prime), kW/ kVA	400/500	512/640	600/750	656/820
Backup power $P_{backup}$ (Standby), kW/ kVA	440/550	565/706	660/825	720/900
DGU model	C550D5	DFGB	DFGD	C900D5
Type of the engine	QSX15G8	VTA28G5	VTA28G6	QSK23G3
Type of the generator	HC5D	HC5F	HC6G	HC6H
Fuel consumption at $P_{nom.}$ , l	103	140	147	161
Overall dimensions of the DGU, LxWxH, mm	3376x1500x2064	3900x1350x1942	3900x1423x1943	4410x1740x2210
Overall dimensions of the power plant, LxWxH, mm	9250x3200x3100	9250x3200x3100	9250x3200x3100	9250x3200x3100
Weight of the DGU, kg	4200	6040	6700	6825
Weight of the power plant, kg	13400	15200	16000	16150
Remote control	Available			
Operation in parallel with another diesel power plant and the electric power system network	Available			
Fire safety	Automatic gas fire-fighting system (CO <sub>2</sub> , aerosol)			

	Electro-Д751/0,4KH30	Electro-Д800/0,4KH30	Electro-Д1000/0,4KH30	Electro-Д1200/0,4KH30
Nominal power $P_{nom.}$ (Prime), kW/ kVA	751/939	800/1000	1000/1250	1200/1500
Backup power $P_{backup}$ (Standby), kW/ kVA	826/1033	888/1110	1120/1400	1340/1675
DGU model	DFHC	DFHD	C1400D5	C1675D5
Type of the engine	QST30G3	QST30G4	KTA50G3	KTA50G8
Type of the generator	HC6J	HC6K	P7B	P7D
Fuel consumption at $P_{nom.}$ , l	184	202	254	289
Overall dimensions of the DGU, LxWxH, mm	4570x1640x2240	4547x1722x2332	5105x2000x2240	5811x2033x2333
Overall dimensions of the power plant, LxWxH, mm	9250x3200x3100	9250x3200x3100	9250x3200x3100	9250x3200x3100
Weight of the DGU, kg	6800	8000	10100	11950
Weight of the power plant, kg	16500	17700	20100	22500



## Power Complex

REP Holding manufactures modern power complexes of various power to be used as a main, backup or standby power supply.

## 2MW Power Complex

This power complex consists of two containerized diesel power stations and a packaged transformer substation. Power of each station is 1 MW with the voltage of 0.4kV, power of the packaged transformer substation is 2,5MW with the voltage 0.4/6.3 kV.



2MW Power Complex



Container Production Area. Container Production Facilities



Power Complex Testing Bench



## Modular Package Gas-Piston Power Plant of MPGPPP 0.4 (6, 10)-1500-Y1 Type, 0,4; 6; 10 kV

### Description:

The gas-piston power plant (GPPP) is designed for use as a primary or backup power supply of the customer's consumers. The power plant is aimed to be used as a power source for various industrial applications, as well as a captive power plant at the gas transmission system facilities.

The automated containerized Modular Package Gas-Piston Power Plant "BKGPE 0.4 (6, 10)-1500-U1" rated at 1500 kW, based on gas generator units made by Mitsubishi Heavy Industries, the output voltage of 400, 6300, 10500 V, current-AC, 50 Hz.

### Climatic version of thermal power plants:

Moderate and cold climate, placement category I as per GOST 15150. The value of air temperature during operation-from 213 to 313 K (-60 to +40 °C) – in a standard scope of delivery.



Gas-Piston Power Plant on CS "Kazachya"

### The Main Technical Characteristics of the GPPP:

Name of parameter	Value
Nominal electric power, kW	1500
Nominal voltage, kV	0,4
Nominal current frequency, Hz	50
Power factor (Inductive)	0,8
Electric efficiency, no less than, %	41
Starting system	Electric starter
Automation degree as per GOST R 50783	3
Fuel gas	Natural gas
Fuel gas pressure, kPa	350...600
Low heat value of fuel gas, kcal/Nm <sup>3</sup>	8480
Minimum continuous load, % of the nominal value	50

### GPPP Component Parts:

- heat-insulated block-box consisting of a middle module and two side modules;
- gas generator unit MGS1875-G;
- automation system;
- fuel gas supply system;
- oil system;
- cooling system with a side-mounted dual-circuit air cooler and circulation pumps;
- starting system;
- exhaust system;
- ventilation system;
- heating system for transportation and operation;
- operating and emergency lighting system;
- automatic fire alarm and fire warning system;
- automatic gas fire-fighting unit;
- gas analysis system by fuel gas;
- an optional dispatching desk is supplied with a possibility of the power plant remote control up to 50 m.

### The Main Technical Characteristics of the GS16R2-PTK Engine:

Total displacement, l	79,9
Number of strokes	four
Number of cylinders	16-V
Pressure ratio	12,0 : 1
Cylinder diameter, mm	170
Piston stroke, mm	220
Speed, rpm	1500
Oil volume in the engine, l	460
Oil flow, g/ kW*h	0,34
Gas flow Nm <sup>3</sup> /h at 100% load	371,1
Exhaust gas temperature, at 100% load, °C	400



### The frequency converter ПЧТ-6-2600-B-01

#### Application:

It's designed for utilization in structure of:

- variable frequency drives;
- null-balance units.

#### Technical features

The parameter	The value
The full nominal output power, kVA	2600
The nominal current on the converter output, A	250
The nominal output voltage, kV	6
The nominal current frequency of the supply mains, Hz	50
The efficiency of converter of the nominal mode, %	98
The power factor of the nominal mode	Not less than 0,95

#### Competitive advantages:

- saving of consumed power;
- increasing of the equipment efficiency;
- reduction in expenditure for repair and service of equipment due to extracting of hydraulic, mechanical and electrical impact force and overloads;
- possibility of integration the electric drive into automated process control systems for upper level by the realization of remote control, parameters monitoring and diagnostics.



Frequency converter ПЧТ-6-2600-B-01



## Equipment for Power-Generating Industry

### Generation

REP Holding offers manufacturing and supplying of a package of hi-tech equipment for construction of power generating units on the basis of 6MW-32MW steam and gas turbines.

Main equipment is mostly standardised and is made up of modules. The gas-turbine power units manufactured by REP Holding are highly efficient with low emissions as compared to other units of the same power class.

All GTU systems are designed to provide improved performance and be comfortable for servicing in the field.

#### Advantages of Power Plants:

- High reliability due to modern designing techniques, materials and applicable technologies for manufacturing of the basic element, i.e. gas-turbine engine;
- Total life cycle - 200 th. hours;
- Large overhaul intervals:

- High electrical efficiency;
- High efficiency in various operation mode;
- Use of components that are predominantly manufactured by Russian companies and mostly by REP Holding;
- Ability to perform repair on the Customer's site;
- Ability to promptly remove GTE during repair due to lateral roll-out from under the enclosure.

#### Package supplies of REP Holding equipment allows to:

- Reduce cost of the main and auxiliary equipment due to manufacturing on the production facilities of REP Holding;
- Apply modern technical solutions;
- Reduce operation cost;
- Provide highly reliable operation of all components of the gas-turbine power plant;
- Reduce equipment delivery time;
- Provide integrated servicing.





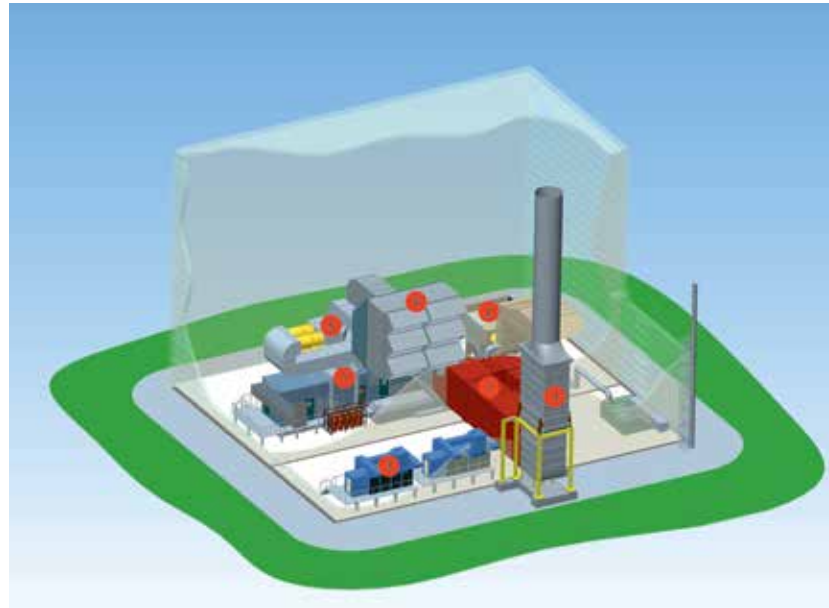
## Gas turbine power station (GTPS) on the base of the gas turbine MS5002E with the power 32 MW

### Description

Gas turbine power station GTPS-32 of the single cycle is realized on the base gas turbine engine MS5002E, which was manufactured by REP Holding under the license of Oil&Gas Nuovo Pignone, Italy. The main equipment of the plant is maximally unified and completed with module units.

### The set of GTPS-32:

- gas turbine (GT) MS5002E (under the license of GE);
- turbo generator (TG) for GT;
- gear box to supply power to TG of GT;
- filter house (FH);
- waste heat exchanger (if necessary);
- fuel gas booster compressor (if necessary);
- air and gas ducting system;
- automatic process control system (APCS);
- electric equipment.



Arrangement of power unit elements (within one building)

The layout of the power unit components (inside the integrated building)

- 1 — GTU (gas turbine unit)
- 2 — generator with the air cooling system
- 3 — AFHE (air-cooled, fin-fan heat exchanger)
- 4 — exhaust pipe with acoustic absorber
- 5 — air ducting of the cycle air and air cooling systems
- 6 — filter house
- 7 — waste heat exchanger

### Technical Characteristics of GTPS-32:

Parameter	Measuring unit	Value
Electrical power at the generator terminals	MW	31,0
Electrical efficiency	%	35,0
Exhaust gas Flow	Kg/s	102,3
Fuel (Natural gas) consumption, $Q_{ph}=50$ mJ/kg	Kg/s	1,77
Specified Lifetime	h	200 000
Weight of main GTU equipment (without generator and gearbox)	Tons	132
Exhaust Gas Temperature	°C	508
Emissions (at 15% O <sub>2</sub> in the dry combustion products) of:		
Nitrogen oxides	Mg/m <sup>3</sup>	≤40
Carbon oxides	Mg/m <sup>3</sup>	≤38



## Equipment for Power-Generating Industry

### Gas turbine power station with the power 22/25 MW\*

REP Holding offers manufacture and supply of packaged equipment for gas turbine power stations based on gas turbines rated at 22/25 MW.

#### T25 gas turbine

T25 – gas turbine, simple – cycle, the heavy-duty T22/25 GTP are manufactured and assembled in Russia on the production site of REP Holding - Nevskiy Zavod under the license and in cooperation with Solar Turbines. It features high economical efficiency (40%) at a low level of harmful emissions for this power rating.

#### Gas turbine power plant (GTP)

GTP scope of supply includes the following main equipment:

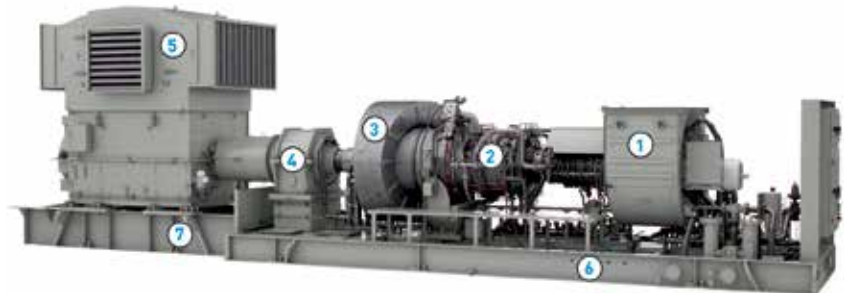
- Gas turbine engine on a base plate (GTE);
- Turbo-generator (TG) for GTE;
- Gear box to transmit power from the GTE to TG;
- Inlet air filter;
- air and gas duct system;
- heat-recovery boiler (option\*\*);
- Automatic process control system (APCS);
- Electric equipment;
- Support systems;
- Metal structures.

\* It is planned to increase the capacity of GTU gradually.

\*\* Is used for combined generation of electric and thermal power.



External view of the power unit in the noise-proof and heat-insulating enclosure



The main equipment of the power unit on the base plate (with enclosure removed):

- 1 – air inlet
- 2 - engine
- 3 – exhaust collector
- 4 – gear box
- 5 - generator
- 6 – engine skid
- 7 – generator and gear box skid



GTP – T25



## Performance

The gas turbine power unit is operable at the ambient air temperature from -55 to +50°C.

Parameter	Measuring unit	Value
Electrical power at the generator terminals	MW	21,75
Electrical efficiency	%	38,9
Exhaust gas Flow	Kg/s	68,24
Fuel (Natural gas) consumption, $Q_{ph}=50$ mJ/kg	Kg/s	1,11
Specified Lifetime	h	200 000
Weight of main GTU equipment (without generator and gearbox)	Tons	59
Exhaust Gas Temperature	°C	467
Emissions (at 15% O <sub>2</sub> in the dry combustion products) of:		
Nitrogen oxides	Mg/m <sup>3</sup>	≤50
Carbon oxides	Mg/m <sup>3</sup>	≤50



Configuration of the main equipment for GTP – CHPP (Central Heating and Power Plant)

1. Gas turbine power plant
2. Generator with the air cooling system
3. Oil air-cooler
4. Exhaust pipe
5. Air ducts for cycle air and air cooling system
6. Filter house
7. Waste-heat recovery boiler





## Gas turbine power station with the power 16 MW

### Description

GTE-16 high-tech gas turbine power plant, simple cycle, based on T-16 gas turbine engine developed by REP Holding together with GE Oil & Gas (Nuovo Pignone S.p.A.).

The gas turbine engine, industrial type, features high efficiency (37%), high service life, high availability and serviceability, low harmful emissions ( $\text{NO}_x < 25 \text{ ppm}$ ). Full compliance with GOST R 29328-92 "Gas Turbine Units to Drive Electric Generators".

The main equipment of the unit is standardized as much as possible and is completed using modular blocks.

### Purpose and Application

- The power unit is designed to generate electric and thermal power;
- To be used at thermoelectric power stations and central heating and power plants;
- As an option, it can be equipped with a waste heat recovery boiler, steam or hot water one, for simultaneous generation of electric and thermal power (cogeneration) with a coefficient of fuel heat utilization more than 80%;

• GTE-16 is installed in the main building of the electric power station or in the individual easy-to-assemble hangar-type building.

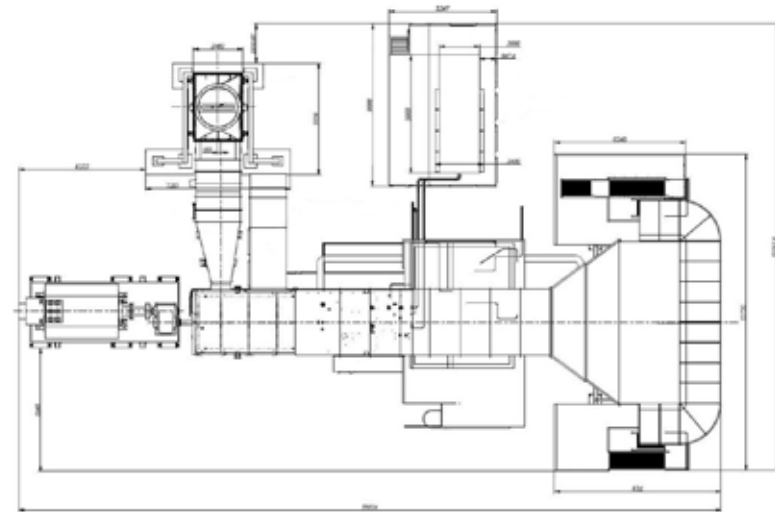
### Hangar-type building for installation of GTE-16 with functional systems:

- 1 - Filter house
- 2 - fire-fighting facilities compartment
- 3 - oil air-cooler
- 4 - building air heating unit
- 5 - gas duct with a silencer
- 6 - exhaust pipe

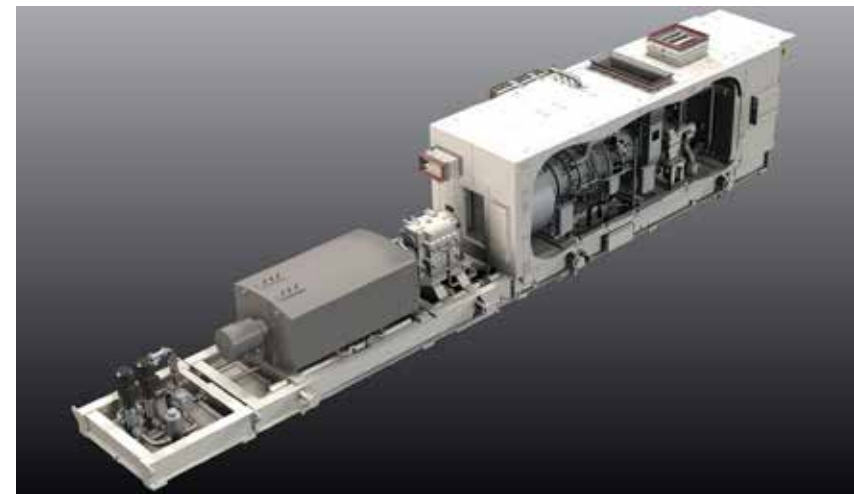
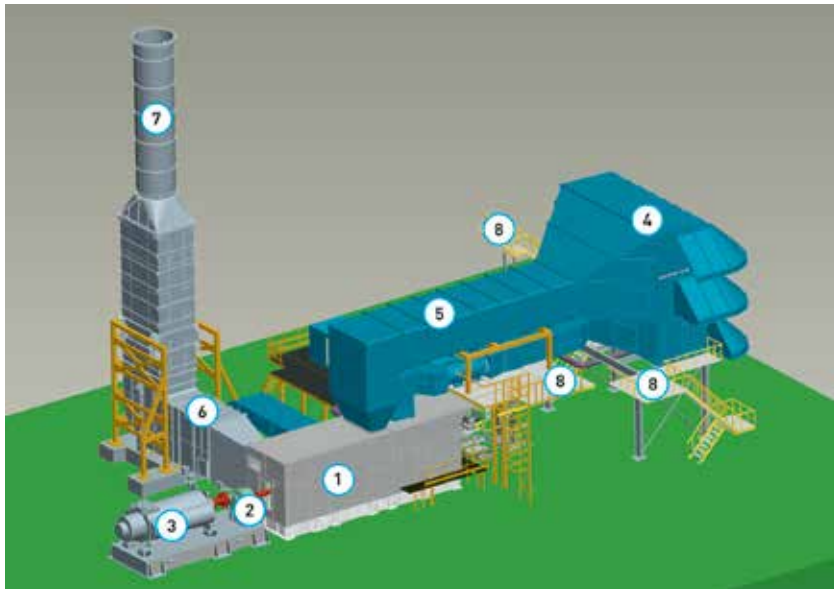
If necessary (depending on the reconstruction project for a specific power facility), an option of placing the unit in the existing building can be considered.

### GTE-16 components

- Gas turbine (GT);
- Turbo-generator (TG) for GT;
- Gearbox between GTU and generator;
- Filter house;
- Waste heat recovery boiler (option – if required);
- Fuel gas booster compressor (option – if required);
- Air-, gas – duct system;
- Automatic process control system (APCS);
- Electric equipment;



GTE-16 equipment layout



GTE-16 equipment layout

•Metal structures, maintenance platforms etc.

**GTE-16 power unit (the hangar walls are not shown for clarity)**

- 1 - gas turbine
- 2 - gearbox
- 3 - turbo-generator
- 4 - filter house
- 5 - cycle air duct
- 6 - gas duct with a silencer
- 7 - exhaust pipe
- 8 - maintenance platforms

### Performance characteristics

GTE-16 can be operated at the ambient air temperature from -60 to +50°C.

### GTE-16 parameters (at the nominal conditions, ISO)

Parameter	Measuring unit	Value
Electrical power at the generator terminals	MW	16,0
Electrical efficiency	%	35,86
Exhaust gas Flow	Kg/s	54,3
Fuel (Natural gas) consumption, $Q_{ph}=50$ mJ/kg	Kg/s	0,892
Specified Lifetime	h	200 000
Weight of main GTU equipment (without generator and gearbox)	Tons	75
Exhaust Gas Temperature	°C	490
Emissions (at 15% O <sub>2</sub> in the dry combustion products) of:		
Nitrogen oxides	Mg/m <sup>3</sup>	≤50
Carbon oxides	Mg/m <sup>3</sup>	≤40



### Combined Cycle Power Plants

REP Holding package supplies 42 and 84 MW combined cycle power units based on the stationary gas and steam turbines, and a set of its own electrical equipment.

Combined Cycle Power Plants are designed to significantly increase economy of electrical and thermal power generation maintaining flexibility and reliability of the permanent power, heat and process steam supplies.

#### Advantages:

- Higher economy and flexibility of power generation due to heat recovery from the gases exhausted by the gas turbine in a steam loop of the combined cycle gas turbine (CCGT);
- Electrical efficiency of 46.7 %;
- Ability to generate thermal power.

### Combined Cycle Power Plant with the power 42 MW

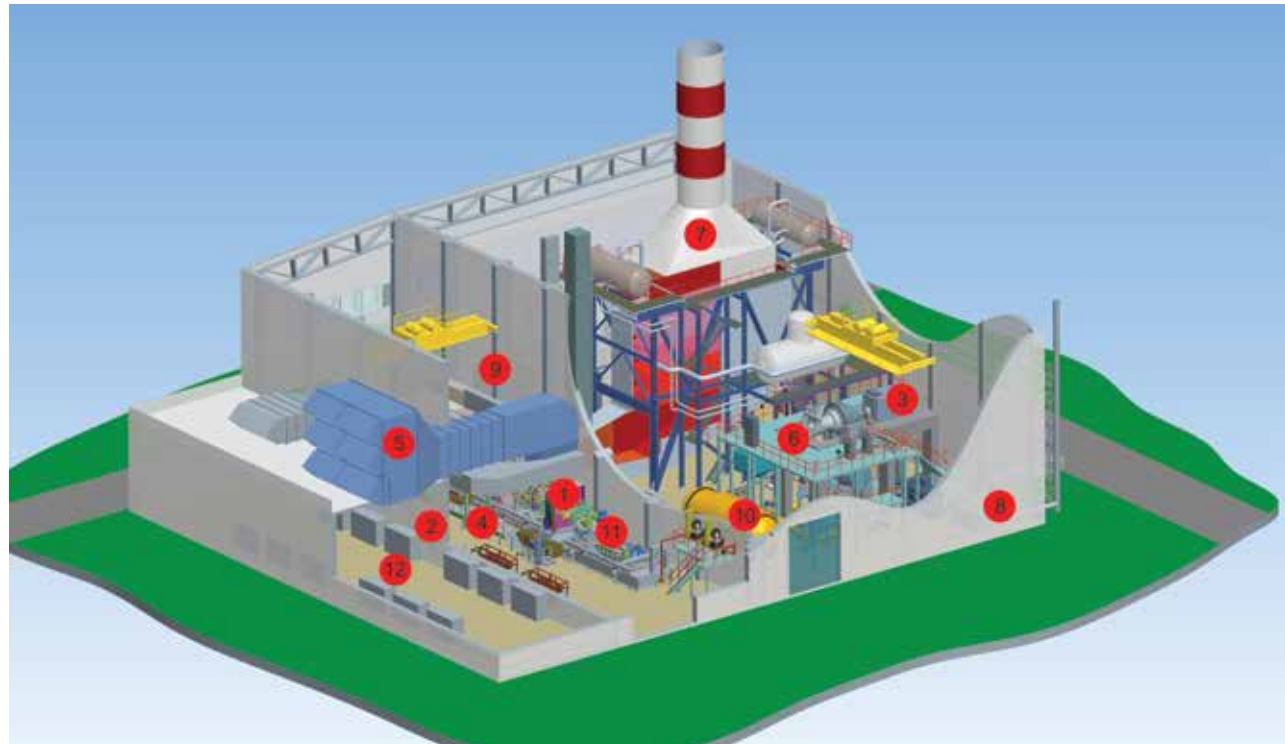
#### A single-unit CCP-42 includes:

- the gas circuit equipment:  
gas turbine unit based on T-32 (MS5002E) gas turbine engine produced by REP Holding with a gearbox and turbo-generator;
- steam circuit equipment:  
waste-heat boiler and steam turbine unit (STU) T-12-6,0/0,12 produced by REP Holding with a turbo-generator.

The layout of the power unit components (inside the integrated building)

- 1 — Gas turbine engine GT-32 (MS5002E)
- 2 — GTU turbo-generator
- 3 — ST turbo-generator
- 4 — Gear box
- 5 — Filter House
- 6 — Steam turbine
- 7 — Waste-heat steam boiler SteamGen8

- 8 — Water cooling system
- 9 — APCS MSKU
- 10 — System water heater
- 11 — Auxiliary base plate
- 12 — Electrical equipment compartment





### The technical features of SGP-42 (single-turbine unit)

Parameter	Measuring unit	value
The nominal electrical power, including:	MW	42
The power of GTU	MW	30,4
The power of STU	MW	11,5
The electrical efficiency of GTU	%	34,5
The exhaust gas flow rate	Kg/s	102
The boiler exhaust gas temperature	°C	120
The fuel flow rate (natural gas)	Kg/s	1,795
The steam-generating capacity of STU	Kg/s	12,6
The electrical efficiency of STU	%	46,7
The fuel gas pressure required	Kg/cm <sup>2</sup> (g)	31
Lube-oil system of turbo units		forced
The oil for application		ТП-22С
SLL; Service Life Limit	H	For GT and ST = 200000
Time between overhaul	h	For GT = 48000
The weight of the main equipment	Tons	675

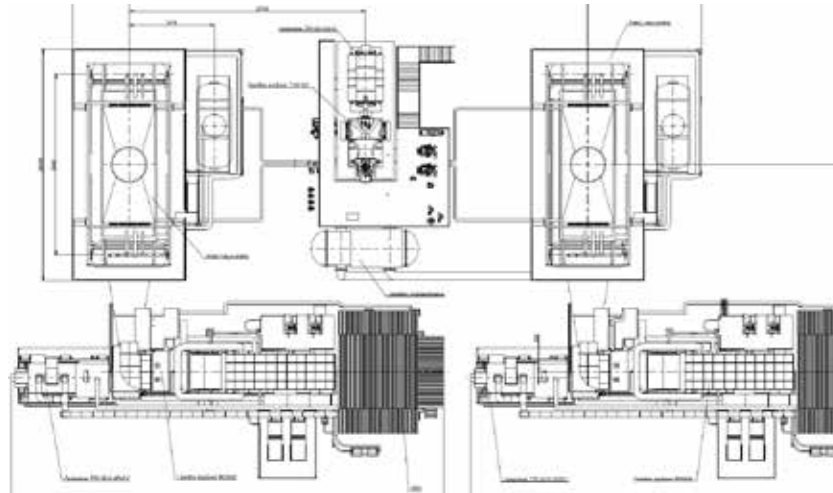


## Combined Cycle Power Plant with power 84 MW (SGP-84)

A double-unit CCPP-84 includes:

- the gas circuit equipment: two gas turbine units based on T-32 (MS5002E) gas turbine engine produced by REP Holding with gearboxes and turbo-generators;
- steam circuit equipment: two waste-heat steam boilers and one steam turbine unit (STU) T-22-6,0/0,12 produced by REP Holding with a turbo-generator.

- 1 — Gas turbine engine GT-32 MS5002E
- 2 — GTU turbo-generator
- 3 — ST GTU turbo-generator
- 4 — Gear box
- 5 — Filter house
- 6 — Steam turbine
- 7 — Waste-heat steam boiler
- 8 — Water cooling system
- 9 — APCS MSKU
- 10 — System water heater
- 11 — Main-line pump
- 12 — Electrical equipment compartment



Equipment layout SGP-84





## The technical features of SGP-84 (two-boiler single-turbine unit)

Parameter	Measuring unit	value
The nominal electrical power, including:	MW	84
The power of GTU (total power)	MW	60,8
The power of STU	MW	22,9
The electrical efficiency of GTU	%	34,5
The exhaust gas flow rate	Kg/s	204
The boiler exhaust gas temperature	°C	120
The fuel flow rate (natural gas)	Kg/s	3,6
The steam-generating capacity of STU	Kg/s	25,1
The electrical efficiency of STU	%	46,7
The nominal fuel gas flow rate for 1 GTU	Kg/s	1,795
The designed inlet fuel gas pressure of STU	Kg/sm <sup>2</sup> (g)	31
The ambient temperature	°C	+15
SLL; Service Life Limit	h	For GT and ST = 200000
Time between overhaul	h	For GT = 48000
The weight of the main equipment	tons	1150

## The set

The power two-boiler single steam turbine unit consists of the following main equipment, which was including in scope of supply:

- gas turbine (GT) MS5002E (under the license of GE) — 2 pcs;
- turbo generator (TG) for GT — 2 pcs;
- gear box to supply power to TG of GT — 2 pcs;
- filter house (FH) — 2 pcs;
- waste heat exchanger of both pressures — 2 pcs;
- steam turbine (ST) — 1 pcs;
- condenser of ST — 1 pcs;
- turbo generator (TG) for ST — 1 pcs;
- fuel gas booster compressor (if necessary);
- air and gas ducting system;
- automatic control system of technological process;
- electric equipment.

## The supply objects

Power and electric technical equipment of REP Holding is supplied for famous power and power generating companies objects, nuclear power branch enterprises, fuel-and-energy company and power supply network complex. The key customers — are OJSC "OGK-2", Rosenergoatom Concern OJSC, JSC "Federal Grid Company of Unified Energy System", "Gazprom Energy" Co., Ltd., JSC "INTER RAO UES" and etc.



## Equipment for Metallurgical Industry

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### Turbocompressor units

REP Holding manufactures blast-furnace turbocompressor units, exhaust fans, general- and special-purpose centrifugal compressors for the metallurgical industry.

#### Basic Advantages:

Package-supplies of all machine components manufactured by REP Holding result in:

- lower cost of the basic equipment due to the fact that such equipment is manufactured directly by CJSC REP Holding subsidiaries;
- application of the up-to-date technical solutions;
- lower operating cost;
- reliable operation of all other components;
- earlier equipment delivery dates;
- integrated servicing.

#### Exhaust Fans

#### Electrically-Driven Equipment of the Sintering Stage

#### Purpose and Application

This group includes compressors purposed to induce air draft through the sinter cake (burden) fused by means of the sintering machine and to remove thus generated agglomeration gases during dry and wet gas cleaning.

#### Machine Structure

The machine consists of a compressor, having a welded or a cast body and a single double-suction impeller, lube oil system, electrical motor drive connected to the compressor either directly, or via speed-increasing gear. The machine is equipped with protective and control devices which ensure its stable operation.

#### Typical Components of the Machine:

- centrifugal compressor with a rotor, foundation frames, tie-rods and base plates;
- reduction gear (in case the compressor speed differs from the electric motor drive speed);
- lube oil system;
- monitoring and protection instruments, instrument transducers;
- heat monitoring, control, protection and signaling board;
- compressor mounting and dismounting tools;
- accessories for lifting and alignment of the rotor and the top section of the compressor housing;
- electrical motor;
- operating documents.

#### Design Features

The group of equipment used for sintering includes the following machine series: 15500-11-1, 15000-11-1, 13000-11-1, 12900-11-1, 12000-11-1, 9000-11-5, 9000-11-4, 6700-12-1, 7700-12-1.

#### General Structure

The compressor includes the compressor itself, the electrical motor drive, the lube oil system, monitoring, protection, and signaling system and the heat monitoring boards.

The shafts of the compressor, the reduction gear, and the electric motor are connected by means of gear couplings. Plate coupling may be used.

The lube oil system of the machine provides forced lubrication of the bearings of the compressor, the reduction gear, and the electric motor, and oil supply to the gear transmission and couplings (if applicable).

Control of the machine start and stop, and the machine performance monitoring is done from the remote control panel located in the operator's room.

The machine control panel is equipped with emergency and warning audible signals and lights and process status indicators.

#### Centrifugal Compressors

Compressors are centrifugal, include the single-cylinder single-stage compressors with the double-suction impellers. The compressor body, either welded, or cast, consists of two suction cavities and a volute. The suction branch pipes are directed upward, the discharge branch pipes, side-ward. The volute internals are lined with removable protection plates. The compressor impeller is a welded piece. The inlet of the impeller is equipped with a removable anti-wear screen. The protective plates and the anti-wear screens prevent wearing of the internal surface of the volute and the impeller by the abrasive dust. The protective plates and the anti-wear screens are replaceable.

#### Compressor 13000-11-1

#### Purpose

The compressor is designed to support air moving through the sinter burden to be fused, and further removal of the flue gases after their cleaning via the gas outlet pipe to the flue gas stack.





### Design Features

The compressor's drive is an electric motor SDZ-900S-4 (СДЗ-900S-4) complete with the frequency converter PChVS-5/10-12UZL4 (ПЧВС-5/10-12УЗЛ4).

Oil is supplied by a main (starting) oil pump. The oil pump with AC motor drive is mounted onto the frame. Another similar pump is a stand-by pump. The main (starting) pump and the stand-by pumps are supplied from two independent power supplies.

Control, monitoring, protection and signaling system includes the heat monitoring boards which are equipped with the machine start and stop controls, the machine operating parameter meters, and emergency and warning signaling devices.

### Compressor 12000-11-1

#### Purpose

The compressor is designed to support air moving through the sinter burden to be fused, and further removal of the flue gases after their cleaning via the gas outlet pipe of the sinter machine to the flue gas stack. The compressible medium is agglomeration gas containing up to 200 kg/m<sup>3</sup> of dust. The compressor may be used for the sintering machines covering from

84 to 312 m<sup>2</sup> (the latter needs two parallelly-running compressors).

### Design Features

Speed-increasing gear installed between the compressor and the electric motor is a single-stage herringbone gear (nitrated teeth). On the frame oil tank there are the basic components of the oil system: starting and standby oil pumps, oil coolers, oil filters.

Oil is supplied by the main oil pump mounted on the speed increasing gear. The main components of the oil system, such as starting and standby oil pumps, oil cooler, oil filter, are mounted onto the frame (oil tank). Another similar pump is a stand-by pump. The main (starting) pump and the stand-by pumps are supplied from two independent power supplies.

Control, monitoring, protection and signaling system provides step-by-step starting and stopping of the compressor, as well as monitoring of the main parameters.

### Compressors 6700-12-1 and 7700-12-1

#### Purpose

The compressors are designed to support air moving through the sinter burden to be fused, and further removal of the flue gases

after their cleaning via the gas outlet pipe of the sinter machine. Another purpose is to exhaust the combustion residues containing up to 80-100 mg/m<sup>3</sup> of dust from the blast furnaces. The compressors are used with the dry and wet gas cleaning systems, and may be used for the sintering machines covering up to 75 m<sup>2</sup>.

The compressors have rather similar design and, mainly, their only difference is the number of the impeller blades, and the type of the electric motor drives.

### Electrically-Driven Equipment of the Basic Oxygen Steelmaking (BOS) Stage

#### Purpose and Application

This group includes compressors purposed to remove oxygen-converter gases from various BOS converter capacities after wet cleaning of the gases.

#### Typical Components of the Machine:

- centrifugal compressor with a rotor, foundation frames, tie-rods and base plates;
- lube oil system;
- monitoring and protection instruments, instrument transducers;
- heat monitoring, control, protection and signaling board;
- compressor mounting and dismounting tools;

- accessories for lifting and alignment of the rotor and the top section of the compressor body;
- electrical motor;
- operating documents.

### Machine Structure

The machine consists of a compressor, having a welded body and a single double-suction impeller, the lube oil system, the bearings, an electrical motor drive.

### Design Features

The group of equipment used for the basic oxygen steelmaking includes the following machine series: 10000-11-1, 8500-11-1, 7600-13-1, 7500-13-1, 4500-11-1. A number of the machines (10000-11-1, 8500-11-1, 4500-11-1) is equipped with a starting frequency converter. The machine is equipped with protective and control devices which ensure its stable operation.

The lube oil system of the machine provides forced lubrication of the bearings of the compressor, and the electric motor.

Control of the machine start and stop, and the machine performance monitoring is done from the remote control panel located in the operator's room.

The machine control panel is equipped with emergency and warning audible signals and lights and process status indicators.



### Compressors

#### General Structure

The compressors include the compressor itself, the electrical motor drive, the reduction gear, the lube oil system, monitoring, protection, and signaling system and the heat monitoring boards.

#### Design Features

The compressor is a single-cylinder single-stage machine with the double-suction impellers. The welded compressor body consists of two suction cavities and a volute. The suction branch pipes are directed upward, the discharge branch pipes, sideward. Due to nitrogen gas supplied to the compressor's end seals, the latter prevent ingress of air into the blading section, and leakage of compressed gas into the mechanical equipment room. A speed-increasing gear is installed between the compressor and the electric motor.

#### Compressor 10000-11-1

The centrifugal compressor 10000-11-1 is purposed to remove the oxygen-converter gases from the converter with capacity of 400

tonnes which applies combined blowing process (with top-blown oxygen and bottom-blown inert gas) after wet gas cleaning without reburning of the carbon oxide, and has the adjustable output.

The compressor is designed for the area class B-1A having the explosive gas category and group PA-T1. The compressor is driven by the electric motor SDZ-900S-4 with the frequency converter PChVS-5/10-12UHL4.

#### Compressor 7600-13-1

The centrifugal compressor 7600-13-1 is purposed to remove the oxygen-converter gases from the converter with capacity of 300-350 tones, and then to transfer such gases to the gas holder, after which, they will be further used as fuel.

The compressor is designed for the area class B-1A having the explosive gas category and group PA-T1. The compressor is equipped with a vaneless diffuser specifically designed to enlarge the working space of the compressor. The compressor is driven by the electric motor SDZ-900S-4 with the frequency converter PCvVS5/10-12UHL4.

#### Compressor 7500-13-1

The centrifugal compressor 7500-13-1 is purposed to remove the oxygen-converter gases from the steel-making converter, which is blown with oxygen from top, and gases of which are removed without reburning of the carbon.

#### Turbocompressor units for Air Supply to the Blast Furnaces

Turbocompressor units are the perfect articles (for the manufacturing process) in terms of the production capacity and techniques. These turbocompressor units are the stationary machines with long operational life and good repairability.

#### Purpose and Application

The turbocompressor units are designed for compression of the atmospheric air containing up to 40% of oxygen, and forcing of such air to the blast furnace.

#### Structure of turbocompressor units

The turboblower includes a centrifugal or an axial compressor, a steam turbine drive, the instruments, and the automated control and monitoring system. All equipment is designed and manufactured by CJSC REP Holding.

#### Turbocompressor units with the Steam-Turbine Driven Axial Compressors

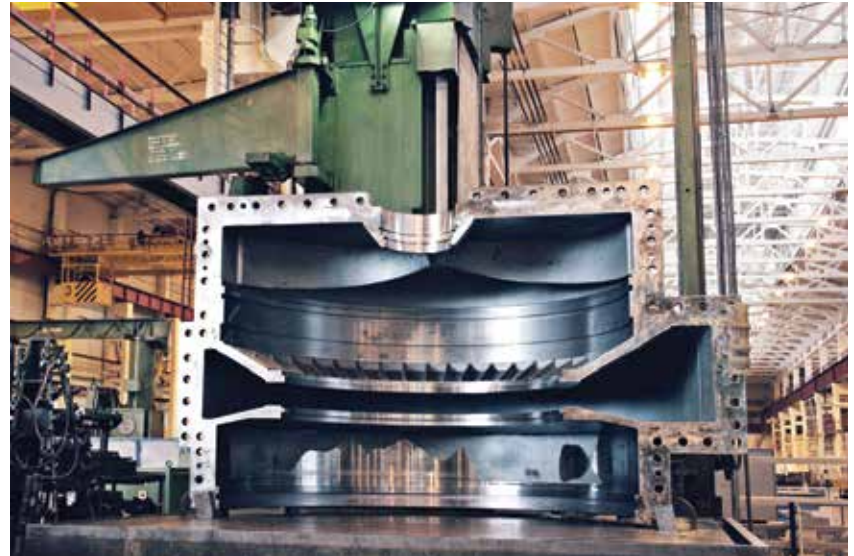
Turboblower	
Compressor	Turbine
K 3750-1	П-16-3,4/0,8
K 4300-1	П-18-3,4/0,8 П-23-8,8/0,8
K 4950-1	П-23-8,8/0,8



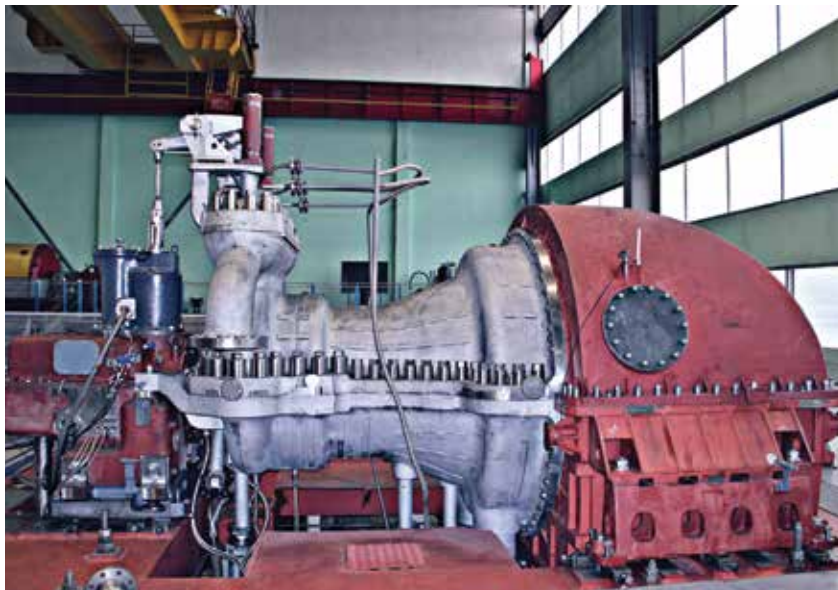
## Equipment for Metallurgical Industry



Turbocompressor Unit 5200/25 at Magnitogorsk Iron & Steel Works



Housing of the Compressor K 5500



The K-25-3,0 steam turbine on the test bed of Nevskiy Zavod production site



Rotor of the Compressor K 5500



## Turbocompressor units with the Steam-Turbine Driven Centrifugal Compressors

Turboblower	
Compressor	Turbine
K 3250-41-2	K-12-35-2
K 3250-42-1	K-12-35-3
K 5500-42-1	K-19-35-2
K 5500-41-1	K-22-90-2
K 5500-41-1M	K-22-90-2M
K 5500-41-1M	K-25-3,0

### Typical Delivered Components of the turbocompressor units:

- compressor:
  - compressor cylinder;
  - air cooler (for centrifugal compressors);
  - couplings;
  - lube oil line;
  - anti-surge control and protection system;
  - non-return damper;
  - venturi nozzle;
  - filter house;
  - an accessory for lifting the upper portion of the compressor cylinder and the rotor;
  - a wrench and a tool for disassembling of the compressor and the turbine;
  - replacement parts;
  - operating documents;
- steam turbine:

- turbine group;
- automatic control and protection system;
- oil supply system;
- associated equipment;
- pipelines;
- operating documents;
- standard set of spares;
- the machine instruments;
- the machine's automated control and monitoring system.

### Design features of the Steam Turbines of the turbocompressor units

The steam turbines manufactured by CJCS REP Holding are, generally, single cylinder units. The initial parameters of the live steam and the turbine output range condition the design of the blading section, which, as a rule, includes double- or single-row control stage and impulse pressure stage with cylindrical blades.

The steam turbine rotor speed required for driving of the compressor is adjusted within the range from 0.7 to 1.05 of the nominal rotor speed. This allows to adjust the compressor output within the same range.

The steam turbines of REP Holding use single-piece forged or prefabricated rotors with pressed-on discs. After assembling every rotor is subject to static and dynamic balanc-

ing, including balancing by means of vacuum acceleration and balancing test bench at the operating speed. Housings of all turbines are horizontally joined. Diaphragms of the turbine pressure stages are welded. Steam is distributed through the nozzles.

The end seals of the turbine are labyrinth-type seals. To seal the turbine in the starting mode and under low load, the end seals are equipped with the steam pressure regulators. The rear support bearing is built into the exhaust pipe resting onto the lateral foundation frames. The turbine is equipped with a shaft turning gear driven by an electrical motor. The shaft turning gear provides even heating of the rotor during start-up, and even cooling-down during stopping.

The condenser of the steam turbines manufactured by CJCS REP Holding consists of a surface-type two-pass condenser, main and start-up ejector and a suction device.

The steam turbines may be supplied from the full-flow condensate and feed heating system.

### Oil Supply System

The system supplies required quantity of oil at a required pressure and temperature to the lube oil system, the automatic control and protection system, to the tur-

bocompressor passive fire protection system in any operation mode. In the oil supply system it is possible to check if the start-up, stand-by and the emergency oil pumps can be started when the unit is running.

### Automatic Control System

The system's functions include:

- control of the regulators while starting, changing operation modes and stopping the turboblower;
- support of the continuous turboblower operation when the rotor speed is within an adjustable range;
- maintaining of the pre-set speed with a required unevenness.

The automatic control system is a multi-purpose electric and hydraulic system which controls the turboblower in start-up and operation modes, in standard, emergency or urgent shutdown modes. The automatic hydraulic control system repeats the electrical system, and is designed to maintain control of the turbocompressor (and, consequently, integrity of the blast furnace), in case of an electrical power black-out.



## Equipment for Metallurgical Industry

### Steam Turbines Driving the Centrifugal Compressors

Model	Rated Power, MW	Maximum Power (in cond.model), MW	Steam Rate at Nominal Operation Parameters, t/h	Steam Rate at Maximum Operation Parameters, t/h	Input parameters of steam		Shaft Speed, min <sup>-1</sup>	Diagram	Initial Value, and Adjustable Range Of Steam Rate (t/h) and of Inlet Nozzle Pressure (MPa)	Steam Consumption by the Central Heating System, t/h (parameters °C/MPa)	Cooling Water Rate, t/h	Specific Weight of the Turbine, t/MW
					Pressure, MPa	Temperature, °C						
K -25-3,0	26,0	26,0	116,0	116,0	2,94	400	2500-3500	ПНД			5500	1,54
K22-90-2M	23,0		82,6		8,83	535	2500-3500				4900	2,0
K22-90-2	20,5		79		8,83	535	2500-3500				4900	2,24
K19-35-2	19		83,8		3,43	435	2500-3400				4900	2,21
K12-35-2	12,8		57,5		3,43	435	2500-3500				3300	3,28
K12-35-3	11,6		51,7		3,43	435	2500-3500				3300	3,62

### Steam Turbines Driving the Axial Compressors

Model	Rated Power, MW	Maximum Power (in cond.model), MW	Steam Rate at Nominal Operation Parameters, t/h	Steam Rate at Maximum Operation Parameters, t/h	Input parameters of steam		Shaft Speed, min <sup>-1</sup>	Diagram	Initial Value, and Adjustable Range Of Steam Rate (t/h) and of Inlet Nozzle Pressure (MPa)	Steam Consumption by the Central Heating System, t/h (parameters °C/MPa)	Cooling Water Rate, t/h	Specific Weight of the Turbine, t/MW
					Pressure, MPa	Temperature, °C						
P-23-8,8/0,8		23,6/15,8	94,7/123,4		8,83	535	4600 - 5200		0,59-1,08	86,4	4900	1,78
P-18-3,4/0,8		18,7/12,7	85,5/140,9		3,43	435	4600 - 5200		0,59-1,08	114,5	4900	1,93
P-16-3,4/0,8		15,8/10,8	73,8/118,4		3,43	435	3500 - 5400		0,59-1,08	94,7	3800	2,23
P-10-3,4/0,8		11,0/7,8	50,8/86,9		3,43	435	3500 - 5300		0,118 - 0,245	66,5	3300	3,04
П-30-100/41-1	29,4		350		10,1	482	9300-10000		3,98 - 4,14	280	1500	0,61



## Centrifugal Compressors for the Blast Furnaces

### Compressors

The group of the centrifugal compressors for the blast furnaces includes the following machine series: K5500-41-1, K5500-42-1, K550-41-1M, K 3250-41-2, K 3250-42-1.

### Design Features

The centrifugal compressors for the blast furnaces are a single-cylinder, double-circuit, four-stage direct drive machines with one intermediate cooler. The centrifugal compressors are driven by the steam turbines with output power of 8-30 MW, which allow for the centrifugal compressor to change its operating mode due to change of the rotor speed.

The compressors K3250-41-2 and K3250-42-1 have a similar design, and they differ only in width of the impellers', vaned diffusers' and inverse guide vanes' channels.

The compressors are equipped with the automatic and protection devices, controls, which provide stable operation of the compressors.

### Specifications

Parameters	Compressor Type		
	K5500-41-1 (K5500-42-1)	K3250-41-2 (K3250-42-1)	K 5500-41-1M
Compressed Fluid	Air		
Volumetric Suction Capacity, m <sup>3</sup> /min.	4200 [4000]	3250 [2450]	5200
Final Air Pressure, MPa abs.	0,51	0,441	0.51
Initial Parameters: temperature, °C	20	20	20
pressure, MPa abs.	0,098	0,098	0.098
Rated Rotor Speed, rpm.	3440 [3380]	3370 [3280]	3450
Compressor Consumed Power, MW	17,2 [16,3]	11,2 [8,7]	22
Drive Type: steam turbine	K-22-90-2 (K-19-35-2[3])	K-12-35-2 (K-12-35-3)	BKB-22-II
Cooling Water Rate, m <sup>3</sup> /h	750 [600]	500	750
Overall Dimensions, m:			
Foundation Length	15,3	14,3	15.3
Foundation Width	7,1	6,9	7.05
Floor Level of the Mechanical Equipment Room	7,2	7,2	7.2
Crane Hook Lifting Height in reference to the mechanical equipment room floor level	6,1	5,7	6.1
Weight, tonnes			
Of the as-delivered compressor	112	83	112
Of the heaviest assembly unit during assembling and operation	34,1	24,4	34.1



### Axial Compressors for the Blast Furnaces

The group of the compressors for the blast furnaces includes three machine series: K-3750-1, K-4300-1, K-4950-1, having a volumetric capacity of 3750–4950 m<sup>3</sup>/min. at the final air pressure 0.46–0.54 MPa.

#### Design Features

The compressors of this group are a single-cylinder, single-shaft machines without intermediate cooler. The compressors are equipped with the protection devices and controls, which provide stable operation of the compressors. The control, protection, monitoring and signaling system is the same as the one of the steam turbine, and is an integral part of the turbine. The compressor is operated from the control panel. The compressor is started from the local control panel, and stopping, from the local and remote control panels.

#### Brief Description of the Compressor

The compressor housing includes a suction cavity, a vane carrier and a discharge cavity. Every element of the housing is a horizontally-connected casting.

#### Compressor K-3750-1

The axial compressor K-3750-1 is designed to compress atmospheric air or air containing up to 35% of oxygen, and then to supply it to the blast furnaces with capacities of 1300–1400 m<sup>3</sup>. The vanes carrier has an annular groove into which 13 rows of stationary guide vanes and a row of inlet guide vanes are fit. In the carrier a special segment and an air bypass cavity are installed above the rotating blades which allow to extend a stable operation period of the compressor. The compressor has a drum-type rotor. In the drum 13 rows of rotating blades are installed in the annular grooves.

#### Compressor K-4300-1

The axial compressor K-4300-1 is designed to compress atmospheric air or air containing up to 40% of oxygen, and then to supply it to the blast furnaces with capacities of 1500–1800 m<sup>3</sup>. It consists of a suction cavity, a vane carrier and a discharge cavity. The front part of the vanes carrier contains the variable guide vanes, and the first

to the fourth stages of the guide vanes, which are fit into the radial holes. The stationary guide vanes (from the fifth to the fifteenth stages of the guide vanes) are installed into the annular grooves in the rear part of the carrier. Downstream of the discharge cavity there is an air bypass valve which allow to extend a stable operation period of the compressor. The compressor has a drum-type supercritical rotor. In the drum 15 rows of rotating blades are installed in the annular grooves.

#### Compressor K-4950-1

The axial compressor K-4950-1 is designed to compress atmospheric air or air containing up to 40% of oxygen, and then to supply it to the blast furnaces with a capacity of 2000 m<sup>3</sup>. The basic difference is that the compressor K-4950-1 has a stage at the inlet and does not have any stage at the outlet. The front part of the vanes carrier contains variable guide vanes, and the first to the fifth stages of the guide vanes, which are fit into the radial holes. The stationary guide vanes (from the

sixth to the fifteenth stages of the guide vanes) are installed into the annular grooves in the rear part of the carrier. Downstream of the discharge cavity there is an air bypass valve which allow to extend a stable operation period of the compressor.

The compressor has a drum-type supercritical rotor. In the drum 15 rows of rotating blades are installed in the annular grooves. Manufacturing of this compressor series started in 1994.







### Top-pressure recovery turbines

Top-pressure recovery turbines (TPRT) operating on the blast-furnace top gas are designed to generate electric power at the expense of pressure differential between the gas pressure under the blast-furnace top and pressure in the all-factory top gas reservoir from which gas comes to the consumer.

#### Rotor of top-pressure recovery turbine TPRT 25

REP Holding produces turbines rated at 12 and 25 MW (TPRT-12, TPRT-25). Based on this design manufactured also can be TPRT rated at 16, 10, 8, 6 MW.

#### Special features of TPRT produced by REP Holding:

- speed of 1500 rpm, which provides minimization of possible erosive wear of the blading when operating on dust-laden gas;
- regulation of speed or gas pressure ahead of the turbine by means of the variable nozzles with a hydraulic drive;
- availability of the washing system to wash the flow passage of the turbine, using recirculated water of the blast-furnace shop gas cleaning cycle;
- availability of the condensate removal system to remove condensate from the inlet and outlet branch pipes of the turbine with a float-type hot-well.

Name of parameter	TPRT-12	TPRT-25
Volume flow of gas at 0.101 MPa and 0°C, Nm <sup>3</sup> /h	450 000	900 000
Gas pressure in the inlet branch pipe, MPa	0,31	0,304
Gas temperature in the inlet branch pipe, °C	50	40
Speed, s <sup>-1</sup> (rpm)	25 (1500)	1500
Total power on the turbine coupling, MW	11,5	22,5



Rotor of top-pressure recovery turbine TPRT 25



### General- and Special-Purpose Air Centrifugal Compressors

Centrifugal compressors for air separation units.

#### Compressor K3000-61-1

##### Design Features

Compressor K3000-61-1 is a double-cylinder, three-circuit, six-stage direct-drive machine with two intermediate coolers. The compressor is driven by the steam turbine with power output of 22 MW, which allow for the centrifugal compressor to change its operating mode due to a change of the rotor speed.

#### Compressor K1290-121-1

##### Purpose

The compressor is designed to compress atmospheric air at the low-concentrated nitric acid production line.

##### Design Features

The compressor is a double-cylinder twelve-stage (each cylinder has 6 impellers), four-circuit machine. After every circuit the air is cooled in the intermediate air cooler located outside the housing.

The compressor is driven by a steam turbine K15-41-1 with power output of 15 MW, which allow to change the rotor speed within the

range of 2500-3400 min<sup>-1</sup>. Rotor of the low-pressure cylinder is driven directly by the steam turbine, and the rotor of the high-pressure cylinder, via the speed increasing gear.

#### Compressor K1700-61-1

##### Purpose

The compressor is designed to compress atmospheric air, and to supply it to the oxygen units.

##### Design Features

The compressor is a six-stage, three-circuit machine. Each circuit consists of two compression stages. Air is cooled by the intermediate coolers located after the first and the second circuits. Air coolers are located in the basement room. To cool the compressor outlet air, a loop air cooler is provided. The compressor is driven by a synchronous motor STD-10000-2UHL4 with a power output of 10 MW.

#### Compressor K905-62-1

##### Purpose

This compressor is purposed to be used with air headers NAD for supply of air to the blast furnaces for casting.

##### Design Features

The compressor consists of a single-cylinder compressor itself, electric motor drive, and control, monitoring, protection and signaling system. The compressor is a six-stage, three-circuit machine. Between the circuits there are air coolers installed. Each circuit consists of two compression stages. The speed increasing gear is a single-stage herringbone (double helical) gear. The compressor is driven by a synchronous motor STD-6300-2UHL4 with a power output of 6300 kW, voltage 6 or 10, kV and speed 50 s<sup>-1</sup>.

#### Compressor K384-61-1

##### Purpose

The compressor is designed to compress atmospheric air, and to supply it to the user. The compressor may be used for compression of nitrogen and other non-aggressive mediums.

##### Design Features

The compressor consists of a single-cylinder compressor itself with an intermediate air cooler, a speed increasing gear, an electric motor drive, the lube oil system of the anti-surge protection and control devices, protection, monitoring and

signaling system and control panels. The compressor is a single-cylinder, six-stage, having three double-stage circuits. Gas is cooled after every compressor circuit.

The end labyrinth seals allow to use the compressor for nitrogen and other non-explosive and non-aggressive gases as the gas supplied to the end seals prevents the compressor leakage. The speed increasing gear is a single-stage herringbone gear with nitrated teeth. The compressor is driven by a synchronous motor STD-3150-2UHL4 with a power output of 3150 kW, speed 3000 min<sup>-1</sup>, and voltage 5 or 10, kV.

#### Compressor K590-41-1

##### Purpose

It is designed to compress air and to supply it to the general service circuits.

##### Design Features

The compressor is a four-stage, double-circuit, single-suction unit with an intermediate cooler. The compressor is so designed that its bearings can be checked without closing of the horizontal joint of the compressor housing. The compressor is equipped with a speed increasing gear.



The end labyrinth seals allow to use the compressor for nitrogen and other non-explosive and non-aggressive gases as the gas supplied to the end seals prevents the compressor leakage. The speed increasing gear is a single-stage herringbone gear with nitrated teeth. The compressor is driven by an electric motor having a closed-circuit ventilation system. The compressor is equipped with protection devices which prevent surging, backflow of air from the compressor to the supply line), axial rotor shift, overpressure (when the compressor is charging the air pressure exceeding the maximum value), excessively low pressure of lube oil, overheating of the bearing liner.

### Compressor K390-112-1

#### Purpose

The compressor is designed to compress nitrogen supplied from the air separation units, as well as to compress atmospheric air and to supply it to the separation units.

#### Design Features

The compressor consists of a double-cylinder compressor itself with an intermediate air cooler, two speed increasing gears, an electric motor drive, the lube oil system, the anti-surfing system, protection, monitoring and

signaling system and control panels. The compressor is a double-cylinder, 11-stage machine. The low-pressure cylinder contains three double-stage circuits, as the low-pressure cylinder of the compressor K420-91-1, and the high-pressure cylinder includes one five-stage circuit. Air (nitrogen) is cooled by the intermediate gas coolers after the first, the second, and the third circuits. The gas cooler of the third circuit has a built-in moisture separator. The speed increasing gears are installed between the electric motor and the low-pressure cylinder, and between the low-pressure cylinder and the high-pressure cylinder. The compressor is driven by a synchronous motor.

### Compressors K420-91-1

#### Purpose

The compressor is designed to compress air and to supply it to the user in various industry branches. Also, they can be used for compression and supply of air for injection of coal slurry into the boiler burners, and for compression of nitrogen and of other non-aggressive and non-explosive gases.

#### Design Features

The compressor consists of a dou-

ble-cylinder compressor itself with an intermediate air cooler, a speed increasing gear, an electric motor drive, the lube oil system, the surging protection and control system, protection, monitoring and signaling system and control panels, end air cooler.

The compressor is a double-cylinder, nine-stage machine. The low-pressure cylinder contains three double-stage circuits, and the high-pressure cylinder includes one three-stage circuit. Air is cooled by the intermediate air coolers after the first, the second, and the third circuits. The first air cooler located under the low-pressure cylinder contains tube bundles which are used for cooling of air after the first and the second circuits. The air cooler of the third circuit, located at the level of the mechanical equipment room floor, has a built-in moisture separator. The compressor has no leakages due to gas supplied to the end seals.

The speed increasing gear is installed between the electric motor and the low-pressure cylinder.

The compressor K420-91-1 is driven by an asynchronous motor.

### Compressors 1000-31-1, 1000-32-1

#### Purpose

The compressors are designed to compress air, and explosive gases

with fluid dynamics parameters similar to those of air.

#### Design Features

The compressor consists of a compressor itself, an electric motor drive, a speed increasing gear, the lube oil system, and the control, monitoring, protection and signaling system.

The compressors are the single-cylinder, three-stage machines. The compressor housing is an iron casting. Suction and discharge branch pipes are directed downwards. The compressors are equipped with the speed increasing gears. The compressors are driven by a synchronous motor.

### Compressor 1400-31-1

The compressor 1400-31-1 is an upgraded version of the compressor 1000-32-1.

The parameters of this machine were obtained due to replacement the following parts of the standard delivery set of the compressor 1000-32-1:

- electric motor;
- compressor rotor;
- pair of speed increasing gears;
- liners of the compressor and the speed increasing gear;
- set of seals.



## Equipment for Metallurgical Industry

The parameters were also obtained due to upgrading of the diffusers of all three stages and of the suction cavity bore in situ according to the Supplier's drawings. Gas dynamic testing of the upgraded compressor in situ proved that it has the required parameters.

### Compressor K3000-63-1

#### Purpose

It is designed to compress atmospheric air and to feed it to the air separation units.

#### Design Features

The compressor consists of a compressor itself, an electric motor drive, the lube oil system, a speed increasing gear, and the control, monitoring, protection and signaling system, and heat monitoring system.

The compressor is a single-cylinder, six-stage machine having three double-stage circuits. After the first two circuits, air is cooled by two intermediate shell-and-tube coolers with finned tubes. After the third circuit, air is cooled by the three parallelly-connected end air coolers.

The first and the second compressor stages are equipped with the inlet guide vanes extending a sta-

ble operation period of the compressor, and, meanwhile, retaining its efficiency.

The compressor is driven by a synchronous motor TDS-20000-2UHL4 with output power capacity of 20 000 kW.

### Compressor C525-61-1

#### Purpose

It is designed to compress and supply industrial air.

#### Design Features

The compressor is a single-cylinder, six-stage machine having three circuits. The compressor housing has the integrally cast iron bearing sleeves. The compressor housing has horizontal and vertical joints. The suction and the discharge branch pipes are directed downward. After the first and the second circuits there are intermediate coolers located outside the housing. The compressor is equipped with the automated monitoring and control system, and the instruments. The automated monitoring and control system controls the following:

- pre-starting;
- start-up;
- operation;
- normal stopping;
- emergency shutdown.

The compressors are protected from the backflow of gas from the main line to the compressor by means of a back-pressure valve located on the discharge pipeline.

A speed increasing gear is installed between the compressor and the electric motor. The compressors are driven by a synchronous motor.

### The supply objects

The compressors manufactured by REP Holding are supplied to the large metallurgical plants and companies in Russia and in the foreign countries, including, but not limited to Magnitogorsk Iron and Steel Works, Novolipetsk Steel Works, Nizhniy Tagil Iron and Steel Works, Severstal Iron and Steel Works, as well as to the metallurgical segment of the Mechel Group of Companies, "EVRAZ", corporation "Kazakhmys" (Kazakhstan), groups "Metinvest" (Ukraine), Bokaro Steel Plant, Bhilai Steel Plant, Durgapur Steel Plant (India), Paksteel Mill (Pakistan), Baotou Iron & Steel (Group) company (China), etc.



K-22-90-2M Turbine Rotor



## Equipment for Metallurgical Industry

### Compressor Specifications

Parameters	Compressor Type													
	K3000-61-1	K1290-121-1	K1700-61-1	K905-62-1	K384-61-1	K590-41-1	K390-112-1		K420-91-1/2	N1000-31-1	N1000-32-1	K3000-63-1	K525-61-1	
Compressed Fluid	Air						Nitrogen	Air	Air	Air	Air	Air	Air	
Volumetric Suction Capacity, m <sup>3</sup> /min.	3000 (2700)	1210	1700	950	403	580	370	390	395	925	1025	3300	525	
Final Air Pressure, MPa abs.	0,6	3,53	0,736	0,735	0,883	0,431	3,24	3,24	1,6	0,284	0,334	0,706	0,88	
Initial Parameters: temperature, °C	20	20	30	20	20	30	30	30	20	25	25	30	20	
pressure, MPa abs.	0,098	0,092	0,095	0,095	0,098	0,098	0,103	0,0953	0,098	0,0981	0,0981	0,095	0,098	
Rated Rotor Speed, rpm.	3250 (3280)	3300/ 9240	4554	5690	9100	7628	9100 16333	9100 16333	9008	4600	5070	3000	7628	
Compressor Consumed Power, MW	20,5 (18)	12,0	8,35	4,6	2,3	2,3	3,65	3,7	2,9	2,4	3,15	15,5	3,0	
Drive Type:														
Electric Motor	STD-10000-2UHL4	STD-6300-2UHL4	STD-3150-2UHL4	STD-2500-2UHL4	STD-5000-2UHL4c	4AZM-3150/6000	STD-3150-UY4		STD-4000-2U4	STD-20000-2UHL4	STD-3150-2UHL4	ТДС-20000-2УХЛ4	СТД-3150-2УХЛ4	
Steam Turbine	K-22-90-2 (K-19-35-3)	K-15-41-1												
Cooling Water Rate, m <sup>3</sup> /h	1000	560	1024	650	315	295	326	326	373				1572	352
Overall Dimensions, m:														
Foundation Length	17,8	15	13,15	11,6	9	2,3	11,5	11,5	10,7	8,75	8,75	15	9,7	
Foundation Width	6,9	6,8	5,1	5,0	3,15	3,4	3,5	3,5	3,15	3,80	3,80	7	3,5	
Floor Level of the Mechanical Equipment Room (Height of the Basement Room)	7,2	6,0	4,8	4,2	3,6	3,6	4,8	4,8	3,6	3,6	3,6	6	3,8	
Crane Hook Lifting Height in reference to the mechanical equipment room floor level	5,5	6,5	5,0	5,5	2,5	3,5	3,5	3,5	2,5	4,5	4,5	7	3,5	
Weight, tonnes														
Of the as-delivered compressor	122	122	82,1	60,5	27,25	30	54,1	54,1	38,3	25,9	25,98	224	35,9	
Of the heaviest assembly unit														
during assembling	12,9	45,2	37,5	12,72	10,9	13,67	13,67	13,7	17,5	17,5	40,5	13,34	13,34	
during operation	9,0	17,5	12,0	2,9	4,5	4,7	4,7	4,7	6,7	6,7	39	4,7	4,7	



## Management System Policy



### Certificates

REP Holding owes high quality, reliability and competitive ability of its products and services to the implemented unified Integrated Management System (IMS) based on the standards GOST ISO 9001-2011 (ISO9001:2008), GOST R ISO 14001-2007 (ISO 14001:2004), GOST R 54934-2012 (OHSAS 18001:2007) and STO Gazprom 9001-2012. Compliance of IMS with the Russian and International standards and internal standards of OAO Gazprom for quality, health, labour safety and environmental safety is proved by the certificates issued by the large independent certification authorities: "Test-S.-Petersburg" Co.Ltd., International Certification Network IQNet, Italian National Accreditation Association ACCREDIA which is a member of the International Accreditation Forum (IAF), and "Russian Register" Association.

### License

REP Holding holds licences of such leading machine-building companies as GE Oil&Gas, Solar Turbines, Siemens SKF,Rittal, etc. All types of activities of the subsidiaries of the holding company are sufficiently licensed as required by the federal laws "On Licensing of Certain Types of Activities", and "On Use of Nuclear Power".

### Product conformity assessment

The products undergo the procedure for conformity assessment of the security in the form of certification and declaration according to GOST R and in accordance with the requirements of Technical regulations and the Federal Law "On Technical Control", Technical Regulations of the Customs Union.

REP Holding has obtained about four dozens of compliance certificates and conformity declarations for new and serial products. Saint-Petersburg Administration has granted a quality award to the Holding companies for the significant contribution to development and implementation of the modern product Quality Assurance and Management Systems, and for manufacturing and selling of the high-quality competitive products.





## Human resources policy

JSC REP Holding is a strong and prosperous company which includes industrial enterprises with a long history and vast experience. Our company is based on highly-developed and highly-motivated team, which combines professionals in different spheres of production and engineering.

People are our real treasure. Every employee contributes into the final result of the Company. Every project is a challenge. Every challenge for us is an opportunity to develop and to gain new knowledge and experience. During the process of developing of prototype of new equipment it seems that it is impossible to make it true. But step by step when we work all together as a one team it becomes turn to reality. This is our common success and achievement.

Personnel of REP Holding is a team of highly-experienced specialists who develop unique design solutions, who accomplishes the hardest production tasks, and create hi-tech products so that the key industries have the modern equipment.

We create comfort labor environment and provide a competitive salary level, employment benefits, subsidized catering, and additional

medical insurance. Our people always receive the opportunities to prove themselves, to find new extraordinary solutions for complex tasks. Drive is a great feeling that our company gives.

Production facilities and the scientific and technological resources represent the competitive edge of the Holding.

### Training of Young Specialists

REP Holding applies a group of actions related to recruitment, training and development of career paths of the employees. Special attention is given to training of the young specialists. A number of Saint-Petersburg technical institutes assist in focused training of the students in disciplines required at the production site.

### Training and Development of Employees

Our company takes many efforts to enhance professional skills of our employees. We do everything to ensure that our employees are duly certified and have attended all required trainings. We provide an opportunity of cross-functional exchange of experience, an oppor-





## Human resources policy

tunity to be taught by the professionals, and to continuously grow both linear and upward, climbing the career ladder.

The nearest future task is to implement continuous training and development of management and professional skills of every employee.





## **JSC «REP Holding»**

**Address:** 51, lit. AF, Obukhovskoy Oborony Pr.,  
Saint-Petersburg, 192029, Russia

**Ph.:** +7(812) 372 58 80; +7(812) 372 58 81

**Fax:** +7 (812) 412-64-84

**[reph@reph.ru](mailto:reph@reph.ru)**

**[www.reph.ru](http://www.reph.ru)**