

**FAST TRACK
MODULAR CCPP-20/25
BASED ON T16 GAS TURBINE ENGINE**

JSC "REP HOLDING"



JSC "REP HOLDING" IS A LEADING RUSSIAN POWER ENGINEERING HOLDING, DESIGNER, MANUFACTURER, SUPPLIER OF POWER GENERATION EQUIPMENT OF NEW GENERATION.

Since 2010 it is a part of the Gazprombank Industrial Group. It carries out engineering developments, manufacturing and package supplies of power generation and electrical equipment for the gas, oil, metallurgical and chemical industries, for power engineering and integrated power grid.

The supplied equipment is widely used for upgrading the gas transportation system, in the construction of up-to-date power units and power plants, for small-scale power generation, in the LNG market and in some other industries.

REP Holding incorporates two large industrial enterprises of Saint-Petersburg: Nevskiy Zavod and Elektropult Plant which are a powerful platform for the development and manufacture of advanced high-quality competitive products. The Holding includes its own Engineering Center which carries out research and development activities (R&D) and innovative development.

HOLDING'S PRODUCTS

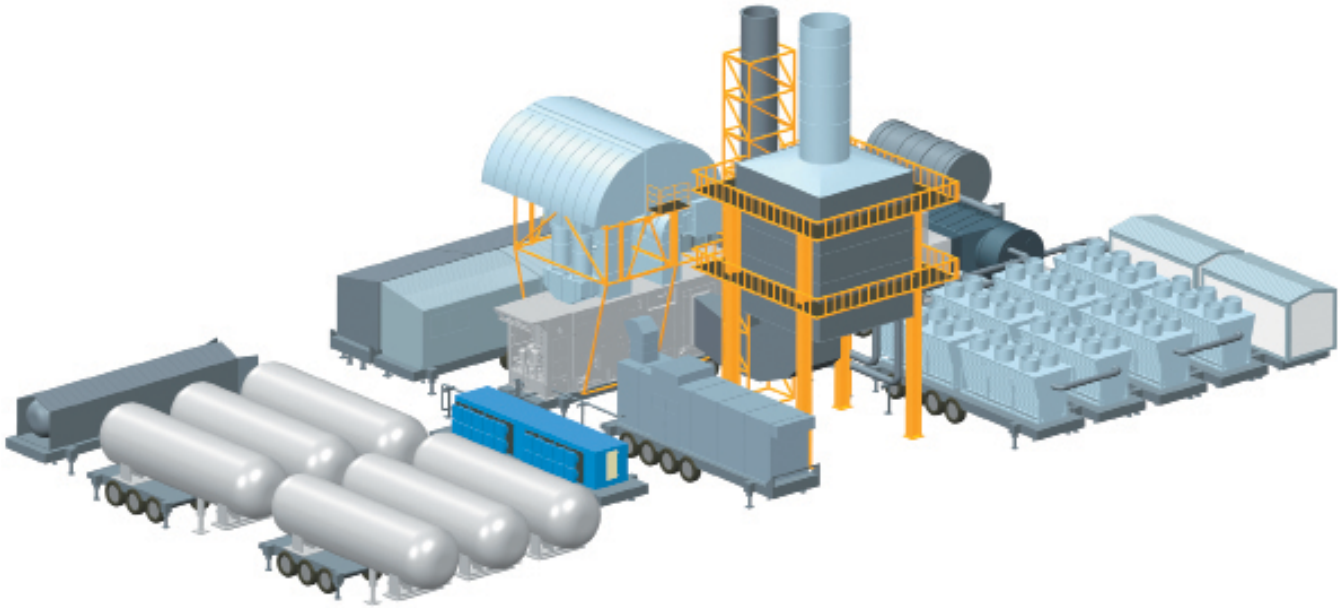
- new generation gas- pumping units rated at 16, 25, 32 MW;
- steam turbine units rated from 6 up to 25 MW;
- complete electrically driven gas- pumping units rated at 4,0; 6,3; 12,5 MW;
- centrifugal compressors with a capacity of up to 32 MW;
- power generating units based on steam and gas turbines with a capacity of up to 32 MW;
- variable frequency electric drives up to 100 MW;
- automated systems of control, regulation, distribution and conversion of electric power;
- systems for complete integrated automation of industrial facilities;
- electrical equipment.

COMPETITIVE ADVANTAGES

- research and development potential, application of unique design and technological solutions;
- advanced engineering and manufacturing capabilities;
- successful experience in localizing advanced foreign technologies;
- production of advanced energy-saving equipment in compliance with the requirements of API standards;
- integrated production management system;
- full production cycle from design to service maintenance;
- «turnkey» packaged supply;
- high reliability and operational availability of the units;
- highly automatized manufacturing techniques;
- unique environmental performance of the equipment.

Combined heat and power plant is designed to maximize economical efficiency in generation of electrical and thermal power while maintaining the flexibility and reliability in providing the permanent consumers with electricity, heat and process steam.

Combined Cycle Power Plants are designed to maximize the economical efficiency of electric and heat power generation while maintaining the flexibility and reliability in supplying of electric power, heat and process steam to regular consumers.



APPLICATION AREAS

- Cogeneration-based district heating of medium and small populated areas, modular additional structure for district boiler houses as a source of medium voltage power supply
- Electrical power supply for industrial facilities with the possibility of integration into the process cycle and production site due to the modularity of the supplied equipment.
- Temporary source of power supply for civil construction activities and to cover temporary peaks (for example, emergencies, various activities), etc.
- Easily installed power supply source for hard-to-reach areas (as an alternative to capital construction projects)
- Replacement of worn-out generating capacities of the Regional Generating Companies (in the absence of free space and the need to continue generation at existing TPPs).

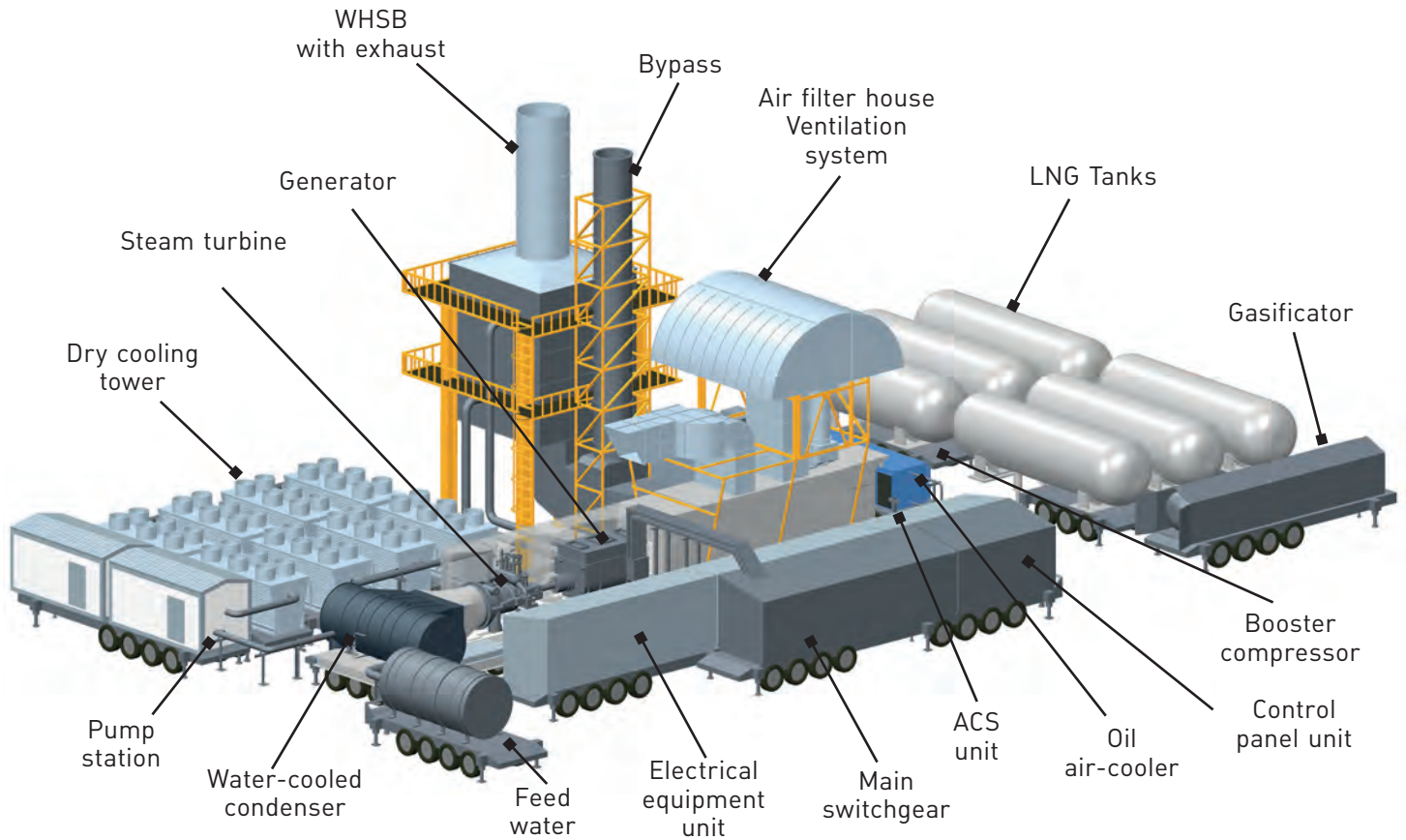
3 OPERATION MODES

- Simple cycle: electric power – 16 MW
- CCPP mode: electric power – 20 MW
- CCPP mode with combined heat generation: electric power – 18 MW/heat power – up to 25 MW

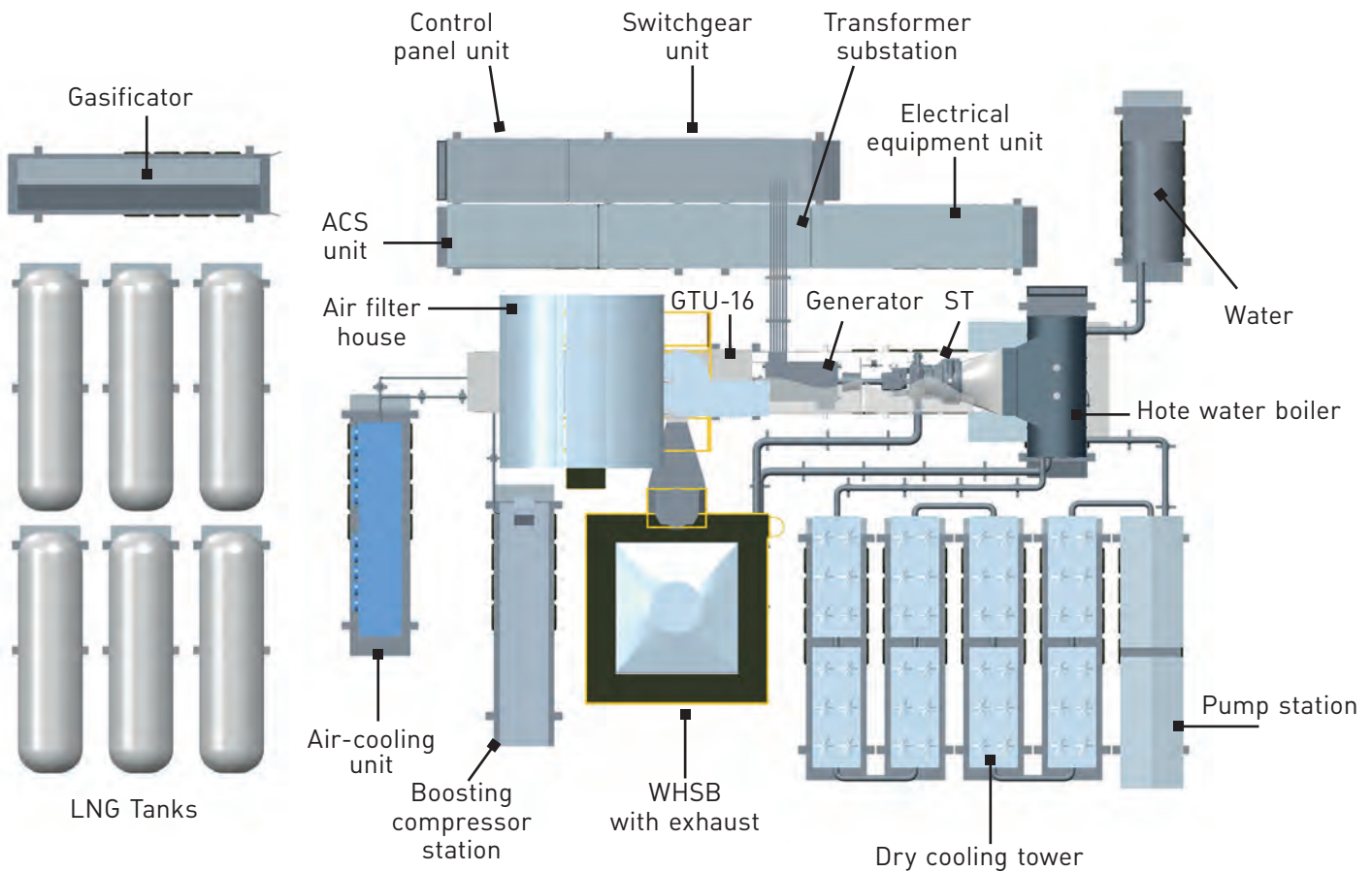
ADVANTAGES

- Modular concept of supply for a single CCPP platform
- Variability of implementation
- Maximum operational compatibility
- Load test of the assembly at manufacturer's facilities
- Reduced time of installation and pre-commissioning, as well as costs of capital investments
- Possibility to move CCPP-22/25 to another site (say, in case of emergency)
- Mobility and self-sufficiency
- Reduced operation staff requirements
- Small size of the unit
- Reduced installation area and civil works cost (by 80%) due to open air installation concept.
- Reduced amount of construction and erection works up to 80%
- Possibility of step-by-step commissioning and completing with additional modules
- Transportation by any type of transport
- Short lead time of installation and commissioning in the «simple» cycle operation mode (up to two weeks)
- All-mode operation

GENERAL ARRANGEMENT



PLANE VIEW



UNIT CONFIGURATION

Major components:

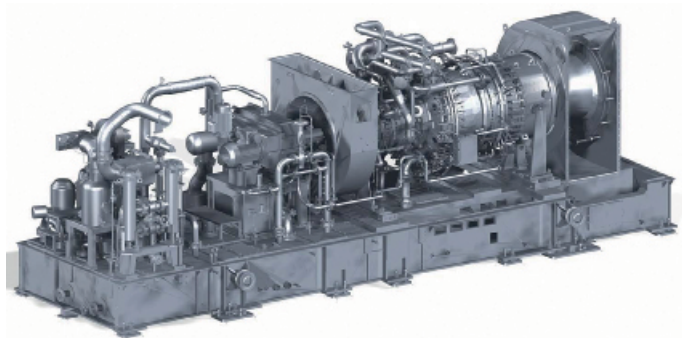
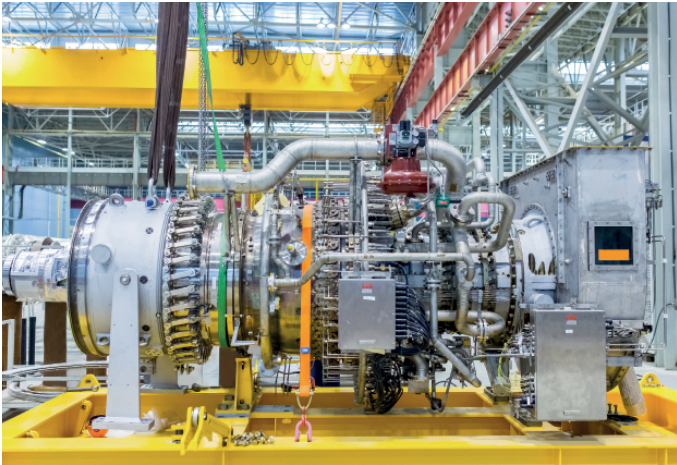
- Gas turbine unit GTU-16 MW
- Gear-box
- Turbogenerator TTK-25-2PY3-Π
- Steam turbine T 4,5-3,0
- Water-cooled condenser
- Waste-heat steam boiler (WHSB) with exhaust
- Air filter house
- Ventilation system
- Dry cooling towers
- Booster compressor station (BCS)
- Control panel unit
- Transformer substation
- ACS unit
- Electrical equipment unit
- Main switchgear
- Pump station
- Oil air-cooler
- Feed-water tank
- LNG Tank

PERFORMANCE SPECIFICATION OF CCPP 22/25 MW

Total electrical power (ISO)	up to 21,3	MW
GTU power	16,0	MW
Steam turbine unit (STU) power (condensation mode)	up to 5,0	MW
Electrical efficiency of GTU	36	%
Exhaust gas mass flow	54	kg/s
Exhaust gas temperature	490	°C
Fuel consumption (natural gas, $Q_{pH}=50$ MJ/kg)	0,892	kg/s
Gas temperature at the boiler exhaust	120	°C
Steam production capacity of STU (efficiency of waste-heat steam boiler (WHSB) 92%)	25,0	t/h
Steam pressure	4,0	MPa
Steam temperature	450	°C
Heat rating (heat extraction mode)	15,2	Gcal/h
Electrical efficiency of CCPP (ISO)	46	%

GAS TURBINE UNIT GTU-16 MW

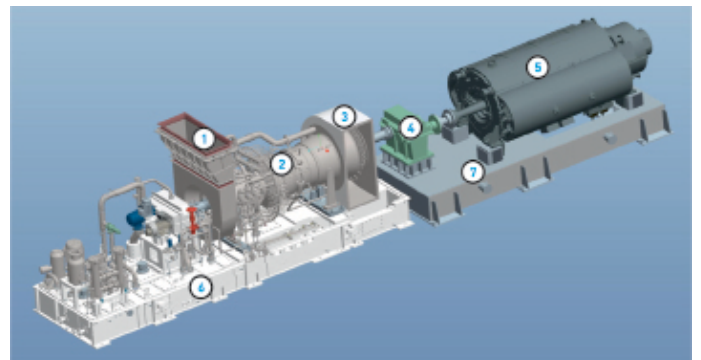
GTE-16 high-tech gas turbine power plant, simple cycle, based on T-16 gas turbine engine developed by REP Holding in cooperation with GE Oil & Gas (Nuovo Pignone S.p.A.).



GTE-16 ADVANTAGES

- High reliability due to modern design practices, materials and technology employed in the design of its main element – gas turbine engine;
- Full life cycle – 200 ths. hours;
- Long maintenance intervals;
- High electric efficiency;
- High economic efficiency of the unit in various operating conditions;
- Component parts mainly from Russian manufacturers, with a high contribution of REP Holding;
- A possibility to repair at the Customer's site;
- A possibility of quick removal of the gas turbine engine for maintenance because of the lateral roll-out from under the enclosure.

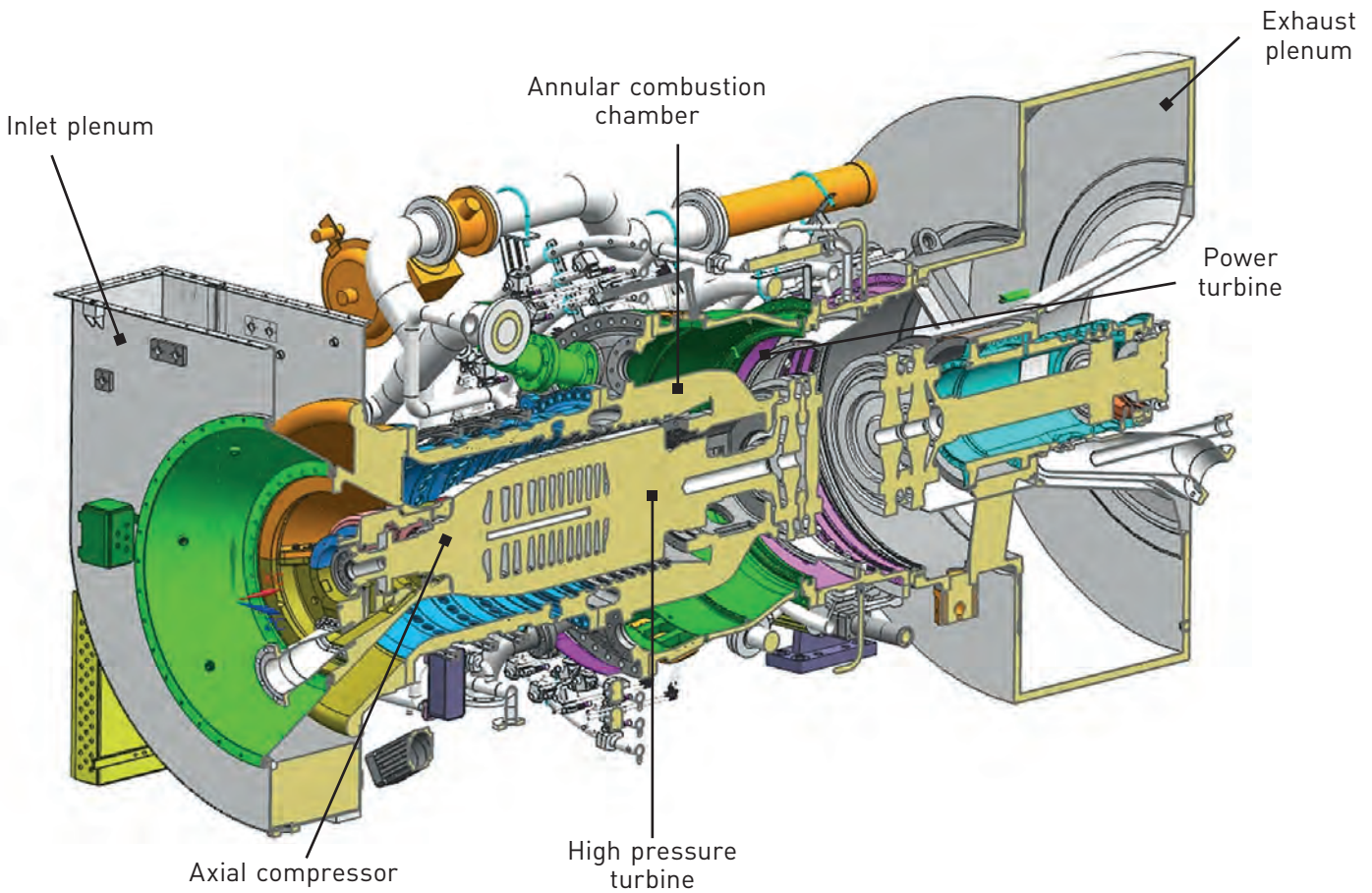
- The gas turbine engine, industrial type, features high efficiency (37%), high service life, high availability and serviceability, low harmful emissions ($\text{NO}_x < 25$ ppm).
- Full compliance with GOST R 29328-92 "Gas Turbine Units to Drive Electric Generators".
- The main equipment of the unit is standardized as much as possible and is completed using modular blocks.



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

- 1 – inlet plenum;
- 2 – engine;
- 3 – exhaust plenum;
- 4 – gearbox;
- 5 – generator;
- 6 – engine base plate;
- 7 – generator and gearbox base plate

GAS TURBINE ENGINE COMPONENTS



Compressor

- Axial, 12- staged, with variable inlet guide vanes and variable guide vanes of 2 stages;
- Casing with vertical and horizontal splits

Combustion chamber

- Annular, with 39 burners
- DLN
- Equipped with flame detectors and ignition units.
- Burners can be checked and removed (if necessary) without opening the turbine casing

Gas generator turbine

- Axial, two-staged, with 3-D optimized profile
- Cooled nozzles and buckets with protective coating

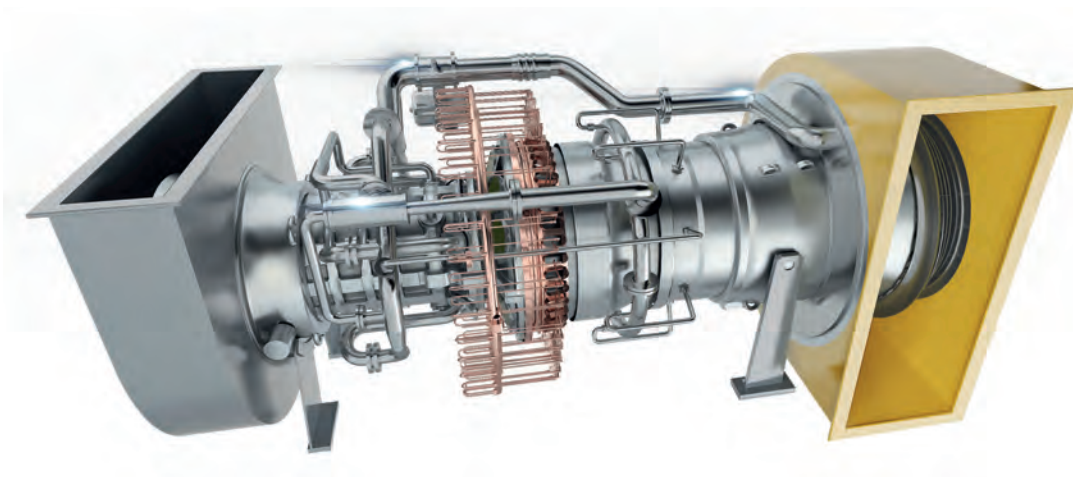
Free turbine

- Axial, two-staged, uncooled
- Uncooled shrouded nozzles and buckets.

GENERAL TECHNICAL DATA

The main technical characteristics of the gas turbine engine at the nominal conditions, ISO

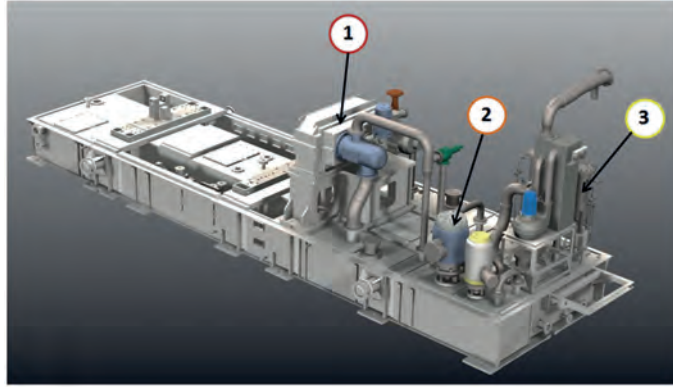
Description	UOM	Value
Shaft power, no less than	MW	16,5
Turbine efficiency, no less than	%	37,0
Exhaust gas flow	kg/s	54,3
Exhaust gas temperature	°C	490
Pressure ratio	-	19,0
Fuel flow (natural gas $Q_{PH}=50$ MJ/kg)	kg/s	0,892
Gas generator rotor speed, maximum	rpm	10200
Output shaft rotor speed, nominal	rpm	7800
Emission (at 15% O ₂ in dry combustion products): nitric oxide	mg/m ³	≤50
carbon monoxide	mg/m ³	≤40
Overall dimensions of the engine (without piping)	m	11,6 x 3,6 x 4,2
Weight of the gas turbine module on the base plate	t	69
Specified service life	H	~200000



Compressor, combustion chamber and turbines of the gas turbine engine are provided with access holes for boroscope inspection of the hot path without opening the unit.

The T16 gas turbine engine is arranged as a single module on the oil tank frame with all the auxiliary devices and systems that provide the gas turbine engine operability.

Lube oil of ТП-22С type is allowed for use.

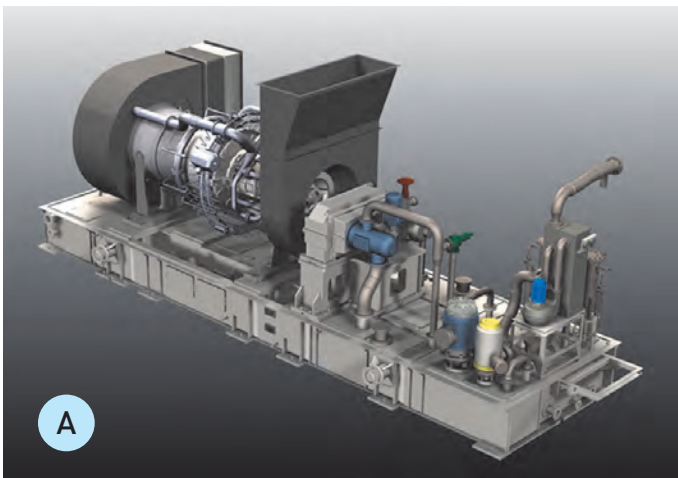


Gas turbine engine oil tank frame with the auxiliary systems:

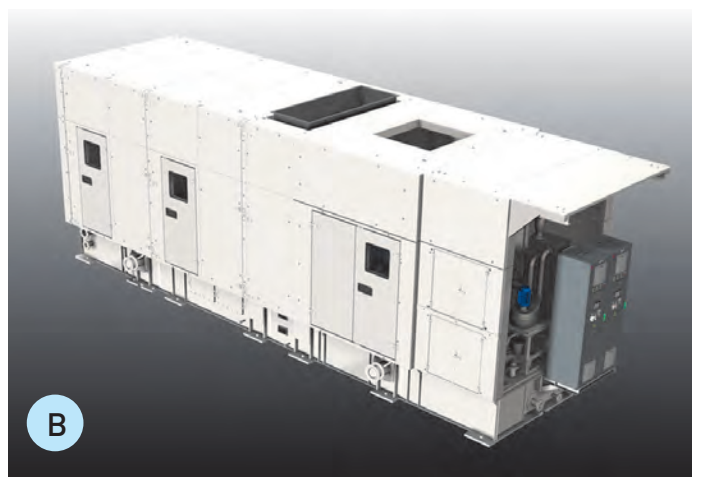
- 1 – starting system;
- 2 – oil supply system;
- 3 – fuel supply system

To reduce the noise level and to maintain the heat balance, the turbo-unit is placed into the noise-proof and heat-insulating enclosure which is also designed for arrangement of the lighting system, transducers equipment and wiring with other components of the unit.

T16 TURBO-UNIT WITH THE AUXILIARY SYSTEMS ON THE BASE PLATE



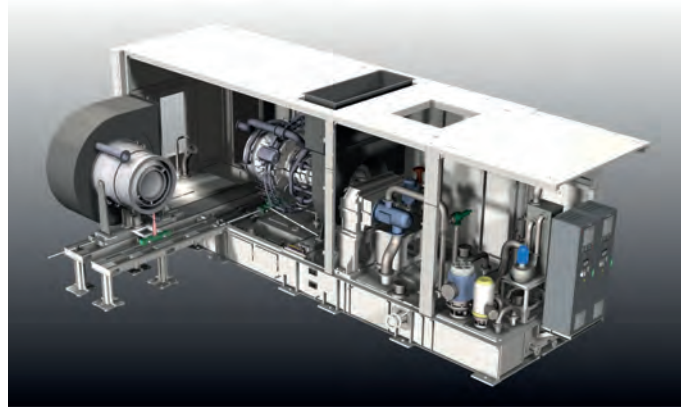
A) with the enclosure removed



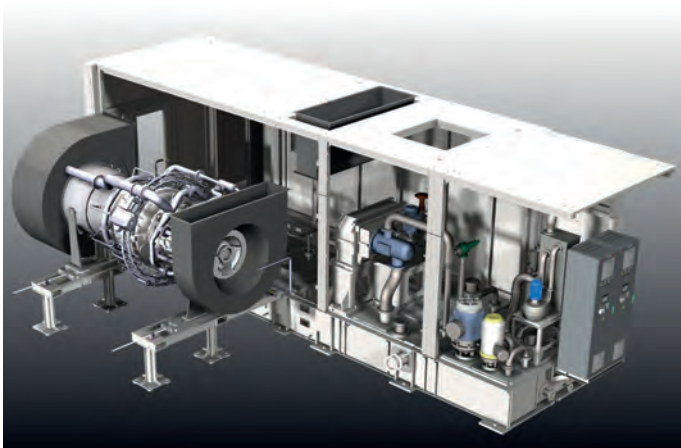
B) under the noise-proof and heat-insulating enclosure

The modular design of T16 and easy access to the auxiliary systems simplifies considerably technical maintenance and care of the turbine.

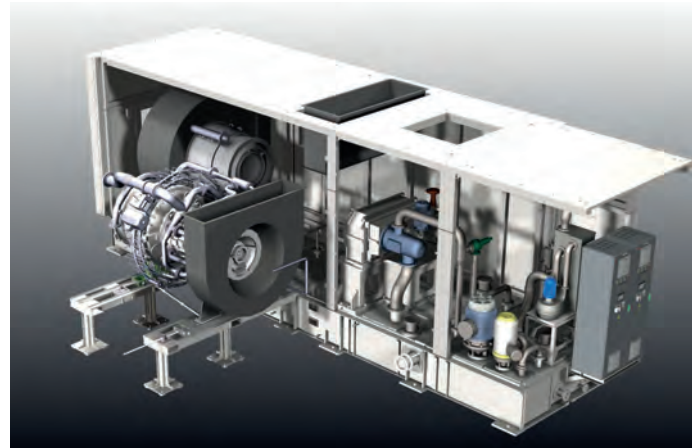
T16 arrangement on the base plate provides lateral roll-out of the high and low pressure parts, as well as the entire turbo-unit, which makes it possible to perform complete prompt technical maintenance.



Lateral roll-out of the gas turbine engine from the enclosure



Lateral roll-out of the power turbine from the enclosure



Lateral roll-out of the gas generator from the enclosure

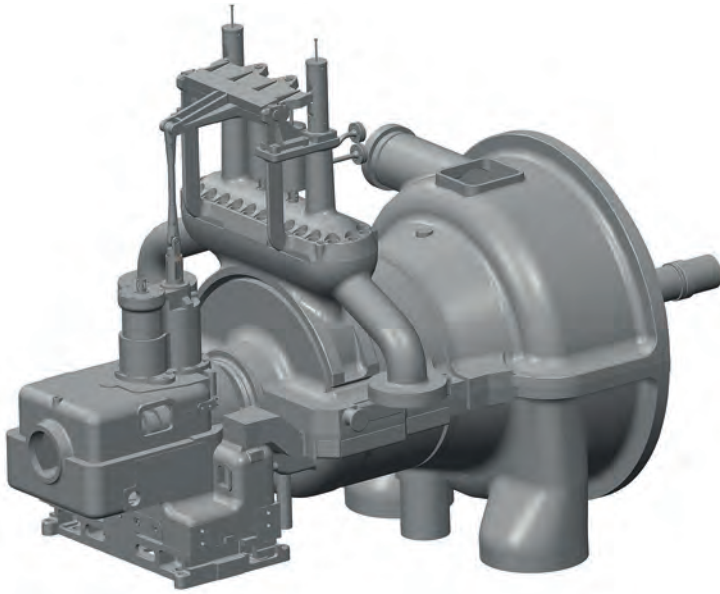
PERFORMANCE CHARACTERISTICS

■ GTE-16 can be operated at the ambient air temperature from -60°C to $+50^{\circ}\text{C}$.

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

Description	UOM	Value
Power at the generator terminals	MW	16,0
Electric efficiency	%	35,86
Exhaust gas flow	kg/s	54,3
Exhaust gas temperature	$^{\circ}\text{C}$	490
Fuel gas flow (natural gas, $Q_{PH}=50$ MJ/kg)	kg/s	0,892

STEAM TURBINE T-4,5-3,0



Condensing steam turbine with heat extraction T-4,5-3,0 – one-cylinder, single-flow, active type. Steam distribution is of nozzle type. Turbine rotor speed – 10000 rpm.

The turbine drives a synchronous generator at the rotor speed of 3000 rpm via gearbox. The waste steam after the turbine arrives to the axial condenser. A transition duct is used for connection with the condenser.

The turbine is equipped with a barring gear with an electrical drive mounted on the rear bearing casing that can rotate the unit rotors during shutdown and startup of the unit. The lubrication system of the turbine is common with the electric generator. Oil TP-22c is used in the lubrication system.

TECHNICAL CHARACTERISTICS OF THE TURBINE

Parameter	Operating modes	
	Condensing	Heat-extraction
Power (at the generator terminals rating, MW)	4,5	3,0
HP steam flow, t/h	23,6	23,6
HP steam pressure, MPa	3,0	3,0
HP steam temperature, °C	400	400
Steam flow to steam extraction, t/h	--	18,0
Steam pressure at steam extraction, MPa	--	0,12
Heating load of the turbine, MW	--	13,5

RELIABILITY INDICES

The design of the main and auxiliary equipment of the turbo-unit and the workmanship thereof provide reliable and efficient performance of the turbo-unit during the inter-repair period (between overhauls).

Reliability indices of the turbine:

Specified life time, no less than	40 years;
Mean time between overhauls, no less than	30 000 h;
Mean time to medium repair, no less than	15 000 h;
Mean service life of the turbine rotor, no less than	100 000 h;
Mean time to failure, no less than	6 500 h;
Availability factor, no less than	0.98.

HEAT RECOVERY STEAM GENERATOR (HRSG) WITH EXHAUST

Heat Recovery Steam Generator is water-tube, upright, of modular design. The boiler is supplied in large-sized transportation blocks, ready-to-operate, hydraulically tested. Mass of each block does not exceed 50 t. The blocks can be transported by road, railway and water. The scope of installation works is minimum and includes installation of the blocks onto a support block, welding the sheathing of the blocks to each other and piping. Due to the modular design it is possible to equip the HRSG with an additional block for network water heating.

The boiler operation is based on the multiple forced circulation principle with a steam separator and circulating block pumps.

The outer and inner surface of the boiler blocks are protected by insulation.

The boiler design provides for its operation outdoors over the temperature range from -50°C to +50°C.

To ensure reliable operation of the boiler unit some auxiliary equipment, including the control systems electrically-driven valves, etc., are configured as a containerized air-conditioned unit.

THE MAIN PARAMETERS OF THE HRSG AT 100% LOAD*

Parameter	Value
Steam production capacity, t/h	23,7
Superheated steam pressure, MPa,	3,0
Superheated steam temperature, °C	400
T16 exhaust mass flow, kg/s	56,4
Exhaust gas temperature at the boiler inlet, °C	480
Pressure drop over the boiler, including gas ducts, no more than, Pa	3500
Condensate temperature at the inlet of the condensate heater (CH) CH1, °C	45
Condensate temperature at the outlet of the condensate heater (CH) CH1, °C	85
Condensate temperature at the inlet of the condensate heater CH2, °C	70
Condensate temperature at the outlet of the condensate heater CH2, °C	130
Network water flow, t/h	Up to 60

* The table gives the main parameters of the Boiler KUP 7000 produced by JSC «SKBK».

HEAT RECOVERY STEAM GENERATOR CONFIGURATION

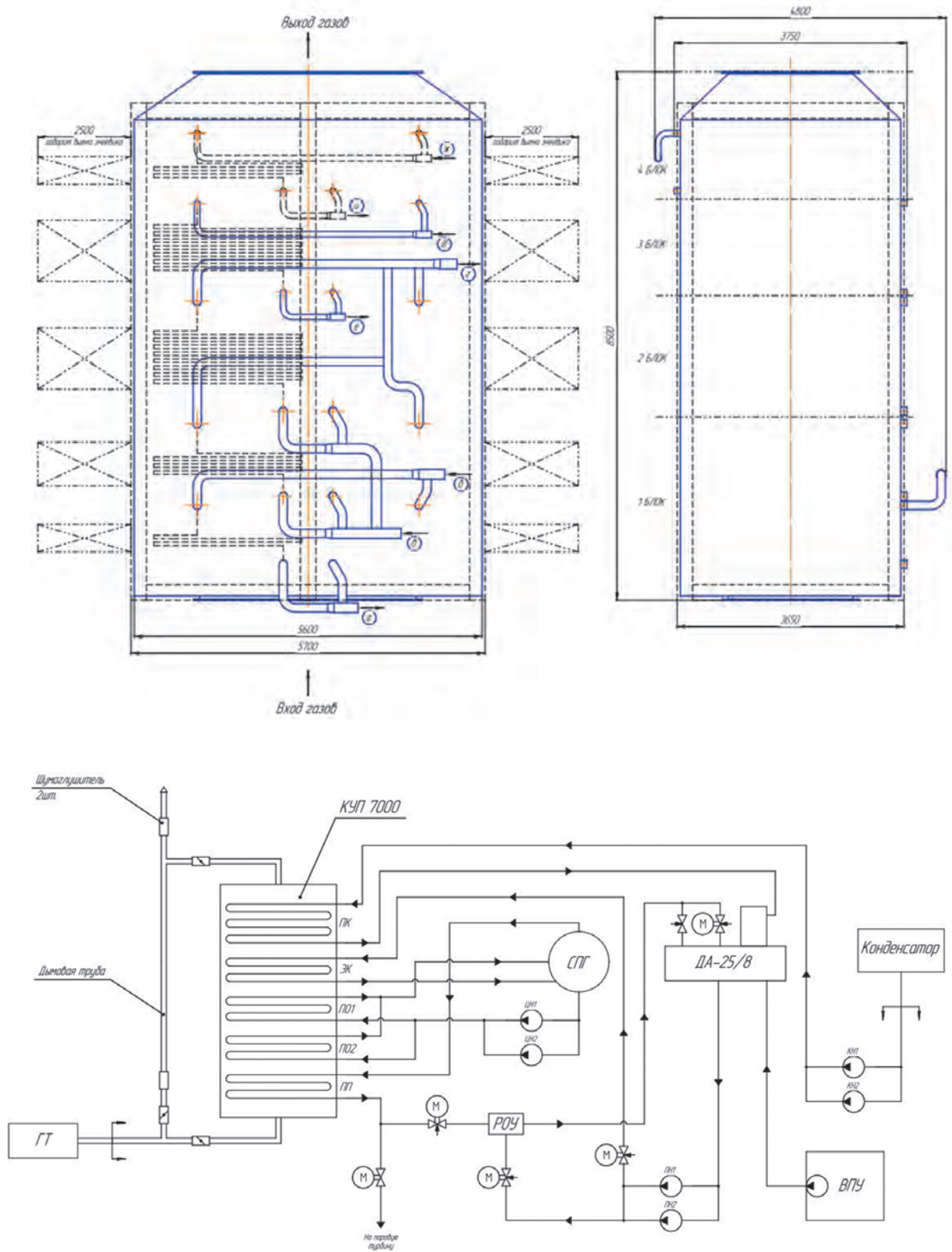
- steam superheater (SS);
- steam generator (SG) consisting of two modules SG1 and SG2;
- economiser;
- condensate heaters (CH) CH1 and CH2.

Reliability indices of the boiler:

full mean life time, years, no less than	40
mean life time to overhaul, years, no less than	6
full mean service life, h, no less than	150000
mean time to failure, h, no less than	8000

The boiler is delivered in 4 main blocks including economizer, steam releasing surface, steam superheater, condensate heaters, pipelines within the boiler, valves and thermal insulation.

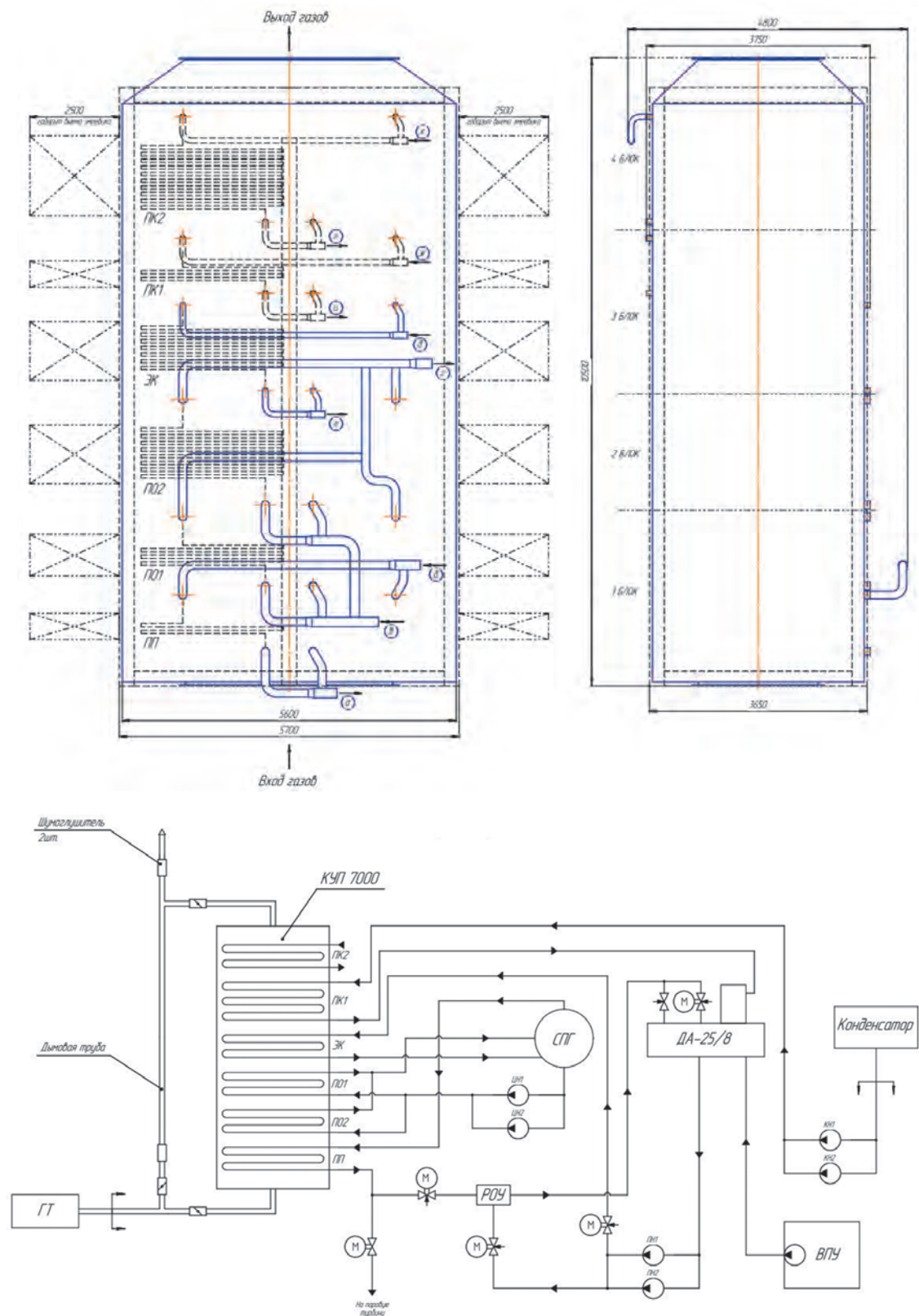
DESIGN VERSION OF THE BOILER WITHOUT NETWORK WATER HEATING



Design version of the boiler without network water heating (diagram)

Mass of the boiler without network water heating block is 99600 kg.

DESIGN VERSION OF THE BOILER WITH NETWORK WATER HEATING



Design version of the boiler without network water heating (diagram)

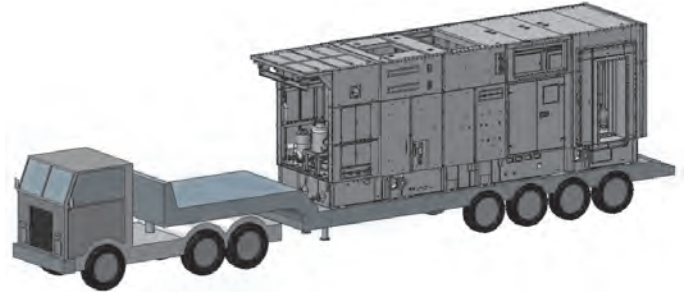
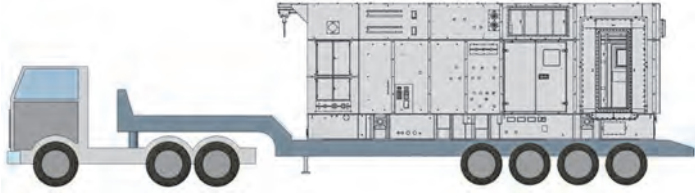
Mass of the boiler with the network water heating block is 149000 kg.

TRANSPORTATION BY TRUCK

GTU-16

L x W x H – 11 x 3,2 x 4,2

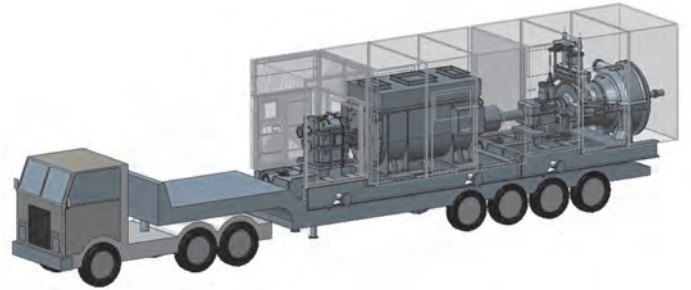
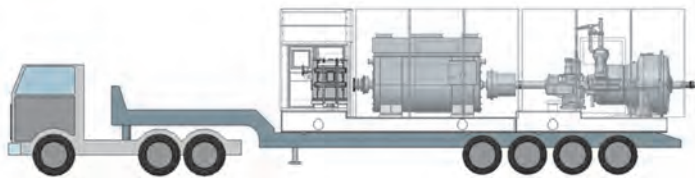
Mass 65000 kg



GENERATOR, GEARBOX, STEAM TURBINE

L x W x H – 13,0 x 3,2 x 4,2

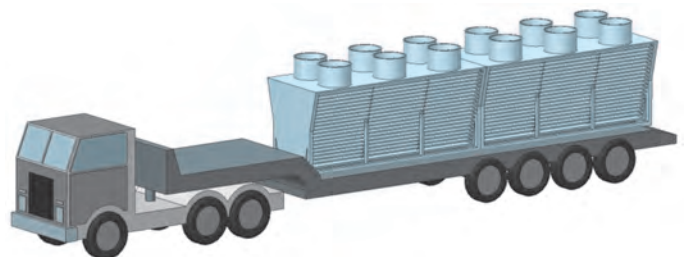
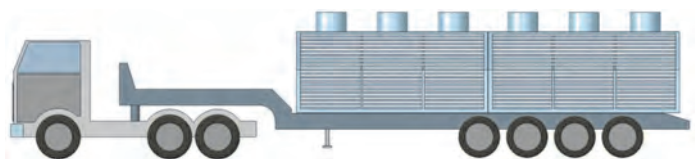
Mass 60000 kg



DRY COOLING TOWERS

L x W x H – 6,0 x 2,4 x 2,4

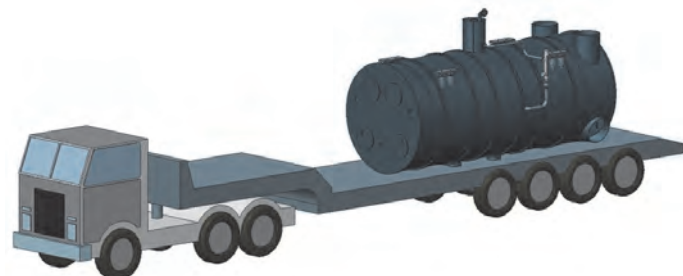
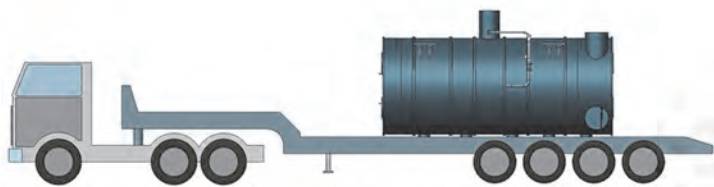
Mass 2700 kg



WATER-COOLED CONDENSER

L x W x H – 7,0 x 3,9 x 4,3

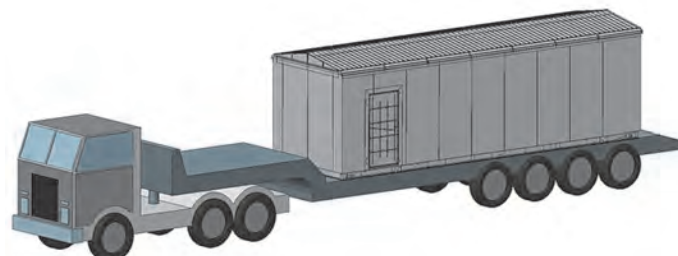
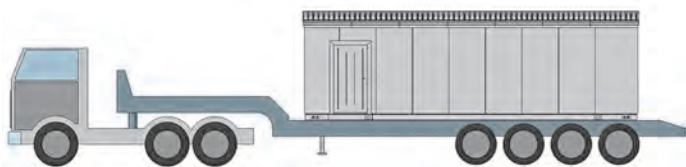
Mass 29500 kg



ELECTRICAL AND C&I CONTAINER

L x W x H – 10,5 x 3,2 x 3,4

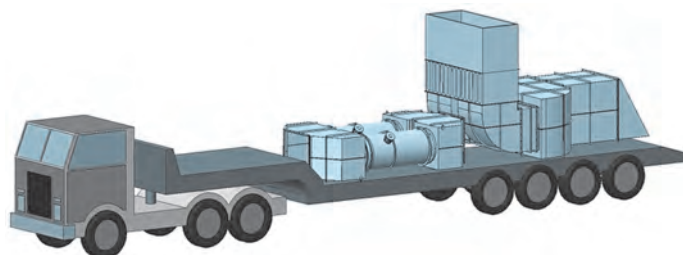
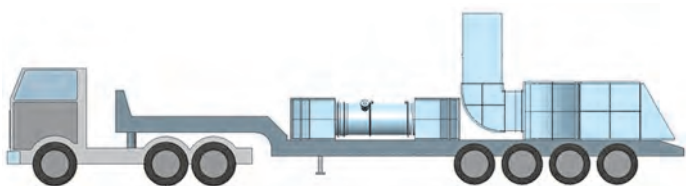
Mass 10000 kg



INLET AIR AND EXHAUST GAS PLENUMS

L x W x H – 12,0 x 3,2 x 3,9

Mass 14000 kg



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