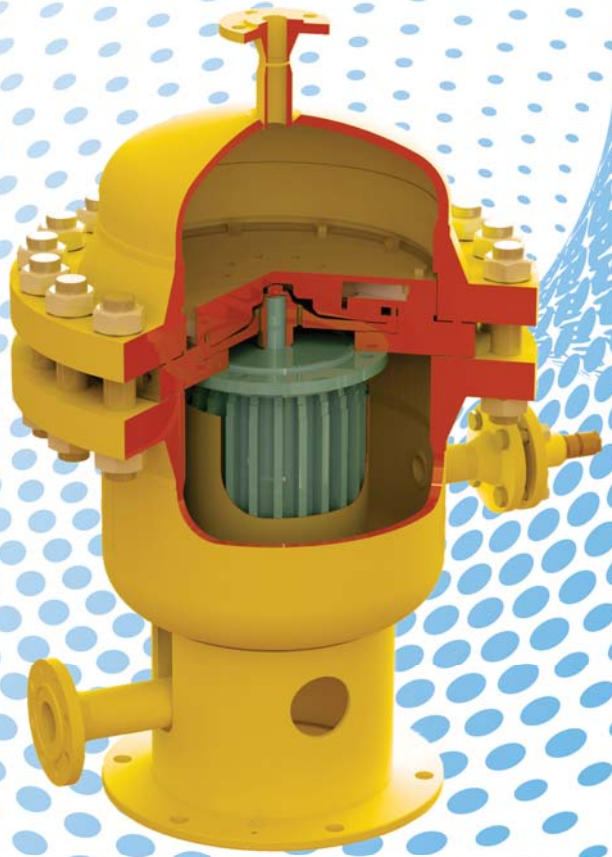
Turbogenerator unit «TURBOSPHERE»



THE GROUP OF INNOVATIVE COMPANIES

- EnergoTech Scientific and engineering center LLC
  Resident of «Science and Technology Park BNTU «Polytechnic»
  Belarus

- TurboEnergy LLC
  Skolkovo participant
  Russia

About company

The group of innovative companies «TurboSphere» represents Your partner in gas industry and consists of EnergoTech Scientific and engineering center LLC (Resident of «Science and Technology Park BNTU «Polytechnic» and Minsk free economic zone, Belarus), TurboEnergy LLC (Skolkovo participant, Russia), TurboEnergy sp. z o.o. (Białystok Science and Technology Park, Poland).

We offer you an innovative product for the electric energy generation due to the overpressure energy of natural gas without additional fuel combustion!

The turbogenerator units TurboSphere (TGU TurboSphere) is intended for a generation of additional electric energy at the expense of pressure difference of natural gas that allows to increase fuel efficiency, to receive an environmentally friendly electric power source and also brings additional income for the enterprise, equivalent to annual cut on electric energy purchase from external network, or by its sale to a third-party consumer!

We design and produce compliant certified turbogenerator units comprising TGU turbogenerator and automatic control system of TGU. We are engaged in the development of innovations in the field of energy and energy saving.

Director Kiril Levkov

The history of development

2004 – idea generation

2007 – patent for invention of the Republic of Belarus received

2011 – prototype creation

2014 – model sample and testing base created for laboratory tests. TurboEnergy LLC established. Skolkovo participant status received

2015 – Pre-production models TGU-11-54 and TGU-15-6-H created together with production testing base for research and acceptance testing of samples

2016 – carrying out of research and acceptance testing. Pre-production model modification. Implementation at the operating facility of Minsk heating networks. EnergoTech Scientific and engineering center LLC established

2017 – 55 kW power unit development, Technical Regulations of the Customs Union certificates obtained. Patent for utility model received. Became the winner of the international competition of Expo Live program in preparation for the world exhibition EXPO 2020 in Dubai, awarded a grant and the right to participate in the EXPO 2020 in the UAE

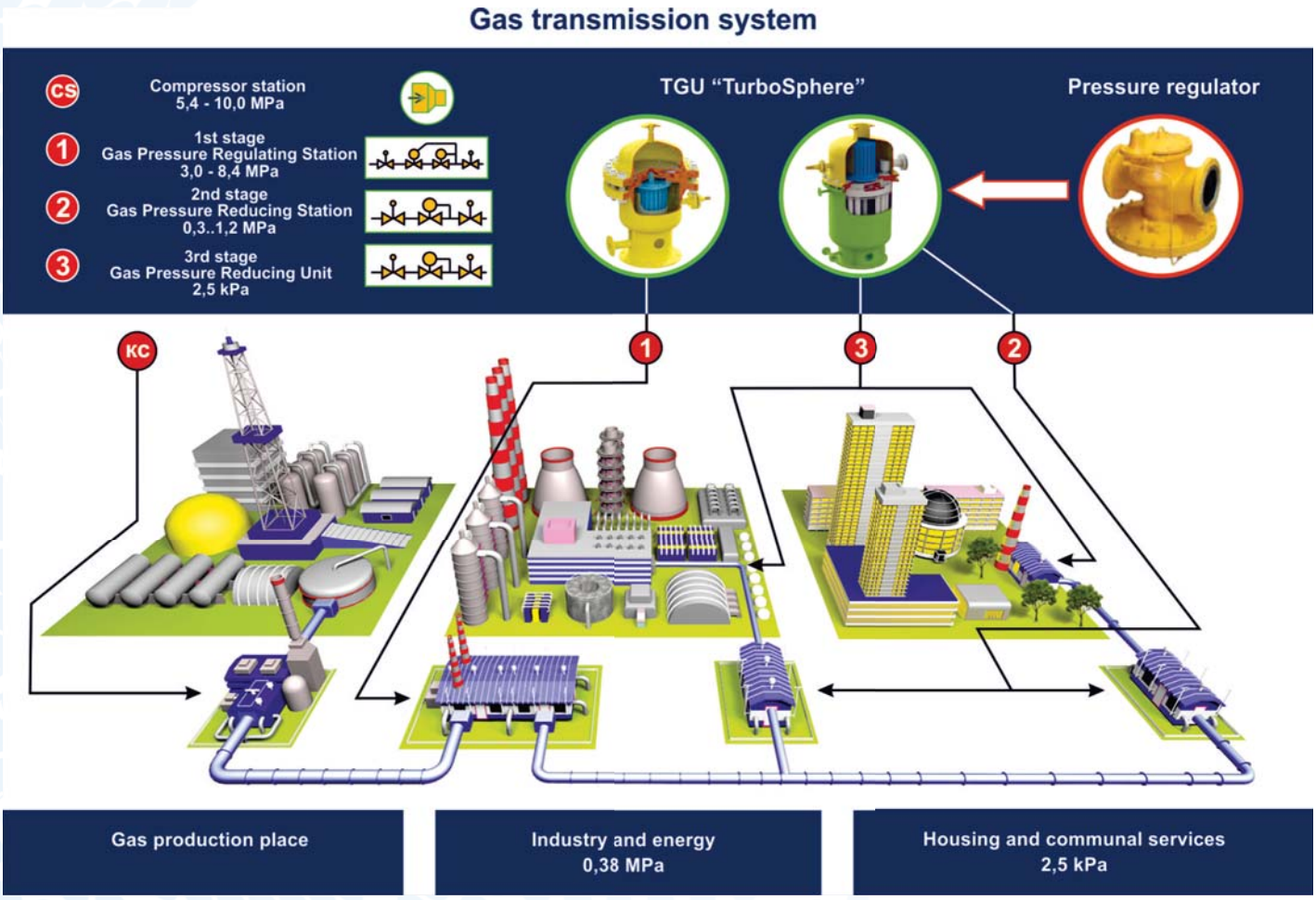
2018 – the status of the resident of Minsk free economic zone obtained. Eurasian patent for invention received. Certificates of the European Union and Gazpromsert obtained. Construction and installation work at the Minsk heating networks mini-CHP completed.

2019 – Our own production facility was created for the manufacture of the most complex unit components. TurboSphere entered the European region. The Poland Prize (PARP) competition was won. A company was created in Białostocki Park Naukowo-Technologiczny. TGU TurboSphere was applied at the Vitebskoblgaz test facility.

Throughout the duration of the project we received the following accolades:

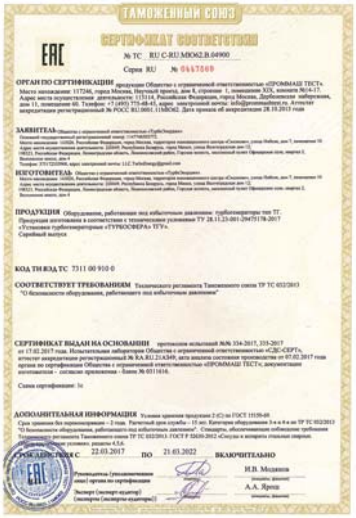
more than 30 diplomas, 16 letters of the project relevance, 12 certificates, 8 memorandums and agreements, 6 completed expert councils, 3 patents for invention and 1 PCT application.

The description TGU «TurboSphere»



TGU «TurboSphere» - new type of turbogenerators (turboexpander or expander generating) units. TurboSphere is intended for production of electric energy by transformation of natural gas overpressure energy to the electric power. TGU TurboSphere applied at Gas Pressure Regulating Station, Gas Pressure Reducing Station and Gas Pressure Reducing Units in gas transmission systems, the industry, the municipal sector and energetic.

Product has obtained certification on compliance to requirements of existing norms and rules in the Customs Union (TR CU) and the European Union (CE, ATEX). We work according to requirements of standards of Quality System Standard of ISO 9001:2015.


ТАМОЖЕННЫЙ СОЮЗ

СЕРТИФИКАТ СООТВЕТСТВИЯ

№ ТС RU C-RU.МЮ62.В.04900

Серия RU № 0447569

ОРГАН ПО СЕРТИФИКАЦИИ

ЗАЯВИТЕЛЬ

ИЗГОТОВИТЕЛЬ

ПРОДУКЦИЯ

КОД ТН ВЭД ТС 7311 00 910 0

СООТВЕТСТВУЕТ ТРЕБОВАНИЯМ

СЕРТИФИКАТ ВЫДАН НА ОСНОВАНИИ

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

ПО 21.03.2022 ВКЛЮЧИТЕЛЬНО

Руководитель (уполномоченное лицо) органа по сертификации

Эксперт (эксперт-аудитор)


TSU.

CERTIFICATE
EU DESIGN EXAMINATION

Module: H1

No. 181299092

Manufacturer:

Product:

Type:

097738

The TurboSphere units and its mechanics are protected by regional and international patents, including the patent of Republic of Belarus.

PTGU TurboSphere development and production is carried out on the basis of the requirements and needs of the customer using advanced PLM-systems and consists of 2 blocks:

1. Turbogenerator unit – complex, consist of:

1.1. Turbogenerator – main component. It consists of body parts, internal filling parts, electrical elements, if necessary, a heat exchanger and the magnetic clutch.

1.2. Automatic control system of TGU
intended for control, monitoring and dispatching of data on TGU operation to the operator station. It consists of control locker and power locker (if necessary), built-in microcontroller and touch control panel.

2. Auxiliary items – part of the energy efficiency unit which provides integration at the facility. Includes gas, electrical and other subsystems. Completeness is determined based on the needs of the customer and the object capabilities.

The principle of operation

Thermodynamic process graph

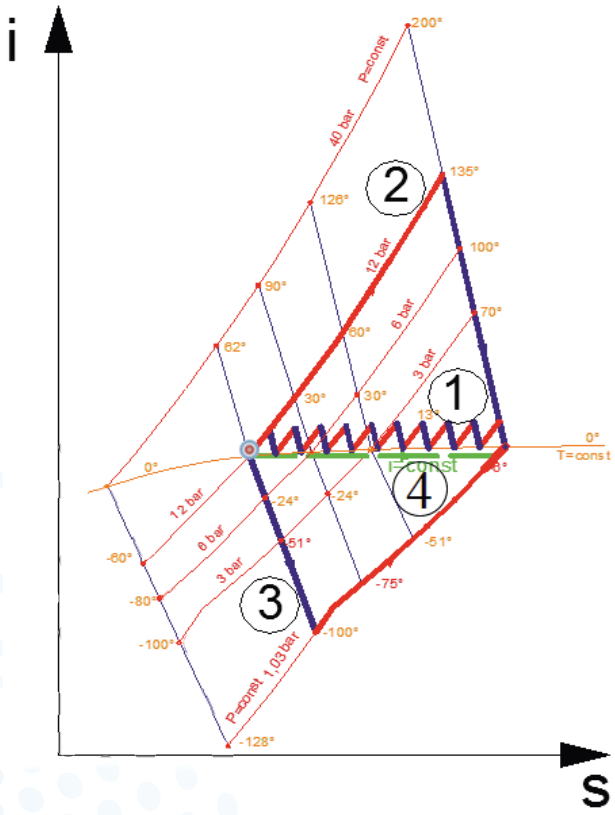
i-s methane diagram

1 – multi-stage gas-flow expansion with heating gas between stages (in TurboSphere)

2 – single-stage heating with expansion (in powerful turboexpanders with gas combustion)

3 – single-stage gas-flow expansion with heating gas (for getting cold)

4 – throttling (process without electricity production in pressure regulator)



The TurboSphere simultaneously combines several units, such as a turbine, a heat exchanger, and a power generator. This is an innovative solution that has never been implemented before. The gas expansion process in the TurboSphere is close to isothermal, which is the most effective, and allows utilization of low grade energy sources and low rate flows for energy generation.

The turbogenerator consists of a split outer enclosure, one blade wheel, a nozzle cascade. Gas channels allow for the redistribution of gas between stages and the sectional supply of gas to the blade wheel, and in the process of gas flow through the pipeline - it is heated by low-grade heating liquid.

The gas flow enters the turbogenerator through the gas pipeline, passes the nozzles of the first stage and the blades of the wheel, enters the gas channels and forwards it to the part of the nozzle passages of the next stage. After passing through the nozzles of the second stage, it again enters the blades of the third stage wheel through the gas channels and so on, moving successively through the channels through several stages, and then leaves the turbine unit through the gas pipeline with the required final pressure. The multistage stream expansion is carried out due to sector flow of gas on the working wheel blades. The ability to redirect gas flow through the channels allows the use of a single working wheel, which leads to cheaper and more efficient expansion process.

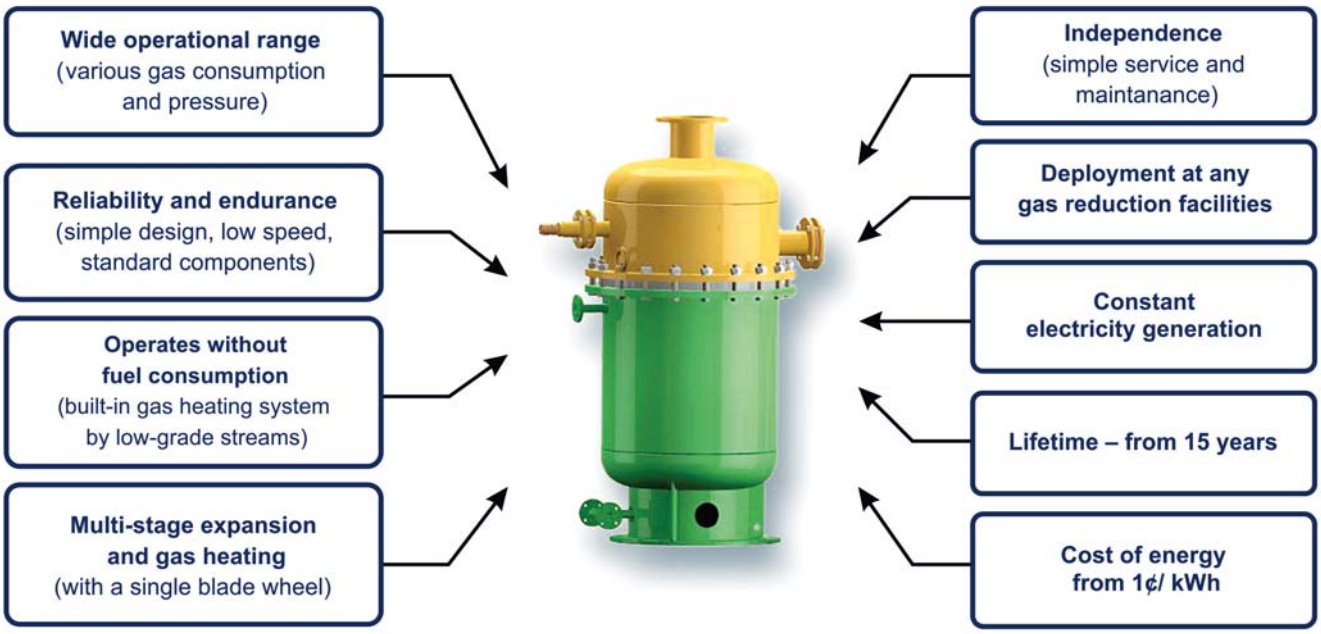
In the TurboSphere, the working fluid is heated between stages. Working fluid moves within the channels, and heating liquid enters through the pipe to the annular space and the tube heats the expansion stream. The cooled liquid is drained through the pipes.

Multistage gas expansion in a turbogenerator allows multiple gas heating between stages, which contributes to an increase in unit efficiency, and also makes possible the use of low-grade heating liquid, such as waste heat and circulating water supply.

The power generator is located within the TurboSphere. The working wheel has direct flange connections to the rotor.

The advantages and differences

Technical advantages:



Generated electricity (5-500 kW) can be spent as for own needs and for sale by energy service contracts

The main difference of the TurboSphere units from turboexpander and detander-generating units:

- it is capable to work in the wide range of expenses and gas pressure, keeping at the same time both required parameters and quality of the generated electric power;

- it is reliable, rather inexpensive unit, the minimum requirements to technical services;

- it is applicable for both autonomous power supply where the main goal is to ensure needs for the electric power of object's own needs and for parallel work with an external network when the purpose is to generate maximum power using all potential from gas stream while delivering electric power to an internal network of an enterprise and with sale (if needed) of overpressure energy to an external network;

- during operation, the entire gas volume is saved.

The specified advantages are reached mainly by:

1) The original patented construction at which there is a high level of use of standard elements, details and nodes of local production that also excludes dependence on import.

2) Use of common industrial asynchronous generators and bearing blocks with consistent lubrication and also absence of dynamic multiplexing.

3) The relative simplicity of construction due to minimization of quantity of details and elements and also a turbogenerator low speed (the synchronous rotating speed - 3000 rpm).

4) Besides we managed to realize the diagram of multistage extension of gas on one driving wheel with a possibility of the intermediate heating of gas in the course of extension by means of the built-in heat exchanger heater, using low-potential heat and thermal waste of the enterprises.

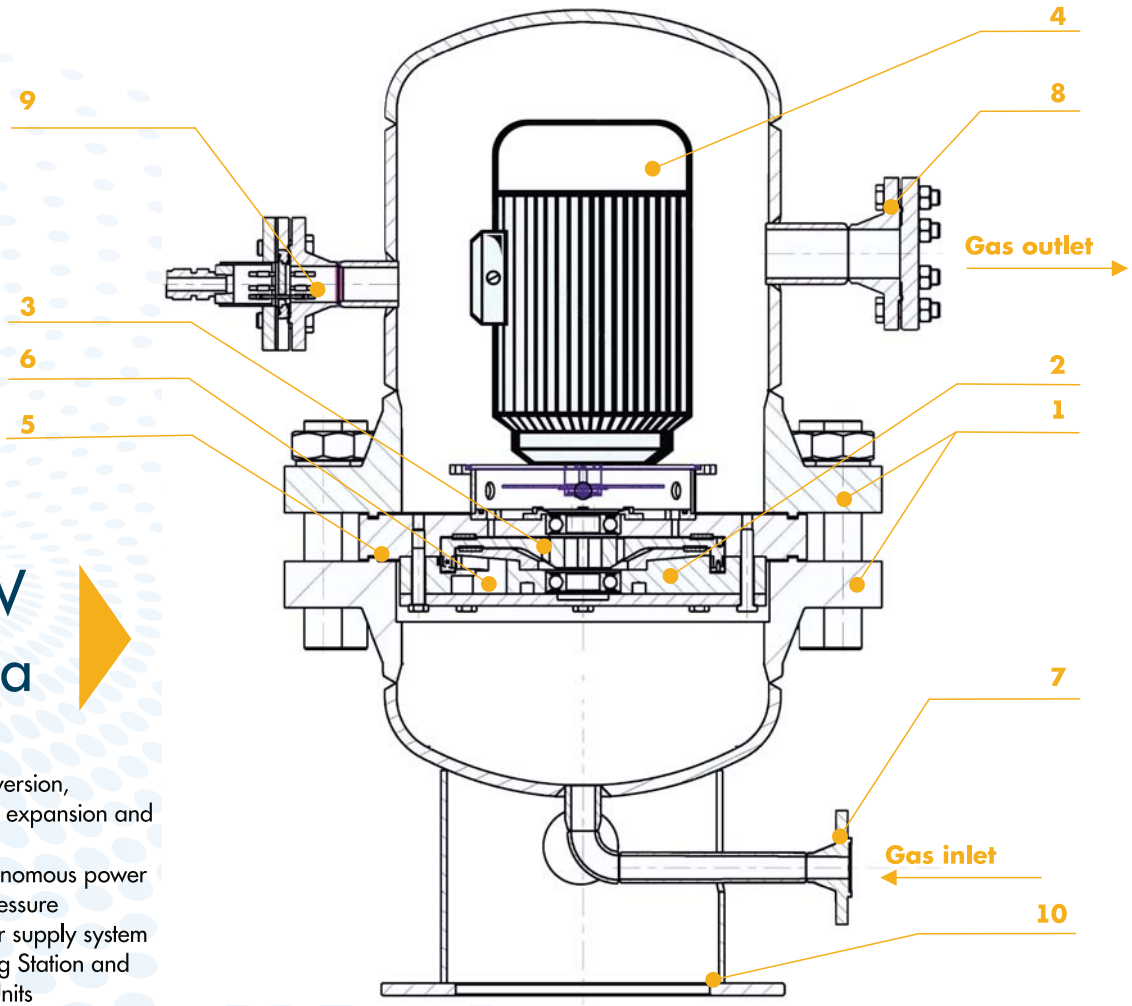
5) Unit is intended for operation not only on natural gas, but also with others non-aggressive gases.

The model range

Application areas:

1) for energy efficiency needs:
to generate additional electricity and provide some of the company's own needs (up to 15%)

2) for power supply of facilities:
to provide the facility with electricity, incl. autonomous (up to 100%).



to 132 kW
to 6,3 MPa

Features: the simplest version, providing multi-stage gas expansion and power generation
Installation site: autonomous power supply system for Gas Pressure Regulating Station, power supply system on Gas Pressure Reducing Station and Gas Pressure Reducing Units

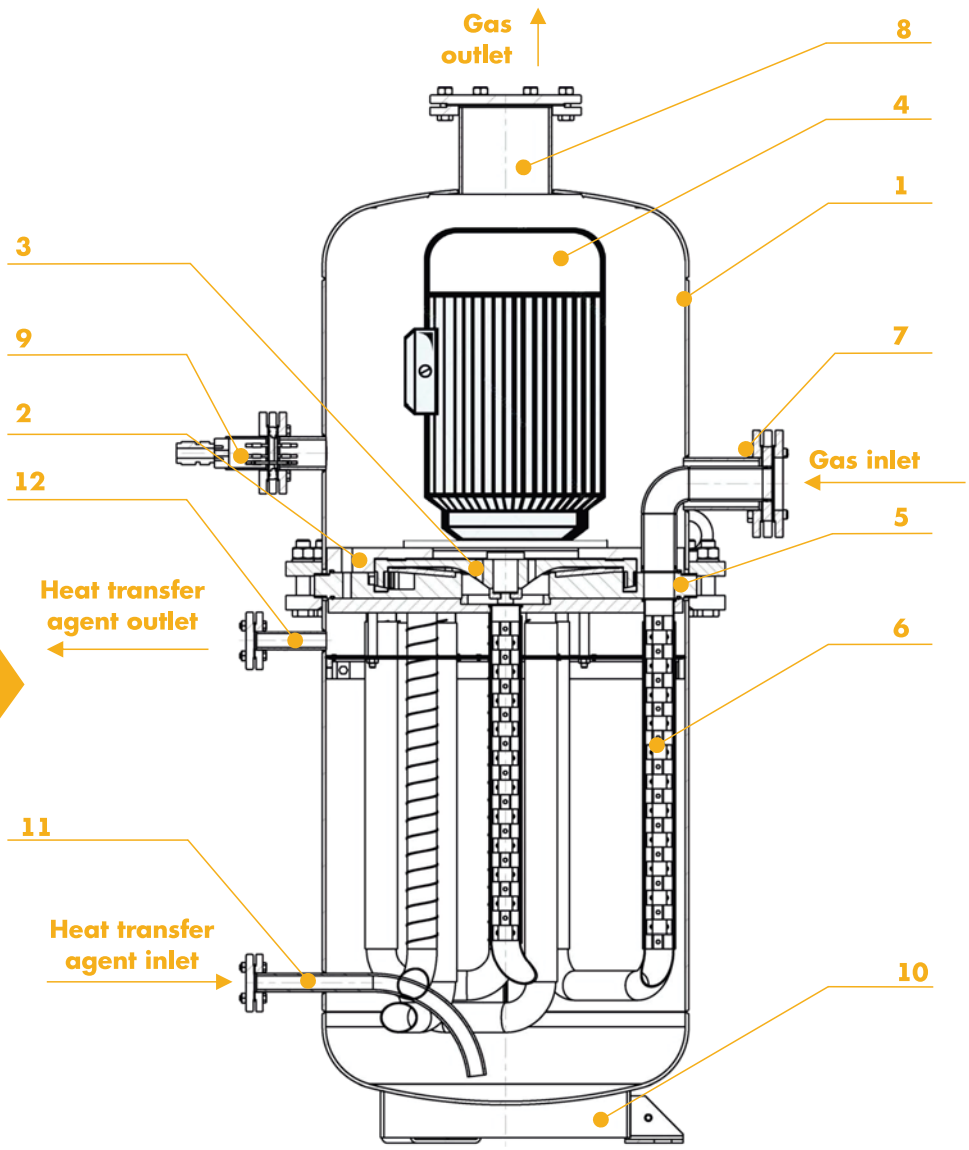
Turbogenerator in basic execution

1 - Separable enclosure
2 - Nozzle assembly
3 - Blade wheel
4 - Alternator
5 - Diaphragm
6 - Redirecting apparatus
7 - Gas inlet connection pipe
8 - Gas outlet connection pipe
9 - Cable gland assembly
10 - Base ring

to 55 kW
to 1,2 MPa

Features: built-in heater (heat exchanger) provides multi-stage gas heating between the expansion stages by any low-temperature source

Installation site: power supply system on Gas Pressure Reducing Station and Gas Pressure Reducing Units



Turbogenerator with heater

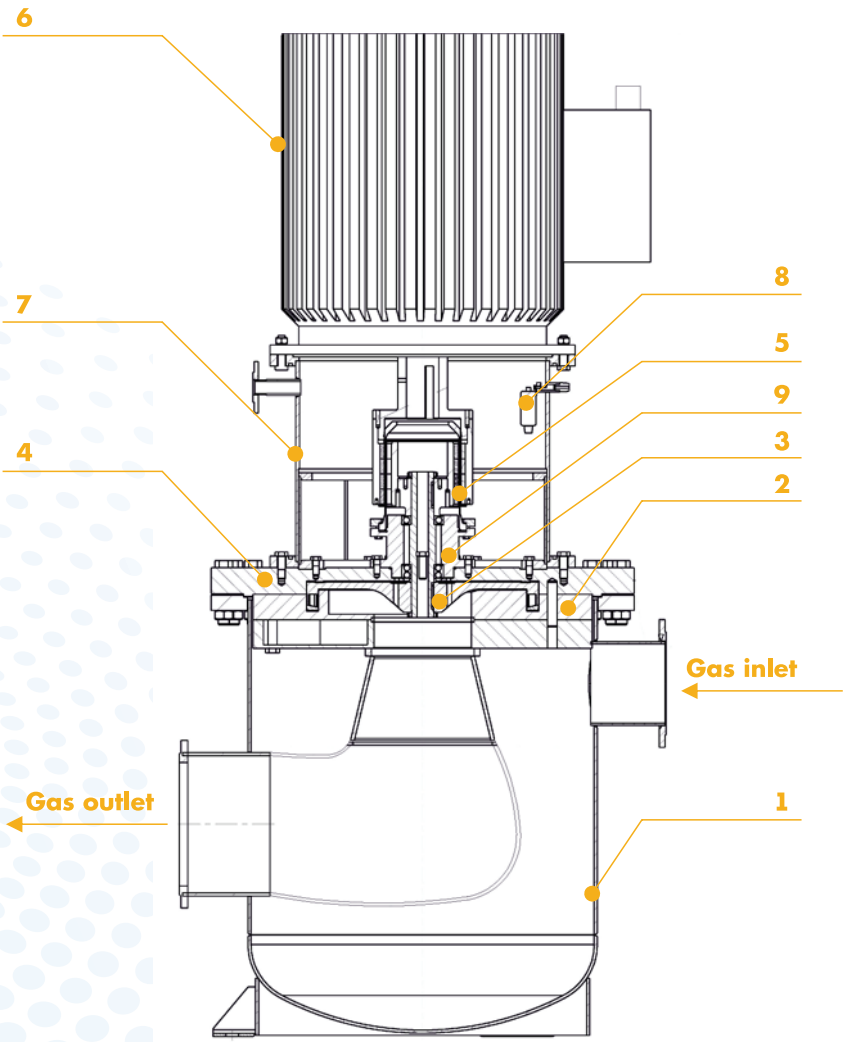
1 - Separable enclosure
2 - Diaphragm
3 - Blade wheel
4 - Alternator
5 - Nozzle assembly
6 - Heater
7 - Gas inlet connection pipe
8 - Gas outlet connection pipe
9 - Cable gland assembly
10-Base ring
11 - Heat-exchange inlet connecting pipe
12 - Heat-exchange outlet connecting pipe

The model range

to 400 kW
to 6,3 MPa

Features: ммagnetic clutch provides contactless torque transmission and is used for high power TGU to reduce overall dimensions and simplify maintenance

Installation site: : power supply system on Gas Pressure Regulating Station, Gas Pressure Reducing Station and Gas Pressure Reducing Units



Turbogenerator with magnetic clutch

1 - Separable enclosure
2 - Nozzle assembly
3 - Blade wheel
4 - Diaphragm
5 - Magnetic clutch
6 - Alternator
7 - Splice
8 - Fuel gas skid detector
9 - Bearing housing

The main parameters

No.	Technical parameters	Possible value*
1	Maximum casing pressure, MPa	0,6/1,2/5,4/6,3
2	Maximum generating (output) electrical power, kW	5/8/11/15/18,5/22/30/37/45/55/ 75/90/110/132/160/200/250/ 315/400
3	Presence of a heater	yes / no
4	Presence of magnetic clutch	yes / no
5	The way of connection to electrical grid	autonomous / connected to electrical grid
6	The way of mounting at the facility	indoors / on the open area / block-modular
7	Rotation speed, rpm	3000/3600
8	Gas flow rate needed to generate 1 kW electrical power (for the ratio of reducing gas pressure equal 3), Nm3/h (Ncum/h)	70-120
9	Voltage, kV	0,4/0,66
10	Frequency, Hz	50/60
11	Ingress protection rating: Enclosure of TG, not lower	IP66
12	Ex marking: - for modifications without magnetic clutch - for modifications with magnetic clutch	1ExsdIIAT3X II Gb d IIA T6

* Note: specified parameters can be changed in coordination with the customer according to the questionnaire

TGU "TurboSphere" delivery comprises:

- Turbogenerator (according to the selected model);
- Automatic control system of TGU (ACS TGU);
- Other auxiliary systems and equipment;
- Passport on product;
- Operating manual;
- Certificates of Conformity.

The symbol TGU at the order:

TGU-250-12-H-M

Turbogenerator unit	Maximum generating electric power, kW	Maximum casing pressure, bar	With the heater (falls without heater)	With magnetic clutch (falls without magnetic clutch)

Example of TGU identification number at the order:
"Turbogenerator unit "TurboSphere" TGU-15-6-H-C of TU 28.11.23-001-29475178-2017" – Turbogenerator unit "TurboSphere" with the maximum generating electric power of 15 kW calculated on the maximum casing pressure of gas of 6 bars, execution – with the heater and the magnetic clutch..

The economic benefits

It is possible to decide whether TGU "TurboSphere" will be favorable specifically to you in only 3 steps:
1. To define an expense and pressure difference of natural gas on your object (to provide the completed questionnaire for the analysis – in the application).
2. To pick up a unit from the model range given below (or to contact our experts for selection).
3. Evaluate effectiveness indicators:
Electricity generation from TGU for the year of TGU operation:

$$W=N_{TGU}\cdot\tau,\ kW.h$$

N_{TGU} – TGU power (calculated by the formula at the page 12), kW,
τ – the number of TGU working hours per year, with a three-shift mode of operation about 8000 h.
Savings (income) in monetary terms for the year:

$$S=c_e\cdot W,\ Euro.$$

c_e – cost of electricity at the facility, average is 0,1 Euro/kW.h.

Reduced CO2 emissions per year due to electricity production:

$$CO_2=488*W/10^6,\ t$$

Calculation example:
On an object with an average consumption of natural gas in 10000 m^3/h and absolute inlet pressure of 0,4 MPa and output – 0,12 MPa the average generated power will be 110 kW that corresponds to annual power production at the level of 880 thousand kW·h. The energy received during the year is able to provide about 35 houses.
At an average tariff for electric energy of 0,1 Euro for kW·h and the conditions described above annual cut will make up to 88K Euro. At the same time, a reduction in CO_2 emissions will be about 438 tons per year, which is equivalent to an emission that is absorbed by about 20 thousand trees per year.
The payback period for capital costs of connecting TGU will be no more than 3 years.

The power determination

$$N_{TGU} = \frac{V_a \cdot \rho_n}{3600} \cdot \frac{k}{k-1} \cdot R \cdot T \cdot \eta_o \cdot \left[1 - \left(\frac{P_2^{abs}}{P_1^{abs}}\right)^{\frac{k-1}{k}}\right], \text{W}$$

With standard gas parameters, for simplicity of calculation, the power of TGU "TurboSphere" can be determined by the formula or table (shown below)

$$N_{TGU} = 0,05 V_a \cdot \left[1 - \left(\frac{P_2^{abs}}{P_1^{abs}}\right)^{0,19}\right], \text{kW*}$$

V_a – actual gas consumption reduced to normal conditions, nm^3/h
P_1^{abs} – absolute inlet pressure, Mpa
P_2^{abs} - absolute outlet pressure, Mpa
ρ_n – normalized gas density, kg/m^3
k – adiabatic index for gas
R – gas constant for gas used, J/kg·K
T – gas temperature before turbogenerator, K
η_o – overall efficiency of the gas expansion process in turbogenerator (taking into account the efficiency of the turbine, electric generator, bearing assembly, etc.)
P_2^{abc}/P_1^{abc} – the ratio of the outlet pressure to the inlet gas pressure at turbogenerator.

Model range

Specific power generation per 1000 m^3/h for typical parameters at the facility, kW *

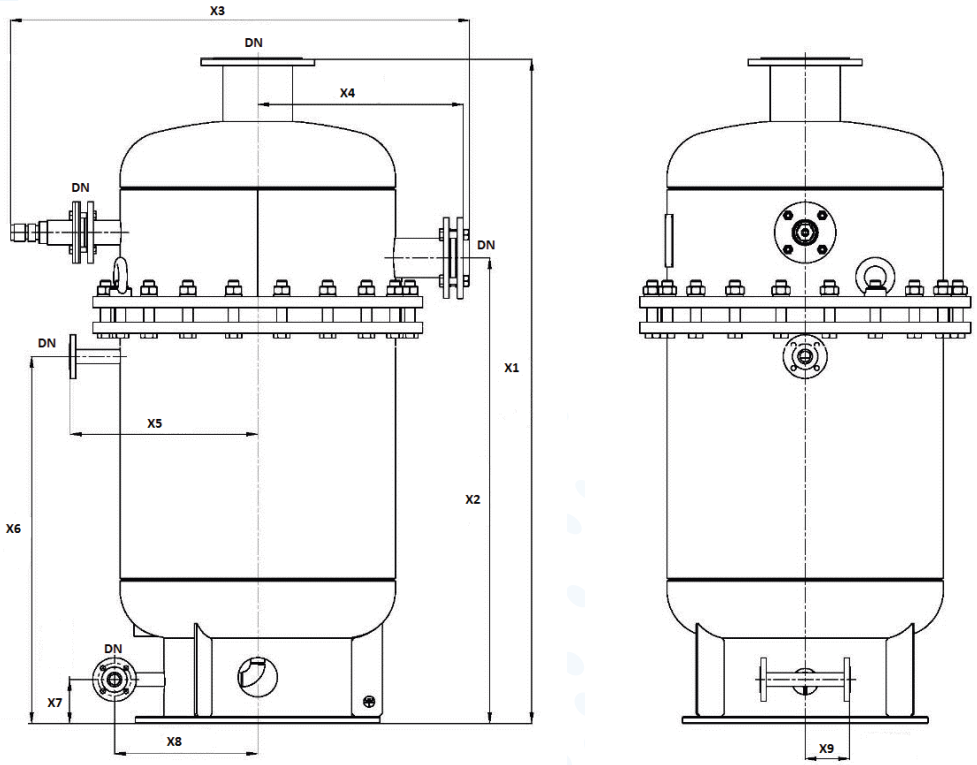
Final pressure, MPa	Initial pressure, MPa					
	0,3	0,6	1,2	2,0	3,6	5,4
0,03	10	14	18	-	-	-
0,3	-	5	10	14	17	20
0,6	-	-	6	9	14	16
1,2	-	-	-	4	9	12

Maximum generating power, kW	Maximum enclosure pressure, MPa			
	0,6	1,2	5,4	6,3
5	TGU-5-6	TGU-5-12	TGU-5-54	TGU-5-63
8	TGU-8-6	TGU-8-12	TGU-8-54	TGU-8-63
11	TGU-11-6	TGU-11-12	TGU-11-54	TGU-11-63
15	TGU-15-6	TGU-15-12	TGU-15-54	TGU-15-63
18,5	TGU-18,5-6	TGU-18,5-12	TGU-18,5-54	TGU-18,5-63
22	TGU-22-6	TGU-22-12	TGU-22-54	TGU-22-63
30	TGU-30-6	TGU-30-12	TGU-30-54	TGU-30-63
37	TGU-37-6	TGU-37-12	TGU-37-54	TGU-37-63
45	TGU-45-6	TGU-45-12	TGU 4554	TGU-45-63
55	TGU-55-6	TGU-55-12	TGU-55-54	TGU-55-63
75	TGU-75-6	TGU-75-12	TGU-75-54	TGU-75-63
90	TGU-90-6	TGU-90-12	TGU-90-54	TGU-90-63
110	TGU-110-6	TGU-110-12	TGU-110-54	TGU-110-63
132	TGU-132-6	TGU-132-12	TGU-132-54	TGU-132-63
160	TGU-160-6	TGU-160-12	TGU-160-54	TGU-160-63
200	TGU-200-6	TGU-200-12	TGU 20054	TGU-200-63
250	TGU-250-6	TGU-250-12	TGU-250-54	TGU-250-63
315	TGU-315-6	TGU-315-12	TGU-315-54	TGU-315-63
400	TGU-400-6	TGU-400-12	TGU 40054	TGU-400-63

Depending on purpose and the place of application, TGU execution can be with the heater (execution – H) and the magnetic clutch (execution - C).

*For information

The overall and mounting dimensions



Connecting dimensions

Dimensions X, as well as the location of the connecting legs are determined at the design stage and can be changed by agreement with the Customer. The diameters of the inlet and outlet connecting legs can be determined using the formula:

$$d = \sqrt{\frac{4 \cdot V_a \cdot 0{,}1}{\pi \cdot 3600 \cdot W\left(P^{абс} + 0{,}1\right)}} \cdot 1000, \text{mm}$$

, Va – gas consumption, nm^3/h; W – gas velocity, m/s; P – gas pressure, MPa

For natural gas the connecting legs (DN) are:

$$d = 1{,}33\sqrt{\frac{V_a}{P^{абс}}}, \text{mm}$$

The diameters obtained are converted to standardized.

The automatic control system (ACS)

Window «Turbogenerator unit mnemonic scheme»

Legend:
1, 5 – shut-off valves;
2 – external heat exchanger for gas heating (if necessary);
3 – gas pressure regulator;
4 – the TGU TurboSphere;
6 – locking device on the main / classical reduction branch;
7 – pressure regulator on the main / classical reduction branch

Purpose – reliable and safe operation of the turbogenerator, recovery of electricity generated in the network in accordance with the requirements.
The ACS is designed to automate the process of the TGU operating and is implemented on the basis of logical programmable controllers, which allow monitoring, starting and stopping the TGU, as well as the protection systems operation. The degree of locker protection from external influences corresponds to IP54 according to GOST 14254-96. According to the method of protection against electricity, the control locker and power locker correspond to class I products according to GOST 12.2.007-75.

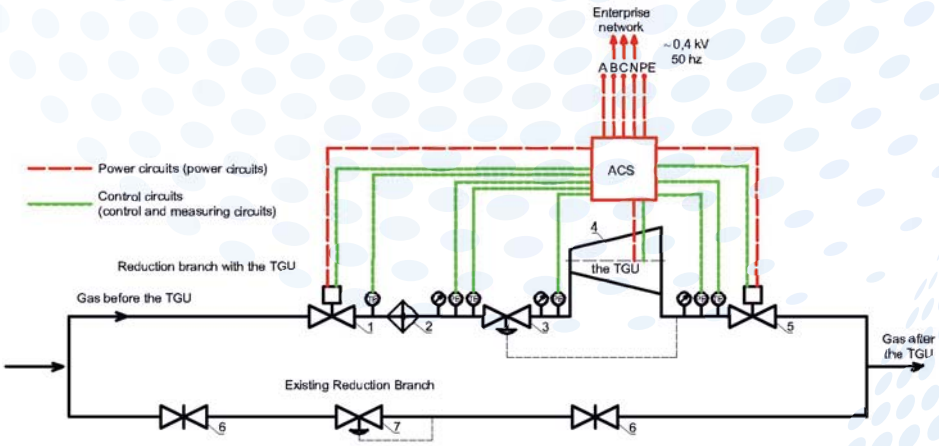
Technical parameters

ACS is implemented on the basis of a Siemens s-1200 programmable logic controller or equivalent.
The controls of the turbogenerator unit are based on the Weintek MX8090XE touch-sensitive graphic control panel or equivalent.
2 control modes: manual and automatic.

Functions

- Control, regulation and management of the TGU parameters;
- Possibility of the TGU remote and local start / stop;
- Provision of the TGU emergency protection system;
- Dispatching data about the TGU work;
- Processing and storage data about the TGU work.

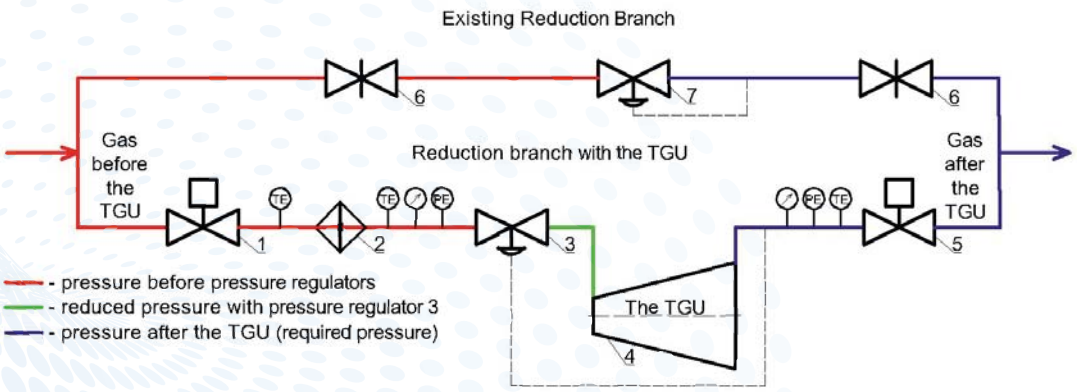
Scheme of the TGU connecting to the electrical network



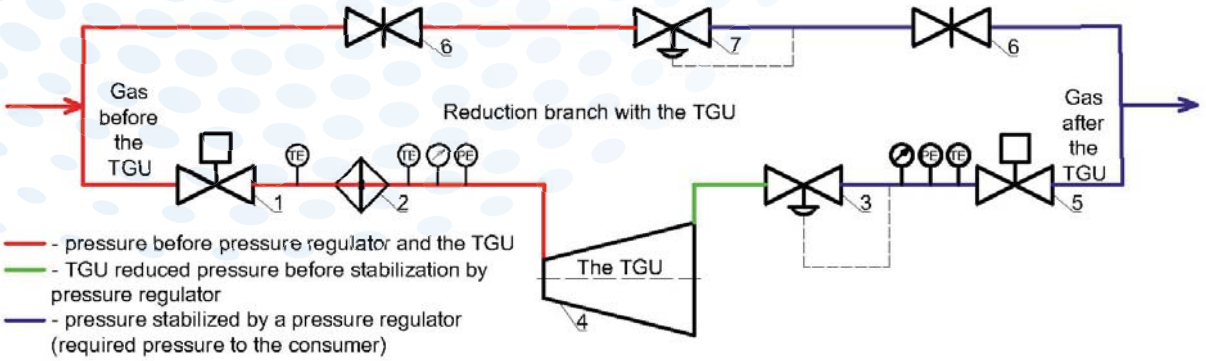
Schematic diagrams of the TGU connecting to the gas transmission system section

Legend:
1, 5 – shut-off valves;
2 – external heat exchanger for gas heating (if necessary);
3 – gas pressure regulator or stabilizer;
4 – the TGU TurboSphere;
6 – locking device on the main / classical reduction branch;
7 – pressure regulator on the main / classical reduction branch

Standard connection scheme of TGU parallel to the main reduction branch (regulator before TGU)

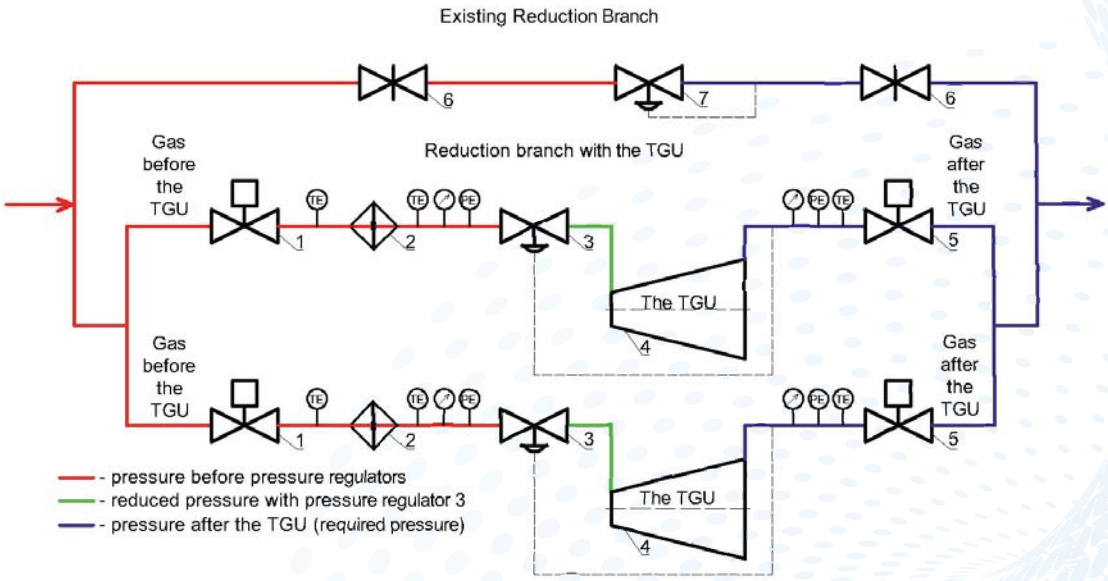


Connection scheme of TGU parallel to the main reduction branch (regulator after TGU)

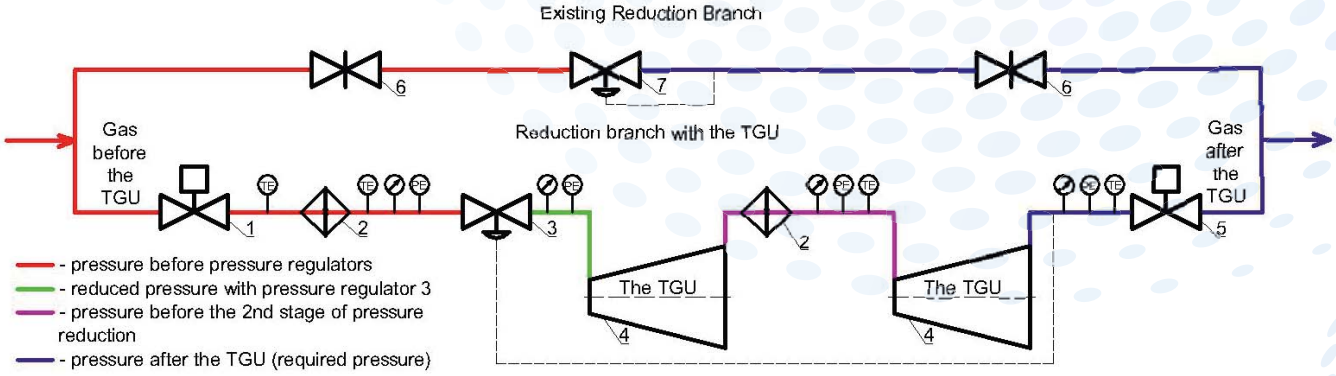


Schematic diagrams of the TGU connecting to the gas transmission system section

Connection scheme of the same TGU parallel to each other and to the main reduction branch (regulator before TGU)



Connection scheme of the same TGU successively to each other and parallel to the main reduction branch (regulator before TGU)



Testing and manufacturing bases

The main parts and assemblies of the TurboSphere are manufactured using our own industrial and technical complex, including modern nc-machining technique.

Before installing products on the implementation venue, TurboSphere is tested on a specially created test facility that simulates the operation of the gas transmission system.

Achievements

We work according to requirements of standards of Quality System Standard of ISO 9001:2015.

The test facility is certificated.

Conformance to European Union directives certificates:
– 2006/42/EC Machinery
– 2014/35/EU LVD
– 2014/30/EU EMC
– 2014/68/EU Pressure equipment
– 2014/34/EU Equipment and protective systems intended for use in potentially explosive atmospheres (ATEX)

Technical Regulations of the Customs Union certificates:
– 012/2011 «About safety of work equipment in explosive environments»
– 020/2011 «Electromagnetic compatibility of technical means»
– 032/2013 «About safety of the equipment functioning under overpressure energy»
– 004/2011 «About the safety of low-voltage equipment»

Products and the project have been noted by 30 diplomas at numerous exhibitions, conferences, fairs, forums: winners of EXPO Live from Expo 2020 Dubai, the finalist of "Startup Village-2015", the finalist of "Tekhnostart-2016", a gold medal of the international exhibition "High technologies. Innovations. Investments", 1st place of the International youth forum of science and innovations of BRICS and The Eurasian Economic Union, finalist diploma of the VII International Prize "Small Energy - Great Achievements" in the nomination "Innovative Development in the Energy Sector".

Contacts:
37/1 Surganova str., Minsk, Belarus
+375 (17) 235-38-05
info@ts.energy

www.ts.energy