

PUBLIC JOINT-STOCK COMPANY «GAZPROM»
LIMITED LIABILITY COMPANY SCIENTIFIC-RESEARCH
INSTITUTE OF NATURAL GASES AND GAS TECHNOLOGIES –
GAZPROM VNIIGAZ

VI International Conference

**GAS TRANSPORTATION SYSTEMS: PRESENT AND FUTURE
(GTS-2015)**

28–29 October 2015

Abstracts

Moscow
2015

VI International Conference «Gas Transportation Systems: Present and Future» (GTS-2015): Abstract of papers presented at the International Conference, 28–29 October 2015. – M.: Gazprom VNIIGAZ, 2015. – 176 p.

The present digest is compiled of the materials of the VI International Conference «Gas Transportation Systems: Present and Future» (GTS-2015), held at Gazprom VNIIGAZ on 28–29 October 2015.

The structure of the digest corresponds to the Program of the conference and includes the following sections: Plenary and Sessions A, B, C, D, E.

The order of abstracts corresponds to the order of presentations at the conference.

PLENARY SESSION

28 October 2015

Directions of scientific and technical innovative development of the gas transportation system of Gazprom PJSC

V.A. Mikhailenko (Gazprom PJSC)

Efficiency of gas transportation system functioning depends on the minimization of operating costs, including costs and down time related to the execution of emergency response operation and on the optimization of capital investment.

These development factors depend on both the general level of the technical process and the scientific and technical achievements, the implementation of which will allow ensuring a high competitive power.

The effectiveness of research and development works will be particularly high if the sectoral research institutions see the mainstream goal and targets in the achievement of which Gazprom PJSC is very interested.

The report demonstrates the main directions of the scientific and technical innovative development of Gazprom PJSC gas transportation system which will allow to ensure a high efficiency of gas transportation system functioning:

- improvement of energy efficiency and resolution of problems related to energy conservation;
- improvement of system of technical state and integrity management;
- new methods and means of diagnostics;
- improvement of maintenance methods and repair technologies;
- development of construction technologies, equipment and management.

The report emphasizes a need to reconsider outdated provisions of regulatory documents which do not match the modern scientific and technical achievements and restrain the development of the sector.

Application of innovative technologies is traditionally the cornerstone of implementation of Gazprom PJSC largest mega-projects. In the nearest perspective this direction is oriented to the development of fields in the Eastern Siberia and Far East, including the construction of the system of trunk gas pipelines Sakhalin – Khabarovsk – Vladivostok, «Power of Siberia», «Altai».

Scientific and technical supervision of the development and operation of gas transmission systems

D.V. Lyugay, V.N. Voronin (Gazprom VNIIGAZ LLC)

Gazprom VNIIGAZ LLC being the main scientific centre of Gazprom PJSC provides scientific and technical justification and supervision of the projects for construction of new, reconstruction and operation of existing facilities of gas transmission system.

It lies in the tradition and purpose of VNIIGAZ to develop applied fields of fundamental science, to develop new technological and technical solution, to determine scientifically justified technical policy of the industry in the long term.

Trunk transport of hydrocarbons today is related to solution of the two main problems:

- construction of high-reliable gas pipelines in extremely difficult geographic natural conditions without developed infrastructure;
- ensuring working capacity and safety of facilities in operation, subject to active physical and moral wear and tear.

Both problems should be solved in the conditions of most efficient use of financial and material resource, involving domestic manufacturers in achievement of the set tasks.

Currently, development of Russian gas transmission system involves diversification of export gas flows, forming new gas extraction centers on Yamal and Arctic shelf, in the oil and gas bearing areas of the Eastern Siberia and the Far East.

New projects in of gas transmission are characterized by complex mining-and-geological, geographic and climate conditions. Diversity of the new conditions is reflected in setting and solving research and technological tasks of scientific and technical support, necessity of development of innovative technical solutions, construction technologies, and structural materials. Results of theoretical research and pilot tests incarnate in design solutions, registers of construction technologies, materials and equipment authorized for use, regulatory documentation.

Functional stability and stability of gas supply to consumers are ensured by maintaining required level of reliability and safety of operated GTS facilities. Efficiency of this process is determined by optimized targeted application of modern methods and technologies of technical diagnostics, maintenance and repair. These tasks are achieved by the System of Management of Technical Condition and Integrity of GTS – result of R&D, regulatory and information developments of the Company.

During the recent years Gazprom PJSC has completed introduction of Bovanenkovo – Ukhta gas trunk pipelines system for gas transmission from Yamal peninsula fields, trunk gas pipeline Nord Stream, gas transmission system Sakhalin – Khabarovsk – Vladivostok. GTS «Power of Siberia» construction has been started; GTS capacities have been enhanced for support of the Turkish corridor.

For all the projects, Gazprom VNIIGAZ LLC was performing comprehensive scientific and technical supervision that involved development of Project Specific Technical Specifications (PSTS), technical requirements to pipes, coupling parts, welding and non-destructive control, testing, corrosion-proof protection, etc.

In relation to the current GTS, significant results of the institute research work are provided in the developed System of Management of Technical Condition and Integrity of GTS, and Programs for the reconstruction and technical re-equipment of trunk gas pipelines of Gazprom PJSC, and for comprehensive overhaul of trunk pipelines line part of Gazprom PJSC for 2016–2020.

Nowadays, research, engineering and technological potential of the Institute is especially demanded by Gazprom PJSC for solution of the first priority tasks of the Eastern Program implementation. Scientific and technical supervision of construction of the gas trunk pipeline «Power of Siberia» has started from pre-investment research and continued during design and construction. Apart from implementation of innovative technologies, with direct involvement of the Institute in this process, we managed to identify and justify cost-efficient technical solutions and to reduce the project capital investment.

I would like to emphasize that in the field of gas transmission, implementation of Gazprom PJSC scientific and technical policy is impossible without creation of modern testing foundation in Gazprom VNIIGAZ LLC, that would be able to ensure performance of exploratory and experimental research, comprehensive qualification and certification testing of samples of structures, materials, technologies and equipment, and to perform the functions of simulator complexes for training and professional development of the gas transmission organizations specialists.

Evolutionary transition to a new stage of UGSS development

*B.V. Budzulyak
(Self-regulated organization Association
of gas and oil complex builders)*

The current state of the gas industry in our country is characterized by the following main conditions:

- depletion of unique gas and gas-condensate fields;
- continuing movement away from the main consumption areas and the rising costs of gas and condensate resources;
- increasing power overcapacity in the trunk gas transportation systems;
- reduction of natural gas consumption in the country and gas sales to foreign countries;
- most sections of trunk gas pipelines have gone beyond the standard service life limits and considerable investment costs are needed for their restoration;
- all new projects are very expensive and, except for the development of the Yamal fields, are implemented outside the existing UGSS.

All this requires a new approach to the basic principles of improving the management and further development of the UGSS, including the rational use of existing production capacities for gas production, processing, transportation and storage.

The report examines the counteractive measures to negatively developing factors, which are mentioned above and others, providing the maintenance of UGSS at a high economic level.

Risks analysis in the strategic planning of gas transportation system development

N.A. Makhutov

(Working group for the analysis of risks and security issues under the RAS President)

The Russian gas transportation systems are the core components of the Russian economy and contain the elements of national and international gas energetic and chemical complex.

The Federal Law «About strategic planning in the Russian Federation», passed on June 28, 2014, is based on the necessity to achieve two main strategic goals:

- social and economic development of the country;
- enforcement of the national security.

For gas transportation systems of international, federal and regional levels in accordance with this law the development of new strategic planning documents for further short-, medium-, and long-term improvement of gas transportation systems for 2015–2017 is required.

Strategic planning of the development of gas transportation systems should be accomplished on the base of risk criteria and restrictions of economic, technological and environmental nature. The development of strategic planning documents can be carried out under academic and information-analytical support of the Russian Academy of Sciences.

The integrated strategic risks should include their two main groups:

- risks of loss of life and health of operators and personnel of gas transportation systems, as well as the population in the areas of their location;
- economic risks of technological, man-caused, natural and artificial nature.

For these groups of risks it is necessary:

- to provide scientific evidence to methods for determining the levels of risks and their components;
- to evaluate and set acceptable risks.

Taking into account this data, the complex measures on the strategic priorities mentioned above will be developed for gas transportation systems with the justification of estimated economic costs needed to meet emerging and acceptable risks.

New diagnostic systems and processes for diagnostics of trunk pipelines

N.P. Aleshin

*(FSAI R&E Center of Welding and Control at Bauman
Moscow State Technical University,
Academician of Russia Academy of Sciences)*

The paper considers new automated means for ultrasonic testing of welded joints in pipelines and pipe body. The scanners are provided with phased arrays, and, as distinct from known counterparts operating in TOFT mode, implement the diffraction-amplitude time of light method (DAFT), which ensures higher detectability of defects and allows evaluation of defect size. The developed method, in addition to determination of crack size, permits to estimate characteristics of other defect types, which is impossible when using TOFT method.

An inspection process has been developed that eliminates «blind zones» on the top and bottom of the item under inspection. Comparative tests of the developed system and other similar systems conducted at Pskovelectrosvar CJSC Plant have shown that the new system ensures 100 % detectability of oxide flaws, while other counterparts, namely, Agrovision (Israel), Pipe Wizard (Canada) showed lower detectability (~72 %).

Comprehensive approach to development, production and supply of specialised products for sites of Gazprom PJSC in the new economic conditions

G.V. Kotishevsky (Gazprom StroyTEK Salavat CJSC)

Reliable and efficient operation of gas transmission systems, their timely development with account for growing demands of the market, is one of priority tasks of Gazprom PJSC, solution of which permits to perform the undertaken obligations on consumers supply with natural gas.

One of the key areas of implementation of this task is application of new modern technical solutions, advanced methods, products and materials used in gas pipelines construction and repair, enabling to ensure high quality, safety, to reduce construction timeframes, as well as to increase gas transmission systems' service life.

In the current economic conditions, with account of implementation of import substitution and imported procurement minimisation program in Gazprom PJSC, increasing requirements to purchased products used at construction and repair facilities, for successful competitive activity in market, a comprehensive approach to development, production and supply of specialised products is necessary:

- analysis of existing products application experience;
- interaction with R&D organisations;
- development of new types of products and upgrading of current ones and technical solutions on this basis;
- maximum utilization of domestic materials;
- implementation of innovative and improvement of currently used technologies, production upgrade;
- comprehensive technical solutions development;
- manufactured products' increased quality control;
- ensuring supplies timeframes and volume.

During the past 2 years, Gazprom StroyTEK Salavat CJSC has conducted significant work in this direction. Constant interaction is carried out with design and construction organisations in terms of analysis of supplied products applicability, and application of comprehensive technical solutions on the basis of manufactured and supplied products. Based on summarisation of gas transmission systems operation experience in close cooperation with scientific subdivisions of Gazprom PJSC, takes part in regulatory technical base improvement. Constantly new products are upgraded, and new products are developed, quality assurance system is being improved – both for own manufacturing, and supplied products. Constant growth is achieved in involvement of domestic manufacturers of crude products and raw materials for products manufacturing. New productions are opened, range of manufactured products is significantly enhanced.

Creation of LNG complexes of different capacities on the basis of domestic technologies and equipment (problems and solutions)

G.E. Odishariya (Gazprom VNIIGAZ LLC)

Currently Gazprom PJSC has everything required for successful solution of the set task within minimum timeframes upon proper arrangement of works and acceptable funding allocation.

Grounds for such statement are the following:

- availability of main scientific center in the field of technologies – Gazprom VNIIGAZ LLC, possessing the required experience and qualified personnel in the field of LNG production, storage and use;

- availability of own technology of natural gas liquefaction by own technical process indicators, including specific power consumption for LNG production, highly competitive to the world its world analogues (Gazprom VNIIGAZ LLC development, patent holder is Gazprom PJSC);

- availability of the above gas liquefaction technology application in LNG complexes of different capacity and designation;

- opportunities of LNG complexes complementation with materials and equipment, including refrigerating cycles compressors, heat-exchange units and common units of own production, for construction of:

- LNG complexes of large capacity of 10 million tons/year and over for the purposes of gas supply to remote markets by sea using tankers of large weight capacity;

- LNG complexes, analogues of foreign «piksheving» units equipped with a gas liquefaction process line of low capacity (up to 20 tons/hour), to cover the peak loads of gas consumption of settlements with small population size and NGV-refuelling compressor stations located at a significant distance from trunk and distribution gas pipelines.

Pressure gas pipelines integrity: some lessons from scientific and technical cooperation of ENGIE and Gazprom PJSC

A. Grigoryan (ENGIE)

1. Problems of gas transmission network integrity in France: tasks and requirements.
2. Procedure for evaluation and inspection of pipelines related to their integrity.
3. Collaboration within the framework of scientific and technical cooperation.
4. Follow-up study perspectives.

Technology development and lessons learned in Russia's gas pipeline industry: a DNV GL perspective

N.A. Masvie (DNV GL)

1. Technology drive – role of players.
2. Steel in the gas pipeline industry.
3. Role of technologies and standards.
4. Submarine gas pipeline projects: comparison.
5. Russian suppliers to offshore pipelines.
6. Lessons – what's ahead:
 - for operators and pipeline systems;
 - for suppliers.

SESSION A

TECHNOLOGIES OF MAIN GAS TRANSPORTATION

28–29 October 2015

Principles of developing the «Complex program on reconstruction and technical modernization of gas transportation facilities for the time period of 2016–2020»

*A.V. Chepkasov, A.V. Zhenev (Gazprom PJSC),
S.Yu. Salnikov, R.V. Shintyapin, S.Yu. Tertichnyi
(Gazprom VNIIGAZ LLC)*

The gas transportation system (GTS) of Gazprom PJSC is operated in the conditions of changing volumes of gas supplies in different directions, due to the movement of production centers from the dwindling sources of Nadym-Purtazovskiy region to Yamal and the shelf, diversification of export gas flows, increasing volumes of gas supplies to GTS by independent suppliers.

Many projects, planned for realization by previous complex programs on reconstruction and technical modernization of gas transportation facilities, are left at the stage of uncompleted engineering and research works.

When deciding on the withdrawal of the object for its reconstruction, the main problem is the lack of common methodological approaches to prediction of the reliability and operational efficiency of the equipment of the main gas transportation facilities.

In 2013–2014 Gazprom VNIIGAZ LLC developed the «Investment concept of reconstruction and technical modernization of gas transportation facilities for the period of 2016–2020», which contains a list of objects, reconstruction of which is needed to ensure the prospective gas flows up to 2030, and began to develop the Complex program on reconstruction and technical modernization of gas transportation facilities for the period of 2016–2020.

In addition to the projects aimed at providing prospective gas flows, the «Complex program on reconstruction and technical modernization of gas transportation facilities for the period of 2016–2020» includes projects aimed at ensuring operational reliability and safe operation of GTS objects, including its industrial safety.

The «Complex program on reconstruction and technical modernization of gas transportation facilities for the period of 2016–2020» being developed is coordinated with other target complex programs.

When developing the «Complex program on reconstruction and technical modernization of gas transportation facilities for the period of 2016–2020», 3 scenarios of its implementation (funding) have been considered, the effectiveness factors of reconstruction projects have been determined.

Improving operational efficiency of gas transportation infrastructure using LNG complexes

*A.Z. Shaykhutdinov, S.I. Dolgov, V.S. Safonov
(Gazprom VNIIGAZ LLC)*

In the boiler-furnace fuel balance of the Russian Federation the natural gas takes about 70 %. Besides that, in winter period the essential portion of gas (75 %), supplied through UGSS, is spent on heat and electric power generation. The gas demand for these needs depends on weather conditions, which unavoidably gives rise to significant short-term fluctuations in gas consumption volumes, which in some regions of the Russian Federation may reach 30–40 % of the average values. The gas balance maintenance in these conditions is ensured by gas withdrawal from UGSF and changes of gas stocks in the pipes. However, UGSF are located extremely irregularly in UGSS and have significantly different processing parameters. Due to this fact, some UGSS segments experience the shortage of UGSF storage capacities for compensation of short-term fluctuations in gas consumption. Thus, the compensation of gas consumption irregularity in these segments is performed by changing the gas transportation mode at long sections of trunk gas pipelines, which leads to a significant decrease in their operational efficiency (frequent starts and shut-downs of GPU, GPU operation outside the maximum efficiency range limits, etc.).

To illustrate this problem, the report considers the service area of Gazprom transgaz Saint Petersburg GTO (GT SPB), within the operating area of which the capacities of Nevsky and Gatchina UGSF are used to control gas consumption fluctuations. It has been proved that the existing capacities of those UGSF are not enough to compensate on the full scale the short-term gas consumption fluctuations generated by consumers of GT SPB. In this case a heavy load for gas consumption regulation is applied on the gas transportation system GT Ukhta.

It has been proved that the usage of «peak shaving» units together with existing UGSS capacities will significantly reduce short-term fluctuations in gas consumption in the GT SPB region and enhance the operational (energy) efficiency of the UGSS-consumer system.

The possibilities of integrated use of LNG for the regulation of short-term fluctuations in gas consumption, as well as in the form of engine fuels (for automobile, railway and water transport), and as backup fuel at power plants have been analyzed.

Research of physical and chemical properties of steel of long-term operated pipelines, safe operation life span evaluation

Yu.V. Lisin (Transneft R&D LLC)

Transneft OJSC trunk pipelines linear part amounts to 73 million metres of pipeline. Linear part contains over 7 million ring welding seams and 75.5 million metres of longitudinal joints. Therewith 50 % of oil lines and 66 % oil-product lines are used for over 30 years.

In 1988 in PMT IPTER a simple theory of «old» pipelines safe operation was developed: reduction of design pressures depending on the terms of operation. Implementation of this theory led to reduction of oil lines throughput capacity by 30 %, which turned out to be a limiting factor in the conditions of growing extraction.

Since 2000 in Transneft OJSC, broad-scale R&D and experimental efforts are being undertaken in research of actual mechanical and chemical properties of the steel of long-term operated pipelines and pipelines being reconstructed. Currently R&D Transneft OJSC and Transneft Diascan JSC are taking part in this work.

In the period from 2000 to 2002 works were performed in the research of behaviour of pipe steels properties in time, and since 2002 this topic includes research of durability and life span of long-term operated pipelines. By the results of bench and laboratory tests of chemical composition and mechanical properties of pipes metal, it was determined that pipes steel properties change takes place as follows:

- to lesser extent in the process of operation, because insignificance of low-cycle loads is noted;
- steel properties deterioration takes place:
 - in the process of pipes manufacturing;
 - in the areas of defects, significant changes of mechanical properties take place towards deterioration;
- impact strength significantly reduces (by 1.5–2 times), as well as ultimate strength and yield limit of the steels with high content of sulphur.

**Gas transportation system development
by Gazprom transgaz Ukhta LLC due to large scale
«mega-projects» as a powerful energy potential Russia**

T.V. Andreeva (Gazprom transgaz Ukhta LLC)

Despite the difficult geopolitical and economic situation in the world, Gazprom PJSC has managed to preserve its position of the largest supplier and effective natural gas exporter. Gazprom currently continues to resolve strategic issues, such as ensuring gas production in the volumes necessary to provide gas supply to the consumers of the national economy of the Russian Federation, performance of export contracts for the supply of gas, as well as diversification of routes of Russian gas, increasing the capacity of the export infrastructure. An important role in the solution of these problems is assigned to the company Gazprom transgaz Ukhta. All major projects in gas industry, which Gazprom PJSC is carrying out in the European North of the country, are directly related to Gazprom transgaz Ukhta LLC, due to the fact that the so-called Northern Corridor of main gas pipelines within the boundaries of operational responsibility of the company is of strategic importance. It is the shortest in the direction from the existing fields of the Tyumen region and promising fields on the Yamal Peninsula to the central regions of the European part of the country and Europe.

The new gas transport systems of the «North European Gas Pipeline» (land part), Bovanenkovo – Ukhta, Ukhta – Torzhok, which, since 2012, have been gradually introduced into operation, have bounded gas fields in Yamal and consumers of natural gas to European countries via the Baltic pipeline system.

The strategic plans of Gazprom PJSC to expand the Nord Stream will lead to the need to expand the gas transmission capacities in the area of the operational responsibility of Gazprom transgaz Ukhta. This proves once again that the gas transportation system of the enterprise, being a powerful energy potential of Russia, becomes not only an important factor for the new stage of development and ensuring the reliability of the existing Unified Gas Supply System of the country, but also becomes a key element of ensuring the European energy safety.

Aerospace technology application for air patrol of the line gas mains

*V.A. Kuznetsov, V.A. Lazutin, N.N. Sevastiyarov, D.A. Cheprasov
(Gazprom space systems JSC)*

The scheduled diagnostic maintenance of the line part (LP) of the gas-main pipelines (GM) is purposed to secure continuous gas transportation and minimize costs, caused by natural or technology-related risks.

One of the sources of objective information on LP GM condition is the aerospace survey data. The technologies of aerospace monitoring realized on its basis are used for obtaining information on GM interaction with the environment, the current status of LP GM, data on the surrounding landscape and its influence on GM status.

Aerospace technologies presume the integrated nature of work performance with the use of all available data on GM and environment conditions, including space-based optic, radar and UAV surveys data, operating documentation, in-line inspection materials and other environmental data.

The efficient combination of spatial information, received from several sources, and also means of its processing and visualization, allows us to significantly increase the contribution of aerospace methods to the effectiveness of the integrated system of GM operations reliability assurance.

Aerospace technologies based on UAV imaging can in many cases provide efficient substitute of air monitoring with helicopter type manned aircraft.

The presentation shows the results of practical activities of Gazprom space systems JSC on introduction of aerospace technologies at affiliate gas transportation companies of Gazprom PJSC during 2011–2015 yrs.

Advanced management methods and technologies of computer-aided design of pipeline transportation facilities

*O.F. Shayakhov (PF Uraltruboprovodstroyproekt LLC),
A.G. Gaynanova (Ufa State Petroleum Technological University)*

It is believed that about 80 % of design labor costs are routine operations, and about 20 % is a creative component, that is the actual design solution. Application of modern technologies allows to significantly reduce the number of routine operations by using already existing developments and automation of routine processes.

One of the features of pipeline transportation facilities is a considerable experience in designing pipeline systems accumulated by design organizations. According to this, one of the ways of increasing design efficiency is widespread use of this experience and knowledge on the base of modern management methods and technologies. Thus, to develop this direction of increasing design efficiency, the following advanced systems for design organizations are proposed for implementation:

- a data management system, which aims at collecting and storing information about a designed object into a unified logical model;
- manufacturing supporting system for controlling project schedules and dispatching;
- special computer-aided design systems for pipelines;
- a design system on the base of the accumulated knowledge.

The design experience in related industries shows that application of special design systems based on the accumulated knowledge reduces design time, in some cases from several weeks to couple hours. However, such systems require significant resources for their development and implementation, which is not always possible and reasonable in the case of designing pipeline transportation facilities, therefore it is proposed to integrate the systems mentioned above on the base of the data management system with existing software solutions available on the market.

Single-line gas metering station DN 800–1400: concept and introduction experience

G.A. Derevyagin (SPA Vympel LLC)

1. Background of the development of a single-line gas metering station (SLGMS) of large diameter in SPA Vympel: a timeline of the ultrasonic flow-metering, development of multi-channel ultrasonic flow meter of high accuracy.
2. Concept of a single-line gas metering station of large diameter
3. Advantages of SLGMS – reduction of production costs, design simplification.
4. Metrological support: development of gas-dynamic calibration unit Vympel-80000.
5. Component parts of SLGMS: a gas metering unit, a gas quality unit, a data collecting system.
6. Preliminary production tests of DN 1400 flow meter: comparison with the standard DN 500.
7. Tests of DN 1400 metering unit in pilot operation conditions, preliminary results.
8. Further tests planning and prospects of this development application.

**Energy-saving policy of Gazprom transgaz Ukhta LLC.
Current trends in the development of Company's business
processes for energy efficiency improvement**

V.N. Yushmanov (Gazprom transgaz Ukhta LLC)

The aggregated task, set by the energy-saving policy of Gazprom transgaz Ukhta LLC (hereinafter – Policy) in terms of optimization of key business processes of the Company's operation, is to increase the efficiency of non-renewable energy resources consumption by saving them, as well as the implementation of energy-saving technologies.

To implement the policy, at this stage it is necessary to determine the energy-saving potential and the possibility of improving the energy efficiency of the Company, while determining the key areas (segments) of its production activities, which may result in the maximum economic benefit at the lowest costs, and the development of the implementation schedule of energy-saving measures and activities in the Company.

The basic element, that provides implementation of the Program, is the regulatory base, which includes methodological approaches and implementation algorithms for energy-saving measures and activities, as well as energy-efficient technologies, including those being implemented in the framework of energy service contracts.

In order to create such element, as well as to formalize approaches to application of energy service contracts in Gazprom transgaz Ukhta LLC with the possibility of their replication in subsidiaries of Gazprom PJSC, R&D work is being conducted in the Company on the following subject: «Assessment of the energy-saving potential and the possibility of improving the energy efficiency of GTS of Gazprom transgaz Ukhta LLC, development of proposals for its implementation for the period until 2025».

Simulation of gas transmission processes to improve energy efficiency

E.A. Zolotarev (Hydroaerocenter CJSC)

In the crisis situation, reduction in energy prices is one of the ways to improve the profitability of Gazprom PJSC. Such reduction in prices is possible by simulating gas transmission processes and determining the modes with minimal expenditures of fuel and energy resources (FER).

For reliable prediction of energy-efficient gas transmission modes it is necessary to get the actual performance values for the equipment of the trunk gas pipeline (TGP) and to perform modeling of TGP operation in the whole range of operating parameters and environmental conditions.

As the result, the optimal transmission modes by gas pressure and temperature parameters at the outlet of the compressor station (CS), by configuration of CS elements can be determined, and the influence of gas transmission volumes and TGP elements on FER expenditures can be studied.

The «Stream» program, which was developed by national specialists, was tested on Makat – North Caucasus TGP, Nord Stream TGP, «Blue Stream» TGP, «Power of Siberia» TGP.

The reliable estimations allowed to give some recommendations concerning configuration of «Portovaya» CS (Nord Stream TGP), «Zeyskaya» CS («Power of Siberia» TGP), «Kubanskaya» CS («Blue Stream» TGP).

New industrial safety requirements and methodological support improvement for accidents risk analysis at hazardous industrial facilities of pipeline transmission

M.V. Lisanov (NTTs PB CJSC)

Implementation of risk-oriented approach to industrial safety regulation is accompanied with significant change of regulatory base of Rostekhnadzor, including introduction of additional requirements on risk analysis to the Federal Rules and Regulations (FRR) «Safety Rules for Hazardous Industrial Facilities», FRR «General Requirements to Hazardous Industrial Facility Safety Justification».

The report considers provisions of new methodological documents on hazard analysis and accident risk assessment at main trunk pipelines, including:

Safety guide (SG) «Methodological Fundamentals on Hazard analysis and Accident Risk Assessment at Hazardous Industrial Facilities» (update RD 03-418-01);

SG «Method of Hazardous Substances Accidental Emission Modeling» (update RD 03-26-2007);

SG «Methodology of Evaluating Consequences of Fuel-Air Mixture Explosions» (update RD 03-409-01);

SG «Methods of Justification of Buildings and Structures Explosion Stability at Fuel-Air Mixtures Explosions at Hazardous Industrial Facilities (new document for explosion resistance justification for control rooms and buildings with presence of people)».

Examples of quantitative risk assessment result for main trunk pipelines are given. Typical errors in calculations are shown, including ones related to risk analysis application during industrial safety justification development.

All the proposals are expressed on improvement of methodological support of risk analysis, including development of software applications, collection and analysis of source data based on implementation of industrial safety remote control system.

Experience and problems of development of project specific technical specifications for gas-transport system facilities

*G. Yu. Churkin, A.A. Sinitsina
(ANO «Agency for the research of industrial risks»)*

Analysis was conducted for the most frequent causes of Project specific technical specifications (PSTS) development for facilities of gas transmission system (GTS). They include the following:

- reconstruction of trunk gas pipelines (TGP) at sites located at a city border or boundaries of population centers;
- TGP installation in confined conditions of functional utility line area;
- installation of gas pipelines with pressure over 2.5 MPa within city borders for gas-turbine units of CHPP;
- LHG pipelines construction with particular deviations from regulatory requirements;
- construction of facilities of municipal infrastructure at the distances to functional TGP less than permitted.

The main mitigating measures used at PSTS development for each of the above-mentioned causes are provided. Analysis of justification of applied mitigating activities was conducted and recommendations on their improvement were given.

Close attention was paid in the report to PSTS development for design of pipelines designated for LHG transmission: NGL and LNG. Demand for these pipelines occur due to works being performed in construction of gas refinery plants and LNG production plants. Analysis of requirements to LNG transmission pipelines within marine process terminals for LNG and NGL shipment was conducted.

Predicting operating reliability of trunk gas pipelines based on the monitoring of factors influencing the occurrence of emergency situations

S.T. Alekperova (The Group of companies «SERKONS»)

The extent of branched system of trunk gas pipelines (TGP) on the territory of the Russian Federation exceeds 174 thou. km. At the same time a significant number of TGP construction and reconstruction projects are being implemented in a space-limited environment which is characterized by:

- passing of TGP route across the territory of cities and residential settlements;
- existence of non-normalized proximities to cities and residential settlements, as well as civil and industrial facilities;
- non-observance of required distances in case of parallel routing of TGP along the same technical corridor with the existing utility lines and operating gas pipelines.

Space-limited environment of TGP construction and operation stipulate a need to reconsider conventional approaches to provision of TGP safety, because under the above conditions there is not only an increasing risk that the number of affected people will grow, but a probability of accident occurrence due to an unauthorized impact.

Identification on the design stage of operating factors characteristic for specific TGP construction and reconstruction projects, as well as the analysis of operating factors combination in a singular TGP, area allow predicting its operating reliability which, in its turn, gives an opportunity to efficiently manage the risk associated with the linear part of TGP.

Key approaches to predicting operating reliability of TGP linear part are discussed using mathematical approaches to establishing forms of relationship between operating factors; a concept of economically acceptable risk is also used.

As a result a need to take into account the character and combination of operating factors in prediction of activities aimed at the prevention of accidents at the linear part of TGP is determined.

Methodological approach to defining liability limits for environmental insurance at development of gas transportation network of the Eastern Siberia and the Far East

S.A. Yamnikov (Gazprom VNIIGAZ LLC)

Development of a gas-transportation networks (specifically, construction of the main gas pipeline the "Power of Siberia") can produce essential negative impact on the state of environment due its length and direct contact with the environment.

One of the ways to mitigate potential negative consequences of emergencies on the linear part trunk gas pipelines (TGP) is the use of environmental insurance mechanism. At that it is necessary to apply a scientific substantiation of requirements to key parameters of Environmental Risk Insurance Programs, including the insurance premium and the limits of liability which can be defined based on the values of the maximum possible damage (MPD) to the natural environment, which may happen at trunk pipelines in case if the following occurs:

- emergencies with ignition of natural gas. Thermal radiation is the main destructive factor (DF) is, and MPD depends on compensation costs for inflicting damage to the main recipients of the negative impact, i.e. forest resources and soil;

- emergencies without natural gas ignition. Outbreak of large volumes of methane to the atmosphere is the main DF. Correspondingly MPD depends on the payment for emission of methane as a greenhouse gas.

Thus, to define MDP it is necessary first of all to assess greatest effects of emergency DF on the environment, taking into account their random nature. To do it, application of the graphic statistical analysis method can be used, i.e. building of quantile-quantile diagrams. It is advisable to compare the obtained results with the results of the forecast of emergency consequence magnitude obtained using the deterministic calculation methods and methods of mathematical statistics, and if they don't contradict each other, further on it is possible to calculate the payments for possible environmental damage in case of emergency with/without gas ignition and choose the highest ones.

Provision of safety in design of trunk pipeline crossings over motor roads and railways

*S.A. Kovalev, M.A. Kirkin, K.S. Zhelezov
(Gazprom VNIIGAZ LLC)*

Crossings over motor roads and railways are considered to be among the most hazardous sections of the linear part of trunk gas pipelines (hereinafter TGP). Accidents along these sections of TGP may be accompanied by significant socio-economical and reputation damage. For the most hazardous sections of TGP linear part the design documentation must include special safety measures mitigating the accident risk. These measures should comply with the RF regulatory legislative acts. The paper describes the assessment of the efficiency of design solutions aimed at the mitigation of accident risks at TGP crossings over motor roads and railways. The main emphasis in the paper is given to the following measures at the reduction of accident risks at TGP:

- installation of valves at the crossings over motor roads and railways;
- improvement of TGP section at the crossing;
- use of a protective sleeve and laying in a tunnel;
- angles of TGP and road intersection.

Efficiency of design solutions were assessed on the basis of results of quantitative analysis of accident risks. Calculation of accident risk parameters at TGP taking into account the implementation of measures aimed at the mitigation of accident risks allowed making several conclusions which has a practical significance, such as:

- placement of a block valve station practically does not influence the potential risk within the road bed;
- improvement of TGP section at the crossing within the limits of the regulatory junction area reduces the potential risk in the area adjacent to the road bed, but the change of risk on the road bed itself is insignificant;
- increase of the length of the junction area above the norm reduces the risk on the road bed;
- change of the crossing sleeve length within 25–50 m from the embankment insignificantly influences the potential risk on the road bed.

Based on the results of the conducted research recommendations for the improvement of the efficiency of design solutions aimed at the mitigation of accident risks at TGP crossings over motor roads and railways were prepared.

Definition of requirements for procedures and organization of preliminary tests of gas line sections

*Yu.A. Mayants, S.V. Karpov, D.I. Shiryapov
(Gazprom VNIIGAZ LLC)*

Modern pipeline construction must be efficient, high-quality and safe.

One of the factors in attainment of these objectives is conduction of preliminary hydraulic tests. They solve the following problems:

- warranty of quality and safety of preliminarily tested sections;
- safety assurance for performance of the main stage of testing;
- decrease in time and cost of the main stage of testing.

Preliminary tests should be regarded not as the initial stage of gas line testing but as the final stage of construction of the given gas line section.

The paper considers the issues of selection of length of the section to be preliminarily tested and sizes of protected zones.

It is shown that, under certain conditions, preliminary tests can be safe themselves and guarantee safety in the local section during the final stage of testing; as a result, interruption of road traffic and economic activities in certain areas in protected zones of the pipeline under testing can be avoided.

Lower costs and shorter time of the final stage of testing after correctly performed preliminary tests are ensured due to a decrease in expenses for organization of protected zones and safety assurance, and reduction of failure risks.

Review of experience in preventing hydrates formation in gas transmission pipelines-offtake pipes and at gas distribution stations

*V.V. Kapysh (Gazprom transgaz Volgograd LLC),
V.A. Istomin (Gazprom VNIIGAZ LLC)*

The report analyzes the practical experience in preventing the formation of gas hydrates in the gas transmission systems, gained by Gazprom transgaz Volgograd LLC over the past few years. The typical cases are highlighted, which allows to use the experience at other gas transmission companies. It is commonly believed that if the gas humidity meets the requirements of the standard for the transmitted gas, the gas transmission pipeline-offtake pipe will be free of hydrates. In those cases when the hydrates are formed, the main way to remove them is to use methanol. In practice, for the humidity conditioned gas the hydrates will not be formed if there are no «narrow sections» in gas transmission pipelines-offtake pipes and at gas distribution stations (GDS). The report analyzes the possibility of such sections' occurrence. The identification of such sections may not be obvious.

The report highlights the causes of such «narrow sections» occurrence, the specific examples of such sections are provided. They include soil erosion or its settlement above gas transmission pipeline-offtake pipe or on the crane platform, long elevated sections of gas transmission pipeline-offtake pipes and the lack of heat-insulation on them, increased humidity of soil, local narrowing of gas transmission pipeline-offtake pipes, and others. The recommendations on their elimination are provided. The emphasis is made on the methods used to prevent the formation of hydrates, which do not require large expenditures.

The condition for hydrate formation is the presence of water in gas transmission pipeline-offtake pipes. The report discusses in details the causes of water presence and the methods of its detection in gas transmission pipeline-offtake pipes.

The application of proposed measures discussed in the report, in some cases, allowed to avoid the formation of hydrates or significantly reduce the probability of their formation.

Landfalls of offshore gas pipelines: construction technology selection based on geological hazards assessment

S.G. Mironyuk (Gazprom Engineering LLC)

The experience of Peter Gas LLC has shown that the geotechnical conditions of the landfall sections of offshore gas pipelines are very complex (SP 11-114-2004) and require a detailed study of geological hazards.

On the Black Sea coast of Krasnodar region, depending on local geomorphological and geological conditions, both methods – trenchless construction of gas pipelines (Dzhubga – Lazarevskoye – Sochi gas pipeline) and the most economically-efficient way – pipeline trenching (Russia – Turkey gas pipeline) – have been used. The most construction-complicated section is a landfall part of the designed pipeline «South Stream». For this section the construction of microtunnels is designed taking into account the high value of slope ratio (40–70° or more) of low-mountain ridge and the high probability of rock block slides development.

The coastline crossing in the Portovaya Bay (the Baltic Sea, Nord Stream pipeline) is realized using the trenching method. The trenching depth was set taking into account the parameters characterizing exaration and lithodynamic processes. To ensure the stability of the offshore gas pipeline and anticorrosive insulation protection in this Bay, as well as for other projects, the continuous concrete weight coating of pipes has been used.

A similar method of pipeline construction is planned to be used at the crossing of the coastline in Opasova Bay (the project of Shtokmanovskoye gas-condensate field development). The maximum bottom erosion there is 0.4 m, which is equal to the thickness of the sand spit. The main feature of the geological structure of this construction area is widespread distribution of ancient high-strength hard rocks.

In the Baydaratskaya Bay, when constructing Bovanenkovo – Ukhta gas pipeline, the bottom reforming and exaration processes, as well as the presence of permafrost formations in the coastal zone and the tendency of bottom soils to liquefaction under wave action, have been taken into account. In accordance with the design solutions the pipeline-collector of the Kirinskoye gas and condensate field (the Okhotsk Sea) was also trenched and backfilled to protect it against ice exaration, abrasion and storm bottom deformations.

Study of offshore pipeline stability in case of changing frozen soil properties in cryolithic zone of shallow water area of Arctic shelf

*T.I. Lapteva, M.N. Mansurov, L.A. Kopayeva
(Gazprom VNIIGAZ LLC)*

Provision of the required level of offshore pipeline reliability is built in at stages of designing and construction and is implemented at the operation stage. However, pipeline operating conditions may differ considerably from conditions adopted at the designing stage, which is due to impossibility of envisaging all factors completely. Since, in water areas of the Arctic continental shelf, frozen soils are sufficiently widely present in bottom soils at relatively shallow depths, one of such factors is assessment of thermal interaction of pipelines with such soils.

Such thermal impact can change spatial position of a pipeline because of its longitudinal and transversal movements due to progressing thawing of soil in the course of prolonged operation of the pipeline, or to freezing of surrounding soil caused by seasonal changes of temperature condition of the transported product. Additional bending stresses occurring in this process can cause, in turn, modification of the stress-strain state of the pipeline wall with reduction of its operating reliability and service life.

Thus, the sufficient safety level with regard for such random natural effects must be ensured as early as at the designing stage.

The presented paper deals with the problems of ensuring offshore pipelines durability related to thermophysical changes in soil structure during thawing and freezing under effect of various pipeline operating conditions.

Investigation of channel processes for construction of underwater crossings

M.A. Shishuk

(Gubkin Russian State University of Oil and Gas)

Oil and gas pipelines are of different lengths and can cross numerous water barriers. The problem of intersection of crossing water barriers is often solved by construction of underwater crossings.

Reliability of water crossings is provided by being well-informed about the structure of underwater crossings and places of their construction.

In this report we are to make the correct choice for construction of the underwater crossing, so we have to carry out the investigation of river geomorphology.

We introduce a modern and convenient method for a more accurate classification of channel processes. The classification is based on data ROSGEN LEVEL II, taking into account the qualitative and quantitative characteristics of the flow, especially the behaviour of rivers in different climatic conditions, soil types and properties occurring at the bottom of the rivers.

This work presents materials describing each channel process separately and its impact on the reliability of position of underwater crossing section. This allows us to take advantage of the most favourable option choosing a place of the underwater crossing based on data of channel and shore deformations.

The main criterion for site selection section line of the underwater crossing is the stability of a particular channel process relative to project parameters of the underwater crossing and the most favourable conditions for the construction and operation of the pipeline based on the laying method.

This model is considered by the example of the section of the river Pechora, km 842.70 – km 847.45, Komi Republic, Russian Federation. The channel process type has been defined, the reliability of position of underwater crossing section has been assessed and the preferred construction technology has been selected.

Sound insulation of industrial pipelines

*A.L. Terekhov (Gazprom VNIIGAZ LLC),
A.V. Sidorina (K-FLEX LLC)*

In the process connection schemes of gas transportation systems equipment there are areas with high noise emissions. To reduce the value of the sound pressure level to the standard value, it is necessary to perform an acoustic treatment of pipelines and other sound-active elements. The choice of material or design depends on the individual level increase measured for each section.

When using materials for sound insulation it is necessary to study the data on the sound-insulation properties according to the acoustic spectrum, at the same time taking into account the dimensions and shape of the insulated pipe, its shaped elements and assemblies.

The choice of material must also be made taking into account the acoustic and financial feasibility, maintainability, as well as vibration and corrosion resistance properties. The technical parameters of different materials should be proved in the corresponding laboratories.

The use of industrial cotton, mastics, hard foam materials is not always enough to solve the problem and meet the requirements.

Nowadays, there are promising developments on multi-layer elastomeric heat- and sound-insulating coatings capable of solving a wide range of tasks on sound insulation of industrial pipelines and other sound-active elements. In addition to high sound insulating properties, the materials and designs on their base are maintainable and durable, do not cause corrosion, they are resistant to vibrations.

The successful experience of their application was proved by sound insulation of gas-distribution point 16 of Mostransgas. The results of the tests on vibration and noise reduction allow to draw a conclusion on great perspectives of application of heat- and sound-insulating elastomeric constructions at Gazprom facilities.

SESSION B

**DESIGN, CONSTRUCTION AND OPERATION
OF COMPRESSOR STATIONS**

28–29 October 2015

Gas-compressor equipment of Gazprom PJSC: current state and development prospects

*V.A. Seredenok, V.V. Sedov (Gazprom PJSC),
S.Yu. Salnikov, A.V. Semushkin, V.A. Shchurovsky
(Gazprom VNIIGAZ LLC)*

Gazprom PJSC is currently operating more than 4,530 gas pumping units (GPU) with total capacity of 52.32 million kW. A gas-turbine engine is the main part in the structure of the gas pumping units' fleet.

This technical fleet of GPU has been formed for almost fifty years and is now characterized by a wide variety of equipment concerning its size and age.

To provide complex and systematic solution to this problem, a scientific and technical policy of Gazprom Company in the field of gas-pumping equipment was developed in 2009. It determines the direction, priorities, goals, objectives and forms of activities aimed at solving the task to meet the needs of Gazprom PJSC in advanced and high-performance gas-pumping equipment for the period up to 2020.

The research center of the gas industry Gazprom VNIIGAZ LLC has developed a regulatory system that provides the uniformity of customer requirements, the methodology of equipment selection and quality control at all stages of the equipment life cycle.

The current directions of GPU development: technical level compliance with the best international practices, standardization of the design for customer needs, import substitution.

The increase in the production capacity of new trunk gas pipelines (TGP) by increasing the operating pressure provides the possibility of equipping linear compressor stations (LCS) with gas pumping equipment with single-unit power capacity of 32(35) MW.

For new construction and reconstruction of compressor rooms (CR) of underground gas storage facilities (UGSF) with out-of-date and worn-out piston gas-driven internal combustion compressors, GPU with single-unit power capacity of 4, 10 and 16 MW have been designed.

The process needs of a booster complex are provided in a wide range of power capacities, pressures and compression rates by optimization of replaceable flow parts and unification with GPU for TGP and UGSF.

Compressor equipment of NPO Iskra. Advanced developments

*V.B. Shatrov, M.I. Sokolovsky, S.I. Burdyugov, Yu.P. Eryshkin,
E.L. Selyanskaya, S.V. Kasyanov (NPO Iskra)*

NPO Iskra has manufactured and delivered more than 200 units of compressor equipment to gas transportation enterprises, booster complex enterprises, underground gas storage facilities and gas and oil processing enterprises.

According to the results of commissioning of more than 150 compressors and replaceable flow parts, a system for analyzing the potential risks of problematic situations occurring during equipment commissioning and operation has been developed, in order to eliminate these risks at the design stage.

Based on the experience of compressors optimization and research works, the enterprise continuously conducts new developments to ensure advanced efficiency, quality and reliability of its products.

All newly-developed equipment involves the application of advanced science-intensive technologies, allowing to reduce production costs, costs of equipment maintenance, and increase the efficiency of gas transportation.

The new standard series of compressors in single- and two-section design configuration have been recently developed. The first batches of compressors have been tested at the acceptance test benches and delivered to the customer.

The performance characteristics of the equipment correspond to the current technical level and are highly competitive with the equipment produced abroad concerning their operating parameters.

For linear compressors the polytropic operational efficiency is increased by 2-3 % as compared with their analogues, previously produced by NPO Iskra, while the cost-effective operation zone is increased by 10–30 %. At the same time, the dynamic stability of the rotor is provided. The measures to protect the cartridges of dry gas-dynamic seals from lubricating oil vapors from bearings and gas coming from the flowing part have been taken.

Since 2001, NPO Iskra has been delivering centrifugal compressors and replaceable flow parts of six different types to the customer's facilities, participating in supplying equipment program aimed at import substitution.

Capabilities of Kazancompressormash JSC, HMS group for compressor equipment delivery

Ye.A. Novikov, A.P. Kharitonov

(NII turbokompressor named after V.B. Shnepp CJSC, HMS Group)

Kazancompressormash JSC and NII turbokompressor named after V.B. Shnepp CJSC form the joint research and manufacturing complex with centralized management at the level of the machine-building complex HMS Group. NTK CJSC has developed more than 420 different types of compressors. About 4700 centrifugal and more than 16800 rotary and screw compressor units have been produced in accordance with documentation of NTK CJSC at six production plants of Russia and neighboring countries. According to customer requirements Kazancompressormash JSC delivers a separate compressor (pressure blower) and a complex unit or plant with their installation and commissioning at the customer premises. Features and advantages of KCM JSC solutions:

- gas pumping units are manufactured in block containers and easily built modular constructions with modular package of all systems;
- the pressure blower design allows to install robust parts for the entire range of engine power capacities and obtain high polytropic operational efficiencies for the required final pressure 56; 76; 85; 100 kgf/cm² and the pressure ratio of 1.36; 1.44; 1.5; 1.7; 2.0; 2.2; 3.0;
- the use of spatial vanes of operating wheels and a vaneless diffuser allows to obtain polytropic operational efficiency at the operating point up to 85 % and a wide range for efficient operation of the blower;
- each unit goes through the control assembly at the factory of the general contractor, which provides minimal costs when installing the unit at the premises;
- the use of oil or "dry" gas-dynamic seals – according to the technical requirements of the customer – in the blowers;
- the use of fluid dynamic oil bearings or electromagnetic bearings, which don't require the installation of oil systems – according to the technical requirements of the customer – in the blowers;
- KCM JSC is the traditional manufacturer of a wide range of compressor equipment for gas transportation and gas injection to the reservoir and underground storage facilities.

Delivery of gas-turbine units for energy supply of gas transportation network facilities

E.V. Guzaev, A.N. Morozov (UEC – GAS TURBINES JSC)

UEC – Gas Turbines JSC is the parent company of UEC for production of energy and gas pumping complexes.

The status of the parent company of the whole Corporation sets serious responsibility to the quality control procedures, that motivated the Company for the development of its own testing facilities on the Company's premises. Production monitoring tests allow to ensure quality control and adjustment of both commercially manufactured units and new developments in order to identify their limitations before delivering them to the Customer.

UEC – GT JSC offers to its customers a wide range of power units with different power characteristics, which are designed using gas-turbine drives, produced by enterprises, being members of UEC, as well as by foreign manufacturers, depending on Customer's requirements. All units within the production series can be supplied in both shop-floor and block-container designs, according to the Customer's requirements. All products are compact, manufactured within the short period of time and easily installed.

The power supply units with a gas-turbine drive are presented in the following power range: from 2.5 to 25 MW.

Gas-piston power units are presented in following power range: from 0.8 to 4.0 MW.

UEC JSC provides a full range of engineering services, from design and manufacturing to putting into operation, and maintenance of power supply units.

RusTurboMash – localised compressor solutions for oil and gas

D. Korobko (Siemens LLC)

During St. Petersburg International Economic Forum in June 2015 a new production premises of RusTurboMash LLC (100 % subsidiary of Siemens AG) was opened in St-Petersburg region. RusTurboMash is nowadays a recognizable brand of a modern high quality Siemens technology compressor production in Russia.

Which advantages does it give to O&G customers in Russia?

First of all, it proves commitment of Siemens to localize high quality compressor solutions from the world market leader in Russia. A clear focus on efficiency of compressors helps customers to achieve lifecycle cost reduction. Last, but not least, the design of RusTurboMash compressors helps to minimize installation and commissioning works.

At the new production premises RusTurboMash continues localized manufacturing of centrifugal compressor equipment for natural gas transportation and other O&G applications.

Experience of UEC – gas turbines JSC (UEC-GT JSC) in designing and manufacturing GPU within a short time period

E.V. Guzaev, A.V. Yablokov (UEC – GAS TURBINES JSC)

Within the frameworks of cooperation of UEC-GT JSC and Gazprom PJSC the gas-turbine and gas pumping units with power capacity of 4–6.3–8–10–16–25 MW are designed and supplied. An important advantage of using GPU produced by UEC-GT JSC is that the minimum number of imported components are used in the construction of GPU, which increases the GPU competitiveness in relation to its foreign analogues. The units are designed and manufactured using advanced technologies and meet all customer's requirements.

The process of designing such units required implementation of advanced and innovative solutions - a fire video surveillance system, a fuel supplying system with direct-acting gas metering unit, the use of gas-oil heat exchanger, a two-stage noise silencer, engine blowing air filtration, increased thickness of noise-suppression panels, two-stage cycle air treatment system with the prospect of the transition to a single-stage treatment process, the maximum autonomous-supply level for GPU systems (barrier air for a centrifugal compressor, heating of GPU facilities against exhaust gas disposition, etc.).

Classification and unification of technical solutions, 3D modeling of units' parts and systems, virtual assembly of systems and the entire unit (for design errors detection), paralleling of design and production processes allowed to minimize significantly the time periods of products manufacturing and delivery to the Customer.

The design and estimation results are verified during prototyping/control assembly of the unit. The production capacities of UEC-GT JSC allow to perform prototyping assembly of the unit to the maximum possible extent, which is very close to the assembly process of the complete unit at operational facilities.

Since 2015, UEC-GT JSC has another tool that allows to check the quality of manufacture and assembly of GPU – complex tests of GPU on a standardized test bench, that was put into operation in the 2nd half of 2015 and is located on the territory of UEC-GT JSC in close vicinity to the assembly facilities.

New business of Siemens company – new extended line of solutions for oil and gas industry

S.A. Leontiev (Siemens LLC)

This year the processes of merger and take over of two world leaders in compressor and gas turbine engine construction, the Dresser Rand Company and Rolls Royce Aviation-derived gas turbines (ADGT) Company by Siemens Corporation have been completed. As a result, within the structure of Siemens Corporation a new global structural division, named Dresser Rand a Siemens business, has been formed.

What benefits will the customers and end users of this new division receive? What product line will be presented at the oil and gas markets? What is its synergetic effect?

First of all, Siemens is expanding its presence at various markets of oil and gas industry worldwide. Thus, at the market of compressors used in the gas transportation system it is achieved with DATUM Series compressors, having the world's highest operational performance indicators. The power range of drives is expanding by using a 60-MegaWatt Trent 60. The range of solutions for the production sector was expanded with a piston-type compressor Dresser Rand.

An important advantage is the broader representation of the new business worldwide and in Russia in terms of production sites and service centers. This allows to provide support to customers and end users to the greater extent than ever before.

The report also contains information about some specific solutions provided by the new expanded product line.

New-generation gas-compressor unit for associated petroleum gas booster compressor stations with intermediate low-temperature separation cycle

O.E. Vasin (NOVATEK OJSC)

The paper considers problems of application of gas-compressor unit (GCU) with two-stage centrifugal compressors (CFC) with intermediate cooling cycles; in particular, analysis of existing GCU kinematic diagrams was performed from the standpoint of efficiency, reliability and repairability.

On the basis of the above-mentioned review, a new-generation GCU for associated petroleum gas (APG) booster compressor stations (BCS) with an intermediate low-temperature separation cycle developed by NOVATEK OJSC is proposed for use. The principal distinction of said GCU is that it includes a two-shaft gearbox providing transmission of the torque from the driving gas-turbine engine to two, positioned in parallel, centrifugal compressors of the first (associated petroleum gas) and the second (dry stripped gas) stages operating at different nominal rotational speeds.

GCU of the above-described configuration can be used with a high efficiency not only in APG BCSs but also in oilfield BCSs and in BCSs of underground gas storage facilities. Further, the use of multi-shaft gearboxes in CFC configuration will make it possible to materialize the idea of «hybride» GCU where an inverter-type motor-generator with free revolutions is mounted in addition to CFC stages I and II.

Implementation of the project: «Improving imported stationary GTU with introduction of advanced domestic developments»

*A.O. Prokopets (Gazprom transgaz Yugorsk LLC),
O.V. Komarov (Ural Federal University)*

At compressor stations of trunk gas pipelines foreign twin-shaft gas-turbine units of GTK-25I(R) type of simple and regenerative cycles are widely used as a natural gas centrifugal blower drive. An outstanding feature of the unit of this type is the presence of a rotary nozzle diaphragm of a power turbine and an adjustable inlet guide vane of an axial-flow compressor, which provides the opportunity to realize an optimal program on the unit control.

At the production site of Gazprom transgaz Yugorsk LLC in accordance with a complex project on improving the gas turbine unit of the mentioned type, the developments of domestic companies aimed at improving environmental and economic performance characteristics of GTU have been tested in industrial operation:

- a combustion chamber of fuel pre-mixing type, has been introduced in the unit construction. That allowed to obtain unique environmental performance parameters (NO_x emission below 30 mg/m^3), which corresponds to current international standards (developer – NPF Thermophysics LLC, Ufa);
- to implement the optimal control program for the unit and to ensure the most favorable modes of operation of a combustion chamber, a frequency stabilization unit has been installed, allowing to have a variable rotation rate of the turbo-compressor during operation (developer – Robiteks CJSC, Yekaterinburg);
- the choice of an optimal control program for the unit has been verified. The corresponding control algorithm has been proposed, implemented and tested. Based on the results of comparative tests, the increase in fuel efficiency of GTU by 4.5–10 %, depending on environmental conditions and GTU load mode, has been demonstrated (developers – Ural Federal University, Yekaterinburg; Vega-GAZ LLC, Moscow).

Gazdynamic designing of centrifugal compressors for gas industry: specifics and special features

*Yu.B. Galerkin, A.F. Rekstin, K.V. Soldatova, A.A. Drozdov
(Scientific Research Laboratory «Gas dynamics of turbo-machines»
of the Joint Institute of Science and Technology SPbSPU)*

The dimensionless number of rotations of compressors of linear gas pumping units is determined by their flow rate, the set value of inlet and outlet gas pressure and the drive rotation rate. The number of compressor stages set by the designer has influence on two main design parameters – the calculated conditional flow coefficient and theoretical head coefficient. At the optimum flow coefficient the minimum sum of all types of head losses is achieved. For compressors of gas pumping units the small coefficients of the theoretical head are recommended. In this case it is possible to obtain maximum efficiency, the best surge margin and minimum power consumption at the design point. The recommendations are illustrated with well-known formulas and empirical equations proposed by the authors. The practical application areas of impellers with cylindrical and spatial vanes, vaneless and vanned diffusers are rationalized. The brief information about the design system used by the authors and the results of work in the interests of industry is given.

Radial and axial-radial impellers of centrifugal compressors – advantages, disadvantages, scope of application

*Yu.B. Galerkin, A.F. Rekstin, K.V. Soldatova, A.A. Drozdov
(Scientific Research Laboratory «Gas dynamics of turbo-machines»
of the Joint Institute of Science and Technology SPbSPU)*

The simplified equations for calculating the inlet size and the rate level for the impellers with spatial blades located in the axial and radial sections of the impeller (ARI) and with non-spatial blades located in the radial part (RI) are presented. The considerations on the loss factors for ARI and RI at different design flow coefficients are presented. The tendency of decrease in potential advantages of ARI at mid and small values of design header pressure coefficients is shown. The data on high-performance compressors and stages, designed with the use of non-spatial impellers with mid-values of flow coefficients, is presented for authors' projects. The achieved level of operational efficiency of 88–90 % makes it doubtful to further increase the operational efficiency through the use of ARI. The design CFD – the analysis of options for the intermediate specific speed stage with ARI and RI has revealed the specific problem of axial-radial impellers (ARI). The design advantage of RI is the ability to use the smaller hub-tip ratio, which allowed to get higher operational efficiency for the option of the stage on the base of RI. However, it is necessary to bear in mind the positive trend of increasing specific speed of drive gas turbines, requiring the use of stages with high flow coefficients with ARI, which allows to work in the direction of improving the mass and dimensions parameters and operational efficiency.

Problems and prospects in developing the booster complex of Komsomolskoye and Zapadno-Tarkosalinskoye gas fields

A.V. Semushkin, S.S. Mikheev (Gazprom VNIIGAZ LLC)

Komsomolskoye and Zapadno-Tarkosalinskoye fields are currently being developed at the stage of declining production, approaching the final stage of their operation, which is characterized by low wellhead pressure in wells, the accumulation of fluid at the bottom of the well, the accumulation of reservoir fluid in the pipelines of the gas-collecting system, operation of gas treatment and compression equipment in inefficient modes with low load.

Nowadays, there is a significant deviation of development indicators of Komsomolskoye and Zapadno-Tarkosalinskoye gas fields from the values approved in project documents. Taking into account the actual rate of wellhead pressure decline and existing equipment, the booster complex will not be able to provide the design development parameters of the fields under consideration starting from 2017.

To solve such problems of fields development at the final stage of operation, the compressed gas distribution technology (the use of mobile compressor units (MCU) in the collection system for reservoir products) is being implemented at Vyangapurovskoye field as the pilot project.

To evaluate the development of the booster complex of Komsomolskoye and Zapadno-Tarkosalinskoye fields in the same way, the technical-economic (feasibility) analysis of various applications of MCU in the conditions of the limiting (in terms of wells' capacities) production capacities has been carried out.

The feasibility analysis has shown that the development of the booster complex using the technology of distributed compression is cost-effective in the terms of economic indicators.

The options recommended for implementation include commissioning of 21 units of MCU at Komsomolskoye field and 9 units of MCU at Zapadno-Tarkosalinskoye field in 2018.

Assessment of efficiency of low pressure and high-performance flow parts use in centrifugal compressors of GPA-C-16 units

*A.V. Krupnikov, A.D. Vanyashov, E.M. Vasenko
(Sibneftetransproekt JSC)*

In the long-term practice of operation on many sites of the gas transport system (GTS), the so-called low pressure operating modes of gas transportation in which the pressure ratio upon compressor stations is within 1.3–1.4 are used and planned in prospect. Commonly used flow parts of centrifugal compressors with pressure ratio of 1.44 are operated with increased consumption of energy resources (work in the right-hand part of the dynamic gas characteristic with the increased flow rate and low polytropic efficiency).

In the study, efficiency assessment for replacement of flow part in the cases of centrifugal compressors with low pressure and high-performance units with pressure ratio of 1.35 in the design point (SPCh-16/76-1.35) in the example of GPA-C-16, equipped with basic centrifugal compressors like NTs-16/76-1.44 driven by a gas turbine engine NK-16ST and NK-16-18ST is performed. Ratio of fuel gas consumption to compressor shop performance was used as efficiency criterion for the use of replaceable flow parts of various types. Calculations were carried out with 3 approaches:

1. Simplified estimated calculation for the fixed compressor shop performance of 99 to 126 million m³/day with other conditions at the inlet and outlet equal, as well as the number of operating GPU, showed effect from application of SPCh-16/76-1.35 compared with the basic value of 1.5–5.7 %;

2. Specified calculation for gas transport system site model with distribution of load between compressor shops within compressor stations and between compressor stations in an annual cycle of operation with quarterly sampling for the characteristic daily modes, annual indicators of fuel gas economy are obtained in the amount of 3.3 to 4.6 % for various compressor stations;

3. On the basis of operation analysis for a compressor station where a part of compressor shop is equipped with SPCh-16/76-1.35, the economy comprised 1.1–5.0 %.

Thus, on the basis of the results obtained, the expected maximum annual economy of fuel gas can reach 5 %.

The assessment of the technological hazards related to the failure to prove the declared level of polytropic efficiency of 86 % (decrease by 1–2 % because of big speeds in branch pipes of centrifugal compressors is probable), and the nominal number of turns of a rotor of 5,300 rpm (probable decrease by 5–6 %) is performed. In the both cases, the economy of fuel gas decreases by 0.9–1.1 %.

Improvement of operational efficiency of gas cooling units of the boosting compressor station while decreasing compression volumes

*I.A. Yanvarev (Omsk State Technical University),
A.V. Krupnikov, A.D. Vanyashov (Sibneftetransproyekt JSC)*

The decrease of reservoir pressure and gas production volumes on the fields causes the use of replaceable flow parts of gas compressors that ensure, taking into account the optimal consumption of energy resources, at the boosting compressor station (BCS) the increase of the total pressure ratio in order to maintain the required gas transportation parameters and the design production capacity of the field.

In these conditions the improvement of operational efficiency of gas air cooling units of BCS requires to take into account the whole complex of varying parameters and their appropriate control.

On the one hand, it determines the new configuration of air-cooling units (ACU), which already exist at BCS, for example when switching its operation mode to two or more compression stages.

On the other hand, in the conditions of gradual reduction of gas production rate during long-term operation of the field, it is necessary to determine the optimal number of ACU engaged in the cooling process, the total number of operated fans or the loading coefficient for all fans in frequency-control mode.

The object of research is generally a process area (PA) which includes two or more compression stages (compressor sections of BCS), with gas air cooling units (GACU), a gas treatment unit, a linear section and the next compressor station (CS) installed after each of them.

Gas-cooling recommended temperatures in ACU and other optimization parameters have been determined in accordance with the developed procedure at the stage of energy optimization for a given part of the process area.

The analysis, that has been conducted, shows that gradual decrease in the number of ACU, being a part of GACU and participating in the cooling process, after each compression stage allows to reduce the required number of fans being operated (the loading coefficient of all fans) while reducing the compression volume, which results in reduction of energy resource consumption by about 20–25 %.

The usage of low power motors in air cooled condenser

V.A. Lifanov (SIC «OilGazMash» LLC)

On the basis of full-scale and bench tests of gas air cooler unit carried out by Hidroaerotsentr CJSC, including AVG-85MG units of SIC «OilGazMash» LLC, as well as empirical analysis, a low power electric motor can be used in air cooled condenser (ACC).

It is most preferable to use high speed motors with the unit to lower shaft speed of blower wheel up to standardized end blade speed.

In order to achieve this effect SIC «OilGazMash» LLC used rack-and-gear mechanism, that combines positive qualities of both gear and belt transmissions.

Considering the obligatory fulfillment of thermal power control in ACC, a motor with variable spin frequency was used. An electronically commutated motor is an electro mechanic system consisting of an electric machine, a solid-state switch of phase windings, control systems and a rotor position sensor, constructively united in one frame. The electronically commutated motor possesses the main advantages of asynchronous motors and at the same time lacks their disadvantages.

The usage of low power electric motors enables not just to lower the overall size of the low-voltage switchgear and controlgear, but also to dispose ACC control system in one frame on the unit's metal framework. The control of gas ACC blowers can be carried out from the modular local control system in auto or remote control mode designed by Gaskholodteknika LLC.

Suggested construction solutions in ACC enable to:

- lower the amount of power cables for ACC;
- lower the amount of low-voltage switchgear and controlgear;
- exclude control cabinet;
- lower the capacity of condenser unit;
- set a step down transformer.

Detailed modeling of «crude» gas cooling process in ACU of BCS

M.V. Smolyaninov, S.A. Zakharov (Gidroaerotsentr CJSC)

A considerable part of Russian gas fields is located in geographic areas with low air temperatures. Moreover, the gas from these fields has a complex composition and comprises water. As the reservoir pressure drops, the need for a booster compressor station (BCS) arises. When compressed, the gas is heated and it must be cooled in the gas air-cooling unit (ACU).

During gas cooling in ACU one of the most critical problems is the possibility of gas overcooling during cold weather periods, which can result in the formation of hydrates and blocking of ACU pipelines. To avoid this problem, at the design stage of ACU it is necessary to conduct detailed modeling of the cooling gas processes throughout the whole ACU pipelines' volume, as the gas temperature varies significantly along the rows of the tube bank and the length of pipelines. In such case the determining factor of hydrates formation in ACU is the temperature of the inner pipe wall, where the gas flows.

Within the frameworks of the presented work on the basis of bench and field tests the modeling program for gas cooling processes in ACU has been developed with the possibility to determine the detailed temperature pattern in ACU tube bank. On the basis of the program the air recirculation system in the gas ACU, which is now tested at Gazprom dobycha Noyabrsk LLC, has been developed.

New tendencies in development of air coolers of gas

A.M. Danilyuk (Genborg JSC)

In the existing air coolers of gas (AVO) asynchronous electric motors of a traditional design are used as the drive of fans. These motors have been known throughout a long time, they have a short-circuited rotor, in vertical execution, with power from 6,5 to 90 kW, and with a frequency of rotation from 250 to 500 rpm. The drive does not have a reducer and is made as a straight line (the wheel of the fan is established on the electric motor shaft), with supply from an industrial three-phase network of 380 or 660 V. In some cases it is completed with a frequency converter for the adjustment of turns. Installation of the fan directly on the shaft of the electric motor permits to expel the reducer from the structure of the drive, but at the same time low turns aren't optimal for an electrical machine regarding material capacity and energy efficiency.

Design and exploration work on creation of the electric drive for AVO is conducted based on:

- the electric motor with a different design of magnetic system and windings (PMSM – Permanent Magnet Synchronous Motor, SRD – Switched Reluctance Drive);
- the system of control and protection.

Having the same power, the specified electric motors possess smaller mass-dimensional sizes (from two to three and more times smaller), a lowered energy consumption (up to 30 %), increased values of efficiency, power factor and the electromagnetic moment.

The control system provides smooth start and the possibility of regulating frequency of rotation in a wide range, for the purpose of optimization of work of AVO (as a part of AVO group).

Design features of the specified electric motors provide the opportunity to reduce mass-dimensional sizes of AVO, due to simplification of mutual configuration of knots “electric motor-fan”.

Direct cooperation of the enterprises (on production of electric motors and on production of AVO) entering in one group of companies will allow us to create a new generation AVO in short terms.

The project needs technical support from structures of Gazprom PJSC regarding preparation and coordination of technical parameters of the new generation AVO.

Using potential energy of natural gas pressure to produce electricity in Siemens gas expansion turbines

A.I. Zhukov (Siemens LLC)

The global economy dictates new rules, and many companies are looking for opportunities and technologies that will reduce internal costs per unit of production. If have a look at any business, it is almost always possible to find one or another way to improve its own efficiency. If a company has steam, rather than simply reducing the pressure in the pressure reduction units, it is better to produce mechanical energy to drive the pumps and other equipment, or to produce electrical energy which will cover a part of own needs, which ultimately means a reduction in specific fuel consumption and improvement of energy efficiency. In addition to steam turbines, Gas expansion turbines exist to work with natural gas. Gas is transported via main gas pipelines under high pressure. In gas distribution stations the pressure is reduced in order to meet the requirements of end-users of gas supply system. Most often it is done by throttling without usage of gas overpressure energy. This energy can be used to generate electricity using gas expansion turbines. Application of gas expansion turbines by Siemens is a real way to improve energy efficiency by using existing resources.

Modern state and development directions of internal pipeline diagnostic means for compressor stations' pipelines of Gazprom PJSC

*V.N. Voronin, I.L. Vyalykh, V.L. Lazarev, A.A. Kaverin,
I.V. Nedopad, D.A. Zotov, A.V. Lipovik (Gazprom VNIIGAZ LLC),
O.V. Burutin (Gazprom PJSC)*

Internal-pipeline diagnostics (IPD) using diagnostic complexes is a part of a complex of diagnostic and computational works on the assessment of the technical condition and the safe operation lifetime of industrial pipelines of compressor stations (IP of CS). Proper performance directly depends on the real capabilities of IPD means, tracking and information processing systems.

The capabilities of modern IPD means for IP of CS are determined by means of standardized test procedures, including the experimental evaluation of technical, flaw-detection and operational parameters of diagnostic complexes for their compliance with the applicable requirements of Gazprom PJSC.

The report considers the methodical, organizational and technical features of IPD means testing. The developed unified structure of test phases is presented, which allows one to check the compliance of actually achieved performance parameters of IPD means with technical specifications of the equipment, the content, completeness and correctness of operational documentation, the ability to operate in real conditions, taking into account technological features of monitored objects.

The real technical capabilities of modern IPD means, used in pipelines of CS of Gazprom PJSC, are presented. The main results obtained during testing IPD means for IP of CS of leading developers are presented.

The analysis of test results has been performed, and the main directions of development and improvement of the IPD means for IP of CS performance capabilities have been determined.

The engineering method for estimation of reliability parameters of compressor stations' industrial pipelines

*S.V. Nefedov, M.U. Panov, V.M. Silkin, V.P. Stolov
(Gazprom VNIIGAZ LLC)*

Nowadays, Gazprom PJSC develops the Control system of technical condition and integrity of site facilities of the gas transmission system (CSTCI of SF of GTS). The main objective of CSTCI of SF of GTS is to ensure the required reliability and safety parameters for SF operation on the basis of objective address planning of control actions and the optimal allocation of financial expenses. Planning of long-term maintenance, technical diagnostics and repair programs for SF within CSTCI is based on quantitative evaluation of technical condition, reliability and technology-related operational risks' indicators. Basic estimation facilities of the maintenance, technical diagnostics and repair program for SF are a compressor shop and industrial pipelines.

The report describes the main provisions of the method for estimation and forecasting of reliability parameters of compressor stations' industrial pipelines. The method was developed with the account for incompleteness of the initial data on pipelines' defects and with the minimum amount of such data to evaluate the current and required forecast range of indicators of reliability for sections of industrial pipelines of compressor stations. The developed algorithm is the common one for the defects of different types. Specific features associated with the defect type are taken into account only when calculating the value of the damage parameter, thus simplifying the application of the developed method in practice.

Experience in application of general electric industrial video endoscopes and analysis of gas-air flow duct condition of compressor stations gas turbine engines

A.V. Yelishhev (GE Rus LLC)

Technical endoscopes are mandatory tools of production divisions of compressor stations, working with GPU operation and repair. GTE manufacturers issue according technical documentation wherein the elements of GTE flowing part that are subject to regular inspection are specified, as well as criteria for making a decision on clearance for operation, frequency of planned inspections and timelines of inspections for GTE life span expansion.

Traditional technical endoscopes have particular flaws and limits, among which are poor quality of images, large dimensions and limited capabilities of application in industrial environment, lack of autonomous power supply, minimal capabilities of registration and analysis of obtained data.

For minimization of these and other flaws, General Electric (GE) offers the newest video endoscopes that enable to not just obtain best quality images of flow part, but to also perform direct measurement of an identified defect, including linear dimensions and depth of defect. Apart from that, these devices enable saving photo and video materials in the internal memory and external media, transmit streaming video via the Internet from a video endoscope to any remote expert, and also to swiftly create a report on conducted inspection, using a unified template made on the basis of instruction of a particular GTE inspection.

One of Gazprom PJSC subsidiary enterprises that regularly uses GE video endoscopes for GPU fleet's flow part inspection is Gazprom transgaz Belarus OJSC. For example, use of GE XLVU video endoscope enabled specialists of one of the TPGD to timely and authentically identify a crack of inner casing of combustion chamber, assess its dimensions and after consulting with manufacturer, to approve possibility of defected unit replacement without sending GTE to manufacturer, which in turn allowed to save significant amount of funds.

Experience of testing multi-stage centrifugal pumps for booster compressor stations of Gazprom PJSC

V.K. Yun, A.S. Reyder (REP Holding JSC)

In the course of testing of compressed gas centrifugal compressors with a multi-stage uncooled liquid end there deviations of gas-dynamic characteristics obtained on a stand at an industrial facility from the ones obtained at an operating location with working gas pressures. It is known that in testing of liquid ends of centrifugal compressors similarity criteria are the most important. Their observance, to a certain degree of approximation, may influence the final result of gas-dynamic and kinematic characteristics obtained during testing and by conversion, such as head h , flow rate Q , polytropic efficiency η_{pol} and equivalent frequency of rotor rotation n_{equiv} . If in the nominal (design) mode which corresponds to the optimum polytropic efficiency factor for multi-stage liquid ends (more than 3 compression stages) procedure of characteristics conversion under similar modes is fair and does not generated large deviations from the parameters obtained under real conditions, under the modes not corresponding to the optimum ones discrepancies with the experimental data are observed.

Based on the experience of singular simulation stages and full-scale multi-stage liquid end parts composed of geometrically similar stages there are always deviations from the dynamic criteria of similarities. Consideration of similarity criteria influence on gas dynamic characteristics of liquid end parts is presented in conventional standards, however there are no explanations how accurately they represent the actual picture of gas flow in the modes of maximum throughput capacity and under pressuring conditions. It has been proven that in these modes a rotating stall prevails either in the channels of impellers or in the channels of stator elements. In this case pulsations of pressures and speed nonuniformities reach high values comparable with their average values. Hence, a kinematic similarity of velocity triangles and of flow rate and head factors, respectively, is violate in these modes. Based on the experimental data a conclusion can be made that it is necessary to introduce a so-called «derivation factor" in the transformation formulas.

Features of gas compressors tests of the GCUS in factory and field conditions

*A.E. Lapitsky, L.I. Kozachenko, A.A. Korolev, A.V. Zdorov
(SU «Lenorgenergogaz», Orgenergogaz JSC),
E.A. Terentev (Gazprom transgaz Ukhta LLC)*

Some reasons resulting in difference of bench characteristics of centrifugal compressors from the characteristics received in field environment are considered. The reasons of nonmodelability of some processes taking place in the compressor on bench tests are explained.

The subject of bench tests raises the questions of the organization of model tests – the choice of model gas, equivalent rotary speed and initial pressure.

The subject of centrifugal compressors tests in the conditions of compressor stations touches on issues not only related to the tests themselves, but also to the circumstances preceding the tests – ensuring start-up and setting-up of surge protection system. Mostly, these problems are related to compressors with magnetic bearings. The main problem of field tests is the definition of flow through centrifugal compressor. The confusor used as the standard flow-measuring device – Venturi's tube, demands to be produced with compliance with the constructional conditions recommended for Venturi's tubes, specifically the angle of the confusor and the arrangement of takeoff «minus» pressure drop. The second most important problem of field test is the accuracy of temperature measurement at the suction or discharge side of compressor. That is caused by influence of heat exchange from compressor case through the tubes to sleeves of temperature sensors.

Within the frame of mutual cooperation of producers and consumers of the compressor equipment (Gazprom PJSC) it would be extremely useful to conduct bench tests on another compressor speed – 0.8–0.9 of the nominal one. The existing methods of conversion of characteristics on different rotary speeds are valid for one-stage compressors. The expansion of these methodologies on a multi-stage compressor does not contribute to an understanding of the complexity of the multi-stage compression process.

Arising problems with rotors axial shifting, which are particularly significant in compressors with magnetic bearings, require pressure monitoring after balance pistons cavity by means of automatic control system.

About the unification of parametric diagnostics methods and estimation of technical condition factors of gas pumping units

*A.V. Semushkin, A.O. Podlozny, E.A. Chernikova,
V.A. Tshurovskiy (Gazprom VNIIGAZ LLC)*

The compressor stock of Gazprom PJSC has a great variety gas pumping units (GPU) by types, dimensions, suppliers and age (there are 65 types of actuators, about 100 types of compressors and more than 200 combinations of them). Automated control systems (ACS) of GPU, ACS of compressor shops (CS) and diagnostic systems also have a great variety of types, age generations and technical level.

The evaluation criteria of the GPU technical state in the terms of power and energy efficiency are the technical condition indicators (TCI) of an actuator and a gas compressor.

Nowadays, the TCIs are used for: designing compressor stations (by standards), monitoring operational parameters, gas transmission system (GTS) dispatching, regulation of energy resources, during all types of control tests (acceptance-delivery, acceptance, and operational tests), in order to meet the requirements of the software for the technical condition and integrity control system.

The criteria and indicators of technical condition often become of a commercial nature, which stimulates the need of their uniform understanding and application to all participants of mentioned processes, which is based on the following methodological principles:

- unified TCI nomenclature and uniform methods for determining such indicators;
- technical condition assessment is performed by comparing the actual and reference characteristics of GPU;
- the use of the results of previous long-term studies and developed normative and technical documentation;
- the preferred use of the standard measured parameters;
- development and creation of a data bank for reference thermal-technical and gas-dynamic characteristics of GTU and centrifugal compressors, which will be unique for the certain type of GTU (centrifugal compressor);
- the use of individual limiting (setting) parameters of GTU;
- the ability to assess the technical condition of GPU without changing operational modes (as well as the results of operational tests).

Composite automatic control systems for electrically driven gas-pumping units

A.S. Khlynin, O.V. Kryukov (Giprogazcentr JS)

In designing of process systems for compressor stations, selection of nominal power of gas-pumping units is based on the forecast of transported gas volumes. Actual volumes may differ from predicted ones significantly, and may vary widely during a year.

In practice, the majority of electrically driven gas-pumping units (EGPU) function under conditions where the load moment, speed and main process parameters do not remain constant as is adopted simplistically in the simplest local drives, but vary in time considerably. This is due both to technological factors and to other external impacts of random character.

For the most energy-efficient and reliable control of operation of electrically driven GPU, it is proposed to use frequency converters in combination with composite automatic control systems (ACS) that regulate rotational speed. At the first stage, the system sets the initial value of rotational speed of the EGPU motor, and then, using feedback from the output pressure sensor, corrects the speed to the optimum value.

The initial speed value set by the system is calculated from regression equations derived on the basis of statistical information about EGPU operating modes and variation of all external and internal effective factors.

The final value of EGPU rotational speed is determined by ACS from output process parameters using an algorithm that calculates optimum distribution of each unit load in case of several EGPU working for the same gas pipeline.

Gas condensation systems and units

Yu. Grishin (INTRA PROJECT LLC)

Preparation of associated petroleum (APG) and natural gas (NG) for transmission by main trunk pipelines and for its use as a fuel for power units is usually performed directly at production fields. It includes APG and NG fractionation. The most efficient method of APG and NG fractionation to date is application of low-temperature gas condensation (LGC) with use of refrigeration systems and consequent low-temperature condensate separation (LCS).

The report highlights the following issues:

1. Brief information.
2. Main gas disposal methods.
3. Gas disposal technologies.
4. Technology of LHG extraction from a main trunk pipeline. Particular regions gas fuel supply.
5. Comparative cost analysis of gas disposal project.
6. Analysis of benefit lost due to gas burning.

Application of home-produced software and hardware tools in contemporary automated control systems

D.V. Mosolov (Vega-GAZ LLC)

1. Modern automated process systems for gas industry produced by Vega-GAZ LLC.
2. Comparison analysis of components used as part of manufactured equipment.
3. Technical properties of controller equipment made in Russia, applied as part of automation systems.
4. Technical solutions of automation of GPU ACS, CS ACS, E ACS, AFAS GCS FS&AS.
5. Implementation experience.

Technical requirements to lubrication oils for gas pumping units

*S.Yu. Polyakov, A.A. Mukhin, A.E. Skryabina
(Gazprom VNIIGAZ LLC)*

Quality requirements to lubricants are determined equally by the construction of units and their operating conditions, and provide reliable, economically-efficient and environmentally safe operation of equipment.

The variety of gas-turbine drives used by Gazprom PJSC provides a wide range of used lubricants. There is a tendency to expand the range of lubricants produced in accordance with the standards of organizations under their own brands.

Gazprom VNIIGAZ LLC developed standard requirements to lubrication oils for gas pumping units (GPU), which are used in Gazprom PJSC.

The developed technical requirements to lubrication oils for GPU are used in the form of Gazprom Company Standard «Turbine oil for heat-stressed gas pumping units». This standard is one of the key elements in the system of quality control of oils, lubricants and special liquids used in Gazprom PJSC and interacts with other regulatory documents in this area, which are already developed or planned for development.

Technical requirements are used:

- when defining industrial technical specifications on the development of new brands of lubrication oils for GPU;
- when carrying out an expertise and submitting for approval regulatory documentation on lubrication oils for GPU developed on the initiative;
- during qualification tests of pilot batches of lubrication oils according to the programs of qualification and periodical tests of commercial batches of oils in the case of necessity;
- in the process of the operational documentation approval by the designers of GPU in the terms of lubrication oils application.

Introduction of developed standard technical requirements to lubrication oils for GPU will increase the operational reliability of gas pumping equipment by improving the quality of lubricants being used.

Innovational solution in the field of overvoltage protection for gas transportation system

A.I. Fedorov (DEN RUS LLC)

Gas transportation facilities belong to particularly critical; therefore there are maximum requirements to their reliability and safety. Considering a broad use of microprocessor-based sensitive equipment establishment of a reliable internal system of lightning protection plays an important role; devices protecting against pulse over-voltage surges (POVS) is its main component. However, not all of presently known variants and designs of POVS comply with the increased requirements to the protection of modern sensitive equipment. Presentation describes an innovative concept of integrated POVS based on controllable spark arresters which provide a comprehensive solution for all the issues related to lightning protection of power supply system of industrial facilities with the maximum reliability requirements, in particular, the provide protection from maximum pulse currents which are required by lightning protection standards, limit over-voltage at the lowest level and, in case of response, do not cause interruptions in power supply of protected units due to innovative technology of automatic extinction of accompanying current arcs. Results of laboratory tests are presented to support the efficiency; they demonstrate the highest protecting effect of such devices even for the most sensitive electronic equipment, for instance, controllers in the automation systems of industrial facilities. The use of consolidated POVS based on spark arrestors satisfies the requirements of the effective Russian norms in the field of lightning protection and allows creating efficient schemes of pulse over-voltage surges for the facilities of the gas transportation system in compliance with the Regulations for ensurance of electromagnetic compatibility of Gazprom JSC (STO Gazprom 2-1.11-290-2009).

SESSION C

**MANAGEMENT OF GTS TECHNICAL CONDITION
AND INTEGRITY**

28–29 October 2015

Concept of control of technical condition and integrity of site facilities of Gazprom PJSC

*S.V. Alimov, O.N. Melekhin (Gazprom PJSC),
V.N. Voronin, S.V. Nefedov, V.A. Shchurovsky
(Gazprom VNIIGAZ LLC)*

Since 2009 Gazprom PJSC has been developing and implementing the modern Control system of technical condition and integrity of GTS facilities (CSTCI). Since 2013 CSTCI has been used on an industrial scale for the linear part of trunk gas pipelines, the methodological part of which is based on mathematical models of estimated forecasting of the technical condition, reliability and technological risk indicators, and long-term planning of diagnostic activities and repair of gas pipelines is optimized in terms of priority in the conditions of financial and resource limitations.

Nowadays, Gazprom PJSC develops CSTCI of GTS site facilities, which covers compressor and gas distribution stations, underground gas storage facilities, system objects of power systems and corrosion protection systems. The main document, within the frameworks of which the assigned task of controlling operational integrity, reliability and safety of pipelines, equipment and site facilities' subsystems on the principles of servicing according to «technical condition» and «purpose» and taking into account man-caused and technological risks is being realized, is "The concept of CTCI of site facilities of Gazprom PJSC, approved in 2015.

The report presents the key provisions and principles of the Concept, the special features of CSTCI for station industrial pipelines and equipment, the description of the process, integrity parameters and decision criteria, as well as the current direction of the methodical and regulatory documentation development.

Life-cycle of long-term programs of management of technical condition and integrity of gas transmission system trunk pipeline line part (GTS TP LP) facilities

*G.A. Milko-Butovsky, S.V. Nefedov, V.P. Stolov
(Gazprom VNIIGAZ LLC),
O.N. Melekhin, A.N. Pasechnikov (Gazprom PJSC),
M.B. Basin (Gaztranzit LLC)*

In 2014 in Gazprom PJSC, implementation of the methodology of management of technical condition and integrity of gas transmission system trunk pipelines line part (MTCI GTS TP LP) started in gas transmission subsidiary companies, and as of the current date, on its basis, the Program of comprehensive overhaul of trunk pipelines line part of Gazprom PJSC was formed and approved for 2016–2020.

Experience obtained from these works showed necessity of changes implementation into the developed in 2012 Gazprom PJSC recommendations «Regulation of formation of programs for technical diagnostics, maintenance and repair of UGSS trunk pipelines line part of Gazprom PJSC» to ensure correspondence with the regulatory documentation changed since 2012 for the MTCI related process of maintenance and repair.

In the report, current representation of all the life cycle processes (planning, execution monitoring, efficiency analysis) is given for long-term Programs of MTCI GTS TP LP, including information flows, works execution timelines, MTCI process interaction with related processes. Necessity of unified approaches application is accounted for in terms of TP LP facilities and GTS site facilities, for which methodological and regulatory documentation is currently being developed within the project of development of Information-Management System «Gas Transmission» (IMS T, Stage 2). Modelling of scenarios of target technical condition and integrity indicators achievement is considered in more detail in the process of development of the Programs of GTS TP LP facilities diagnostics and repair.

Building of the spatial information database of gas mains and adjacencies descriptions for the computation unit of technical condition and Gas transportation integrity management system

*A.S. Vakhtanov, V.A. Lazutin, N.N. Sevastiyarov, D.S. Sergeev
(Gazprom space systems JSC)*

One of the sources of objective information on the line parts (LP) of gas mains (GM) condition is the aerospace survey data. The aerospace methods are used for obtaining information on GM interaction with the environment, LP GM current status, data on the surrounding landscape and its influence on GM status.

Aerospace data is the basis for generation of geospatial data for LP GM objects spatial information database for performing analytical calculations of LP GM health and integrity status indices for drafting the «Program of the integrated LP GM workovers for 2016–2020 yrs.».

The presentation shows the results of practical activities on building spatial information database for the computation center, features of operations with various sources of spatial information, soft and hardware bases, used in the works.

**Implementation particularities of Technical condition
and integrity control system of gas transmission system
in Gazprom transgaz Krasnodar LLC**

V.V. Kim

*(Gazprom transgaz Krasnodar LLC – branch Engineering
technical center)*

In accordance with the instruction of management board Gazprom PJSC, Department for gas transportation, underground storage and utilization, together with Gazprom VNIIGAZ LLC take measures to implement Technical Condition And Integrity Control System Of Gas Transmission System (TCICS GTS) in Gazprom PJSC. Gazprom transgaz Krasnodar operates more than 8000 km of gas pipelines. Gas transmission company shall generate the initial data file – nameplate, technical and space information – in order to analyze technical condition and technology-related risks. On the basis of obtained data Gazprom VNIIGAZ LLC shall perform calculation of technical condition of gas transmission system areas and develop long term production programs. In order to provide sufficient data, it is required to perform supplementary inspections of gas pipelines and description of facilities around them within a radius of 500 meters. The present report shall concern the particularities and problems faced by specialists of Gazprom transgaz Krasnodar JSC in the course of this work.

Main stages and features of the procedure of analyzing accident risks at site facilities within the frameworks of the System of technical condition and integrity control of GTS facilities

*S.V. Ovcharov, Yu.V. Gamera, Yu.Yu. Petrova
(Gazprom VNIIGAZ LLC)*

Accident risk analysis for site facilities (SF) of GTS of Gazprom PJSC is one of the basic processes of the system of technical condition and integrity control (STCIC) of GTS facilities, developed within the frameworks of the Information-management gas and gas-condensate transportation system of Gazprom PJSC. The parameters of man-caused risks together with the technical condition and integrity parameters will be used for ranking SF of GTS in order to justify their priority level and selection of methods for diagnostic and repairing works at these facilities.

This report focuses on the peculiarities of the SF accident risk analysis procedure used in STCIC of GTS facilities, and developed on the base of the regulatory approach presented in Gazprom Company Standard 2-2.3-351-2009. The main stages of the analysis are the following: the collection and processing of the initial data on SF and its surroundings; SF hazard identification (including SF decompositions, release of hazardous SF components); estimation of SF man-caused risk; SF ranking using the selected man-caused risk parameters. A new feature of this algorithm is the application of logical-probabilistic simulation methods directly to the damaging factors (DF), as opposed to the traditional approach with a final limited number of accident estimation scenarios. This allows us, on the one hand, to take into account the full continuous range of accident estimation scenarios, and on the other - makes it possible to avoid the need for preliminary DF ranking within each accident scenario. The basic structural section for SF accident risk estimation (CS of TGP, CS of UGSF) is the compressor room (CR). As the main parameter of the man-caused accident risk, the expected annual direct damage from the accident in CR (overall man-caused risk) is determined. A multi-level facilities ranking procedure based on the developed risk matrix is proposed.

Basic approaches to implementation of technical condition and Integrity control system of site facilities in GIS of TP of Gazprom transgaz Surgut LLC

*M.Yu. Karnaukhov, V.E. Kurilov, S.A. Redikultsev,
A.M. Rudenko, I.V. Kovalchuk, O.S. Pshentsov
(Gazprom transgaz Surgut LLC),
S.V. Nefedov (Gazprom VNIIGAZ LLC),
M.B. Basin, I.A. Veremenko, A.G. Mikhaylenko
(Gaztranzit LLC)*

Gazprom PJSC successfully implements the technical condition and integrity control system (TCICS) of the linear part, based on an assessment of man-caused risks and estimation of possible damages and losses. However, this approach does not take into account the specifics of site facilities, which are characterized by the technical heterogeneity of equipment, the redundancy capability and high-speed development of emergency processes, that can lead to a need to reconsider the approaches at the linear part regarding the development of a new methodology.

Gaztranzit LLC is currently completing the works on a prototype of TCICS of site facilities together with the specialists of Gazprom transgaz Surgut LLC on the base of the geoinformation system of trunk pipelines (GIS of TP) of the gas transportation network. The basic approaches, revised by the company's specialists, allow to solve management scheduling tasks at different levels. At the level of gas transportation companies, some parameters characterizing the technical condition and various types of risks for each piece of equipment are estimated. The facilities are ranked on the basis of the calculated indicators and form a plan of measures for facilities' diagnostics and repairing. At the administration level the parameters of technical condition of a compressor room, as a unified system of elements connected in series or parallel, and an aggregating indicator of a compressor station are estimated for their further comparison according to the indicators of individual rooms as part of the CS and different CS.

Verification of the methodical solutions is performed on the system prototype, covering the first implementation stage – development of the overhaul plan for each facility based on the data for the pilot compressor station. The prototype allows to demonstrate the algorithm application using the real data, identify bottlenecks and make proposals for the improvement and development of a methodological base for the assessment of site facilities when using the chosen solution for all compressor stations of the Company.

Justification of long-term operation of pipes with stress corrosion-cracking defects (areas of concern and experience of operating trunk gas pipelines)

*O.N. Melekhin, A.B. Arabey, O.V. Burutin (Gazprom PJSC),
I.V. Ryakhovskikh (Gazprom VNIIGAZ LLC)*

Due to continuing aging of the gas transportation system of Gazprom PJSC (nowadays, over 80 % of the trunk gas pipelines (TGP) have been operated for over 20 years) the issues of planning and rational allocation of funds for gas pipeline repair become more and more important. Repairing requirements to the pipes with stress-corrosion cracking defects should be differentiated according to their real risks.

The experiment has shown that the main condition for maintaining operational reliability of the pipelines with stress corrosion defects is to prevent access of the corrosion medium to the surface of the pipelines with such defects. The fundamental possibility to operate re-insulated sections of gas pipelines with stress-corrosion cracking micro-defects, with the depth up to 10 % of the pipe wall thickness, has been proved.

The classification method for stress-corrosion cracking defects by their hazard level based on the results of pipes' strength assessment has been proposed. A statistical estimation of the maximum rates of stress-corrosion cracks development in the pipes' metal of long-term operated TGP has been performed.

The top-priority areas for further researches in Gazprom PJSC have been highlighted, and they are focused on ensuring the reliability of TGP, subject to stress-corrosion cracking defects, under conditions of long-term continuous operation:

- implementation of a complex of large-scale experimental-industrial researches, performance of full-scale serial hydraulic tests of tubes and laboratory tests of samples with stress-corrosion cracking defects;
- development of technologies for remote monitoring of TGP sections with left stress-corrosion cracking defects;
- development of innovative technologies of in-pipe flaw detection methods for TGP and measuring methods for automated nondestructive testing of stress-corrosion defects of pipes.

The problems of diagnosing cracks corrosion cracking under stress at an early stage of their development in pipes underground pipelines

I.V. Maksyutin (Gazprom transgaz Ukhta LLC)

The experience of exploitation of main gas pipelines (MGP) shows that one of the most dangerous defects is the stress corrosion cracking (SCC). The identification of these defects at an early stage is hindered by the low sensitivity of the diagnostic equipment used for in-line inspection (ILI). So the minimum threshold for defect detection for SCC «pigs» of SPA «Spetsneftegaz» and Orgenergogaz OJSC «Saratovdiagnostika» with the disclosure of crack edges more than 0.05 mm is the following, respectively: the depth is 15 and 10 % of the wall thickness of the pipe; the length is six times the tube wall thickness and 80 mm. An external scanner-flaw (for example, 2075 «SoNet») used during the inspection of the pipes during the overhaul sections of MGP, can reliably detect cracks 2 mm deep, but does not detect smaller cracks. Moreover, it should be noted that at this point we have an open issue concerning the method of non-destructive testing (NDT), which would allow determining the depth of SCC cracks with the required accuracy in order to assess their hazard.

The present article reviews the possibilities of various NDT methods for detecting stress corrosion fractures and determining their parameters. The results of the in-line inspection and external survey methods are discussed during the overhaul of several sections of MGP. The work gives a comparative analysis of the geometrical sizes of SCC defects, obtained by controlled grinding and the devices operating on the basis of magnetic-eddy current method. In addition, the article presents the results of extended laboratory examinations and testing of templates with defects in SCC, which includes the determination of actual mechanical properties of metal and a study of the microstructure of the metal in the defective and defect-free zones, as well as the results of an experimental study of SCC behavior of cracks under different loads. The work performed allowed us to point out organizational and technical activities to ensure required reliability and a more reliable forecast of the residual life of pipes with defects SCC.

Experience and prospects for R&D Works at the testing benches and sites of Gazprom PJSC

V.V. Vavilov (Gazprom PJSC),

V.V. Kharionovsky (Aerospace Monitoring and Technologies CJSC)

The importance of developing testing systems for formulation and improvement of R&D works is determined by the need for an industry approach to solving the reliability ensuring tasks for the facilities of Gazprom PJSC, as well as by the need for technological development and design of new equipment and technologies aimed at import substitution. In the international practice the tests are considered to be a required element of the production technical level maintenance process, that's why complex tests are known to be the base for development of equipment and technologies in leading industries (aerospace, aviation, engineering). The subsidiaries of Gazprom PJSC operate a network of testing facilities and sites, where the current production and experimental works are performed, which is usually aimed at solving specific technological problems. The main purpose of this report is the development of the concept of an effective system of testing centers. The three-level system of work performance based on centralized management system (level I), with support of the basic centers (level II) and the operation of integrated centers and testing sites in subsidiaries (level III), according to the technologies used in sub-sectors – production, transport, processing, is proposed. The analysis of existing testing benches and sites operation is presented, and the special attention is paid to the northern, sea and foreign testing sites. The information on the testing benches and sites in subsidiaries is also provided, and their classification is given according for the following areas: production, processing and transportation of gas. The analysis of proposals made by subsidiaries shows that the analytical review of their activities, the improvement of their involvement level for the development of technological areas of Gazprom PJSC, the elimination of duplication, the testing of new techniques and technologies are needed. Based on this fact, the management scheme of performing works at testing benches and sites of Gazprom PJSC is developed. In general, according to the provided information, the industry requires the implementation of a new approach to technologies, equipment and materials development and testing.

Modern state and development prospects of internal pipeline diagnostic means for gas pipelines of Gazprom PJSC

*O.N. Melekhin, A.V. Molokanov (Gazprom PJSC),
I.L. Vyalykh, V.L. Lazarev, D.A. Zotov (Gazprom VNIIGAZ LLC),
V.V. Lopatin (Spetsneftegaz NPO JSC)*

Nowadays, the basic element of the diagnostic maintenance system of the linear part of trunk gas pipelines (LP of TGP) during their operation is the internal pipeline diagnostics (IPD).

The results of IPD of LP of TGP are used for solving the following tasks in diagnostic maintenance area:

- ranking of LP of TGP's sectors concerning their technical condition;
- planning the types and scope of repair work at LP of TGP;
- justification of the decision on the possibility and conditions of further operation of LP of TGP, permissible operating modes, the schedule of technical diagnostic works;
- predicting the technical state of LP of TGP.

Internal-pipeline diagnostic devices, used for LP of TGP's inspection and designed on the basis of magnetic non-destructive testing type, have a number of limitations. However, the current state and the main development directions of the gas transmission system of Gazprom PJSC in addition to the traditional task of improving the reliability of internal-pipeline diagnostic results, also set some new requirements to IPD means.

The prospects of IPD means' development are based on the implementation of new design solutions, improvement of diagnostic parameters' base, improvement and optimization of algorithms for processing the IPD results.

This report shows:

- the current development state of IPD means, which are used for diagnostics of LP of TGP of Gazprom PJSC;
- the key results of IPD means' testing, the characteristics of basic inspections and tests;
- the principal directions of improving quality and informational content of obtained IPD results;
- the principal directions of development and modernization of IPD means for LP of TGP of Gazprom PJSC.

Quality improvement and capabilities enhancement of internal pipeline diagnostics. Combined magneto-acoustic diagnostic pigs

*B.V. Patramansky, V.E. Loskutov, V.V. Lopatin
(NPO «Spetsneftegaz» CJSC)*

One of the priority directions in development of the means of IPD control of technical condition of LP of the gas transmission system of Gazprom PJSC is assimilation of new EMA diagnostic methods. They complement traditional magnetic methods by enhancing capabilities and significantly increasing quality of diagnostics.

NPO «Spetsneftegaz» CJSC has worked on development of EMA methods for internal pipe diagnostics for over 10 years. Within this direction, problems were solved in increasing sensitivity, detectability, quality of identification and precision of pipe defects and welding joints dimensions determination, as well as ensuring insulation coating adhesion quality control.

By the result of research, an IPD complex was developed, consisting of combined magneto-acoustic diagnostic pigs of longitudinal and transverse magnetization.

Report presents capabilities and comparative indicators of the new magneto-acoustic and traditional magnetic IPD complexes.

Current state and development prospects of ultrasonic control for pipelines diagnostics

*A.A. Samokrutov, V.G. Shevaldykin (Acoustic Control Systems LLC),
S.Yu. Voronchikhin (IntroScan Technology CJSC)*

Report reviews capabilities of modern means of ultrasonic (US) non-destructive control in application to current tasks occurring during diagnostics of pipelines both at the linear part and at compressor stations. It describes capabilities of US imaging systems built on the basis of antenna arrays and technologies of digital focusing both for high-frequency (over 1 MHz) and low-frequency guided wave methods. Results are given for numerical modelling, experimental research and practical application of the equipment implementing these methods.

Technologies of automated ultrasonic testing of welding joints and pipes body

*V.A. Suvorov (AKS-Service LLC),
A.A. Samokrutov (Acoustic Control Systems LLC)*

The report describes the method of automated ultrasonic testing of welding joints with application of high-frequency (4 MHz) digitally focused antenna arrays technology, and method of pipes body base metal testing with use of scanning systems based on low-frequency antenna arrays with dry pinpoint contact.

It defines tasks faced at system development, describes approaches and principles of their solution. In detail reviews defect detector scanner units: measuring, transporting, laser-optic units. Method of metals ultrasonic imaging using digitally focused antenna arrays with application of two-dimensional DGS diagrams is suggested, principles of the diagrams formation are described, as well as nature of C-SAFT echo-signals processing algorithm. Algorithm of detected defect type automatic definition is described. Report also presents the results of pilot production of internal pipe defect detector scanner identifying defects in pipes body base metal.

Robot-aided internal pipeline diagnostics of gas pipelines sections not adapted for internal pipeline inspection devices

M.N. Lysiy, S.N. Aksenov (Gazproekt-DKR JSC)

Gas pipelines operation safety requires periodic testing of their technical condition, traditionally performed using internal pipe testing devices: diagnostic pigs. Particular parts of gas pipelines are not suitable for diagnostic pigs use due to different inside diameters, presence of branches with $1.5 D$ radius, etc.

For definition of technical condition of such sections, internal pipe testing with use of powered robotic centers is carried out. As result of diagnostics, corrosion and crack-like flaws of pipe base metal are identified, wall loss is measurement and visual and dimensional inspection of ring welding joints are carried out.

Report presents experience in robot-aided internal pipe diagnostics:

- of gas pipeline crossing under motor road Rameshki – Kiverichi;
- of underwater gas pipeline crossing under the Hudson river (USA)
- of trunk gas pipeline section in Paris (France).

As a whole, with the use of Gazproekt-DKR JSC powered robotic centers, internal pipe diagnostics was conducted at over 370 facilities of the Russian Federation and abroad.

Justification of requirements to monitoring systems of geo-technical condition of main gas pipelines based on distributed fiber optic sensors

*I.Yu. Morin, V.M. Silkin, M.Yu. Panov, V.P. Stolov
(Gazprom VNIIGAZ LLC)*

Nowadays in the word practice, the monitoring systems based on distributed fiber optic sensors have become widespread for the purposes of monitoring the deformed state of long critical objects, such as bridges, dams, dikes, as well as individual elements of aircrafts and power units. Such systems are usually used to control the deformed state of the object, its temperature and vibration activity.

To evaluate the feasibility and applicability of such systems at the facilities of Gazprom PJSC, subject to the uniform technical policy in the field of their application, the «Temporary technical requirements to the elements of monitoring systems of geo-technical condition of main gas pipelines based on distributed fiber optic sensors» have been developed.

In the course of developing the technical requirements, the target operational characteristics of monitoring systems determining their applicability at gas transportation facilities have been determined and proved.

When determining the application scope of monitoring systems based on distributed fiber optic sensors, the specific characteristics and parameters of existing systems, such as measurement accuracy and range, systems' capabilities to localize events and specifications of manufactured fiber optic sensors have been taken into account, and the target areas of systems development have been determined.

The summarized results of fiber optic systems certification for their compliance with the provisions of the «Temporary technical requirements of Gazprom PJSC to the elements of monitoring systems of geo-technical condition of main gas pipelines based on distributed fiber optic sensors» are presented. The certification procedure is carried out in accordance with Gazprom Company Standard 2-3.5-046-2006 «The procedure of the expert examination of technical specifications on equipment and materials, the certification of technologies and the assessment of organizations' readiness to perform diagnostic and repairing works on gas transportation facilities of Gazprom PJSC».

Application experience of non-contact magnetometric diagnostics of pipelines and perspectives of its development

A.A. Dubov, A.I.A. Dubov (Energodiagnostika LLC)

At present the practical application of non-contact magnetometric diagnostics (NCMD) during the assessment of underground or underwater pipelines is constantly growing.

NCMD is based on measurement of distortions of the magnetic field of the earth (H_{earth}), conditioned by the variation of the pipe metal's magnetic permeability in stress concentration zones (SCZs) and in zones of developing corrosion-fatigue damages. The pattern of the H_{earth} field variations (frequency, amplitude) is conditioned by the pipeline strain occurring in it due to the exposure to a number of factors: the residual process and installation stresses, the working load and self-compensation stresses at outdoor air and environment (soil, water, etc.) temperature fluctuation.

The criteria and the program software, developed at Energodiagnostika Co. Ltd based on the metal magnetic memory method, are applied for decoding the information about the pipelines' condition by variations of the magnetic field of the earth recorded at the depth of 200 to 300 mm from the earth surface.

A center for experts' training in NCMD operates at Energodiagnostika Co. Ltd Certification Body (Reutov, Moscow region).

In the course of experts' training in NCMD Energodiagnostika Co. Ltd Certification Body issues recommendations on the distinctive features of magnetic anomalies and diagnostic parameters that allow one to distinguish maximum stress concentration zones (before the damage development) from the zone of the developing corrosion damage. The existing criteria allow defected welded joints to be detected and to be distinguished from the joints in satisfactory condition.

The article considers the main problems revealed by the authors as a result of the long-term application of NCMD, the issues of experts training at Energodiagnostika Co. Ltd Certification Body and the perspectives of the NCMD technology development.

The results of field tests of magnetometric means for non-contact ground inspection of trunk gas pipelines

*A.V. Molokanov (Gazprom PJSC),
I.L. Vyalych, V.L. Lazarev, D.A. Zotov, A.V. Lipovik,
A.E. Remizov (Gazprom VNIIGAZ LLC)*

According to the requirements of Gazprom PJSC, non-contact magnetometric diagnostics can be used to identify the most highly-stressed and prone-to-damage areas of the linear part of trunk gas pipelines (LP of TGP). In this case the major tasks of non-contact magnetometric diagnostics is the detection, positioning and tracking (monitoring) of magnetic field anomalies associated with the defects of the base metal, welded joints' metal, as well as the general stressed condition of the pipeline. The usage of magnetometric complexes is most appropriate at the areas of LP of TGP, which are not adapted for internal-pipeline diagnostics. The main condition of using magnetometric means for gas pipelines diagnostics is the compliance of their specifications both in terms of organization of diagnostic technology, and in terms of identification and defects evaluation to the requirements of Gazprom PJSC. The compliance of the technical characteristics of the equipment to set requirements is checked in the course of tests. The report describes the stages of conducted tests of non-contact magnetometric diagnostic means, which have been performed at the linear part of the operating gas pipeline, their flaw detection capabilities have been determined, as well as the features of each diagnostic complex, used in the course of testing. The report presents the main technical characteristics of non-contact magnetometric means, preliminary results of field tests, the main directions of development and modernization of magnetometric complexes.

Prediction of thermal impact of gas transmission systems on permafrost ground

*V.V. Gordiychuk, D.V. Evlanov, I.A. Gishkeluk
(Simmakers LLC)*

One of the main factors ensuring the reliability and safety of gas transmission systems in permafrost areas is the prediction of ground settlement and stress-strain state of pipelines. Estimation of ground settlement resulting from permafrost thawing is closely connected with determining the size of thaw bulb under gas transmission systems.

Ground thermal analysis is conducted to determine the magnitude of frozen ground thawing and should be performed with software based on numerical methods, since simplified analytical methods could be applied only for special cases and cannot be applied for the majority of practical cases.

Currently there are a number of general purpose packages for 3D numerical simulation of thermal processes, however, their employing in permafrost ground thermal analysis is restricted by the following:

- difficulties of considering «water-ice» phase transitions, which cause large errors when using general purpose software;
- there are no embedded tools for creating 3D models of complex geology;
- heat pipes and cooling units to be considered;
- high requirements to the computational mesh, since the quality of meshing directly affects the computation accuracy.
- meshing the models with large quantity of cells (multi-million) is necessary due to large-scale linear and spatial objects, complex geological structure, the objects that require a more refined mesh (e.g. heat pipes, cooling units, thermal insulators);
- conducting the computation within a reasonable time period (several hours) without loss of accuracy.

Frost 3D Universal is the first software package for numerical simulation of thermal processes in permafrost ground. It satisfies all the above requirements, was released in 2014. The authors of the report are the developers of this software package and represent its capabilities for linear and spatial objects of gas transmission systems.

Prediction of the heat effect of gas transportation systems on permafrost soils

V.V. Gordiichuk (Simmakers LLC)

The report presents the methods and means for predicting permafrost soil defrosting as a result of the heat effect of gas transportation systems, including the different sections of the underground pipeline. The proposed method of prediction is based on the numerical solution of the heat-transfer equation in three dimensions taking into account phase transformations and convective heat transfer. The proposed method can be applied in the process of designing and geotechnical monitoring of pipelines and other gas transportation systems in the conditions of permafrost soils presence. The results of such estimations are necessary to assess reliability of gas transportation systems.

Corrosion control when predicting technical state of trunk gas pipelines

D.N. Zapevalov (Gazprom VNIIGAZ LLC)

The development of corrosion processes of underground trunk gas pipelines depends on the conditions of their interaction with the environment, and essentially depends on the nature of the protective coating damages, the primary type of the corrosion process and capabilities of the corrosion protection systems in the terms of corrosive effects' limiting.

The basis for predicting the corrosion process development is the results of corrosion inspections aimed at determining the nature and location of corrosion defects, determining the geometric parameters of through-coating damages, estimation of the environmental conditions and external electromagnetic influences.

The control of the actual corrosion effects using corrosion monitoring tools can significantly improve the accuracy of estimated values for the rate of corrosion processes and the effectiveness of protective corrective actions.

The possibilities of development and implementation of corrosion defects development models for predicting the corrosion rate and evaluating the geometrical parameters of defects on the basis of laboratory and en-route studies have been considered. The expediency of further integration of estimation results in the systems used to evaluate the technical condition of gas pipelines in order to improve the accuracy of subsequent estimations using strength, fatigue life and fracture mechanics' models has been proven.

Experience in use of status GTU software suite and prospect of its application within SMTCI

*I.S. Petukhov (GCE LLC),
D.V. Kosachev (Gazprom transgaz Yugorsk LLC)*

Status GTU Software Suite being developed by GCE LLC is designated for solution of production tasks of Gazprom transgaz Yugorsk LLC in the field of TP LP operation reliability assurance. Experience of Status GTU Software Suite operation is reviewed in the report, in terms of:

- forming consistent initial data array;
- comparison of consequent IPD, including ones from different contractual organizations and with account for conducted repairs;
- corrosion and stress-corrosion defects growth rate calculation;
- forming prognosis evaluations of the technical state;
- use of satellite and air drone images for determination of spacial position of defective sections and facilities of their surrounding.

Status GTU Software Suite enables preparation of the initial data to form a TP LP diagnostics and repair program within SMTCI TP LP developed by Gazprom VNIIGAZ LLC under assignment of DTPKhIG.

Use of Status GTU Software Suite allows to expedite SMTCI TP LP implementation in gas transmission organizations of Gazprom PJSC.

About the possibility of estimating the assigned operational lifetime of the trunk gas pipelines at the design stage

O.V. Limar (TumenNIIgiprogaz LLC)

According to the federal standards and regulations of industrial safety of the Russian Federation "Safety regulations for hazardous production facilities of trunk pipelines" (approved by the order of Rostekhnadzor on November 6, 2013 No. 520) the operational life cycle of the linear part of trunk pipelines is defined in the project documentation. This operational lifetime value is usually taken from the technical specification for design, where it is usually presented. Nowadays, GOST «Assigning the safe operational lifetime for the linear part of the trunk gas pipeline», that must provide the scientific base, is being developed.

It is expected that the operational lifetime of TGP should be estimated by the design organization at the object design stage. However, there are some reasons, including imperfection of the standards base, design deadlines, lack of necessary computational techniques and programs, inaccurate initial data, that make determination of the operational lifetime of the linear part of TGP at the design stage by calculation means completely impossible. In addition, at the stage of developing design documentation the estimation of operational lifetime of TGP is not a relevant task, because all technical solutions chosen at the designing stage are aimed at ensuring safe operation within the set operational period.

The operational lifetime of the object must be defined in the design assignment on the basis of some general considerations, among which there should be the experience of operating similar objects in specific conditions, the economic feasibility of increasing the lifetime compared to other similar objects, etc. All these parameters must be investigated at the pre-project stage by the customer or the authorized organization, having obtained the necessary information. Design organizations do not have all necessary information about the accident risks at the linear part of TGP and their reasons due to the fact that this data is considered to be restricted. However, during operation the need for determining the residual lifetime of the pipeline arises, so it's necessary to change the application scope of GOST «Assigning the safe operational lifetime for the linear part of the trunk gas pipeline».

The problem of safety ensuring during gas discharge into the atmosphere at natural gas transmission facilities

*V.S. Safonov, A.Z. Shaikhutdinov, S.V. Ganaga
(Gazprom VNIIGAZ LLC),
A.V. Melnikov (NIITN LLC)*

At linear and on-sites facilities of Gazprom PJSC there are annually hundreds of cases of natural gas discharge into the atmosphere through special units, which are designed and can provide in most cases the industrial safety requirements.

The practice has proven that gas discharges caused abnormal (pre-emergency) and emergency situations with evident negative consequences in the case of some violations of regulatory procedures and non-compliance of technical and technological parameters of the equipment to its rated values, as well as in the case of unfavorable weather conditions.

The studies of the effect of operating parameters and design features of the gas collection system, topological parameters of the industrial site and meteorological characteristics of the atmosphere on the gas hazard probability were conducted using modern software for gas-dynamic modeling. Three-dimensional gas-dynamic modeling showed a significant influence of near-by buildings and structures on the formation of local turbulence zones and the trajectory of a gas plume, including the possibility of its «forcing down» to the earth's surface;

According to calculations, in the case of some combinations of several factors such circumstances may result in activation of automatic fire fighting systems, which are set to the value of 0.2–0.5 from the lower inflammability limit at the ground level.

For safety reasons the question about the practicability of certain structural and technological improvements, noise reduction systems and «termination devices» being used, as well as gas discharge optimization was raised.

The conclusion includes the results of historical modeling of the reasons for some emergency situations at gas transmission facilities, which were associated with violation of regulatory procedures, as well as with a certain lack of understanding of the physical gas discharge processes.

Pipeline integrity: best practices to prevent, detect and mitigate commodity releases

*A. Albutov, S. Grishanin, T. Lavrova
(Schneider Electric JC)*

Commodity releases can have catastrophic consequences concerning environmental impact, provoke economic losses and damage a company's reputation, so ensuring pipeline integrity is a critical task for pipeline operators and pipeline owners. Pipeline integrity is not just about preventing incidents, but is a holistic approach to the prevention, detection and mitigation of commodity releases. This paper discusses advanced technologies and tools that enable greater pipeline integrity, particularly based on computational pipeline monitoring (CPM) methodologies as a means that signal a possible commodity pipeline release.

The term «Pipeline Integrity» refers to a comprehensive program that ensures hazardous commodities are not inadvertently released from a pipeline and minimizes the impact if a release occurs. Hence pipeline integrity comprises three phases:

- Prevention activities to avoid commodity releases through proper design, construction, operation, training and education.
- Detection activities help pipeline operators to quickly identify the fact that a commodity release has occurred and to determine its location.
- Mitigation activities minimize the impact of the released volume and related damage.

Each pipeline is unique and has individual characteristics: transported product, pipe material, length, operating pressure, topology, surrounding environment and etc. Thereby, in order to provide the complex approach in pipeline integrity, an individual analysis of factors, potential risks, conditions and requirements is needed.

This article observes Schneider Electric Solutions used worldwide providing Pipeline Integrity for pipelines transporting hydrocarbons.

Automated system for crack detection using infrared thermographic testing

S. Starman, V. Matz (STARMANS electronics s.r.o.)

This paper presents our development of the automated system used for crack detection on tubes. The automated system uses the infrared thermographic testing principle to detect cracks and defects on tubes using brief pulsed eddy currents to heat steel components under inspection. Cracks and defects, if present, will disturb the current flow and so generate changes in the temperature profile in the crack area. These temperature changes are visualized using our developed infrared cameras. As the tubes are fully rounded the automated system is equipped with four movable cameras to achieve the best efficiency in terms of surface coverage. The acquired images are evaluated through proposed image processing process. Finally the system sends all detailed information about cracks and defects location to the database for later evaluation. The advantages afforded by the system are its inspection times, its excellent crack detection sensitivity and its ability to detect hidden, near subsurface, cracks and defects. The presented system is a main part of the inspection line where the subsurface and surface cracks are searched. The system is fully automated and its ability is to evaluate four-meter tubes within 18 seconds. This is the unique reason for using this system in a real industrial application.

Implementation of ultrasonic phased array technology using advanced signal processing algorithms in portable and industrial systems

S. Starman (STARMANS electronics s.r.o.)

Over the past few years, all improvements in the field of ultrasonic non-destructive testing have led to significant advances in ultrasonic signal processing and image construction techniques. The main focus in non-destructive testing area is to improve the resolution of defect detection and make the detection process as fast and accurate as possible. Many techniques have been proposed and implemented to improve the flaw and crack detection processes. In general, these techniques can be divided into two main parts. As first, many proposals consider the construction of ultrasonic transducers and systems. The second part is mainly focused on proposal of efficient signal processing algorithms that improve sensitivity (noise reduction) during ultrasonic signal acquisition. This paper presents our fully developed ultrasonic portable system with implemented phased array technology. The knowledge from the portable system has been used for the construction of industrial system for tube testing. This paper briefly describes the real application for tube testing automated system.

Designing and installation of subsurface pipelines using support structures

*A.V. Ushakov (Gazprom PJSC),
Yu.A. Mayants (Gazprom VNIIGAZ LLC)*

Supports are generally used in installation of above-ground pipelines. As for subsurface pipeline laying, it is believed that the load-bearing capacity of soil is sufficient for fixing the pipe spatial position. However, in case of variation of temperature and moisture conditions, soil may be deformed, which results in displacements of the pipeline. In such cases, if the pipeline system has subsurface and surface parts joined rigidly, displacements of subsurface pipelines may lead to accidents. Such problems are characteristic for compressor stations, which required provision of fixing of underground sections of pipelines. However, requirements for utilization of subsurface support structures were not accompanied by instructions regarding calculation methods and designing, which led to errors and lack of optimization.

The conducted research allowed determination of loads and effects on a subsurface gas pipeline mounted on supports; as a result, the following regulative documents were developed: R Gazprom «Subsurface supports of process pipelines and shutoff and control valves. Technical requirements» and R Gazprom «Subsurface supports of process pipelines and shutoff and control valves. Application technologies».

As a result, for the first time in practice of Gazprom PJSC:

- a system of technical requirements for subsurface supports of process pipelines have been established, which ensures the use of good-quality products in construction and repair of gas pipelines;
- new approaches have been established to support designing, support installation methods and special measures for construction inspection in the course of gas pipeline construction and repair.

It has been shown that the nature and magnitude of the loads depend not only on soil conditions but also on technology and organization of construction work. Therefore, to ensure a stable position of a subsurface pipeline, special attention should be given to requirements for performance of construction and installation operations, especially under winter conditions.

Study of chemical composition of reusable pipe metal

A. Yu. Mikhalev (Giprogazcentr JSC)

Utilization of reusable pipes in general repair of line portions of trunk pipelines (TPL) is a promising trend, development of which permits a significant decrease in demand for new pipes. For ensuring the necessary level of reliability, existing regulative documents (in particular, «Instruction for reuse of pipes in general repair of line portions of trunk pipelines») establish the order of inspection of such pipes, metal quality assessment standards and an algorithm of pipes differentiation by applicability categories.

In compliance with requirements of the above-mentioned documents, chemical composition, mechanical properties, geometrical parameters of the pipe and of detected defects are used as factors of pipe metal quality assessment. Evaluation of chemical composition is regulated for pipe identification and for assessment of metal quality in pipes sent for repair.

Earlier, in the course of studying the properties of pipes susceptible to stress-corrosion cracking, specialists of Giprogazcentr JSC found that metal in corrosion seats was characterized both by non-uniformity of mechanical properties (in particular, hardness dispersion with low load) and by excessive heterogeneity of chemical composition (excessive content of carbon and of a number of alloying elements). The suggestion was made about possible connection of places where local defects occur with non-uniformity of chemical composition.

In order to check the possibility of using chemical composition determination methods not only for identification of reusable pipes and metal quality assessment in pipes sent to plants for repair but also for express diagnostics for determining categories of pipes, experimental studies were conducted at a TPL section under general repair. The results of examination of 20 metal areas (defective or free of defects) have shown that defective areas of metal are characterized by excessive non-uniformity of chemical composition and that the carbon content values regulated by the «Instruction...» are exceeded significantly.

A conclusion was made that it would be possible to develop a procedure that would allow using estimation of metal chemical composition at the stage of determination of the pipe serviceability category.

Diagnostics of around-pipe area of gas pipelines in the zones of natural and man-caused risks

*A.N. Kolotovskiy (Gazprom PJSC),
M.M. Zaderigolova (GEOTEK LLC),
A.S. Lopatin (Gubkin Oil & Gas University)*

The operational reliability of gas transportation systems (GTS) is a top-priority task of Gazprom PJSC, because the continuous operation of all GTS elements affects the overall economic indexes and the company's reputation both at the domestic and foreign levels. Moreover, the actual reasons for possible accidents in the activity zones of hazardous geodynamic processes – HGP – (faults, earth slides, karsts, mountain undermining, etc.) are still present for many GTS.

Existing models and methods of operational monitoring of HGP are now either obsolete (surveying, drilling, rope-reference, etc.) or not developed enough. Analysis of only control results of pipe's technical condition (internal pipe diagnostics, IV-2, ultrasound, etc.) for evaluation of mechanical effect on the pipe of geodynamic processes is not a correct method, because all these monitoring methods fix only those event that has already occurred (cavings, shear, ground displacement). They are unable to predict it from the physical point of view.

Radio-frequency diagnostics, using the Earth's electromagnetic field, allows to control the start of ground deformation processes in their latent development phase, localize the areas of developing ground discontinuity and monitor their development, thus predicting emergency situations and accidents.

Technology of radio-frequency diagnostics of around-pipe area makes it possible to optimize the development of cost-effective management solutions for prevention of accidents and emergency situations on GTS in the zones of natural and man-caused risks.

SESSION D

**LINE PIPE PRODUCTION, WELDING AND ALLIED
TECHNOLOGIES, PROTECTIVE COATING
OF PLANT EXTRUSION**

28–29 October 2015

Improvement of normative base for welding and non-destructive quality control of welded connections

E.M. Vyshemirsky (Gazprom PJSC)

This report is dedicated to the review of the state of normative base for welding and welds non-destructive quality control at Gazprom PJSC facilities, emphasizing the necessity of its improvement.

The report focuses on organization of development of normative documents for welding and non-destructive control, and also on realization of the Concept for improvement of normative documents (actualization, reducing the number and improving the quality of existing standards, and their systematization (ranging by levels).

We have shown changes in technical parameters of gas pipelines, pipes and pipelines connecting elements during the last 15 years, which required application of new technologies at construction of main gas pipelines such as narrow re-grinding edge preparation and the use of up-to-date techniques and technologies of non-destructive quality control of welded connections.

We have pointed out changes in requirements of standard documents of the Russian Federation and Gazprom PJSC, and also noted:

- specifics connected with realization of large-scale investment program for construction of gas mains facilities, and the objective necessity of carrying out increasing annual volumes of gas mains overhaul repairs.
- importance of providing a unified technical policy in the field of welding and welds non-destructive quality control.
- the role of Welding Operations Development Programs at Gazprom PJSC, including organization of development of new standard documents on welding practices;

Processing of information and results of largest qualifying tests of welds non-destructive quality control equipment were finalized in 2014.

Also, other directions of technical policy realization in field of welding engineering have been described, i.e. works carried out on an on-going basis and connected with attestation of new technologies (including non-destructive technologies), expertize to check whether main and accessory welding equipment standards, welding and auxiliary materials meet technical requirements of Gazprom PJSC in accordance with requirements of STO-2-3.5-046-2006 «Standards appraisal procedure...».

About new trends in the development of technical requirements to pipe products for trunk gas pipeline projects

*T.S. Esiev, V.O. Makhanev, S.E. Yakovlev, I.S. Sivokhin,
N.L. Tsalkalamanidze, O.V. Aleksandrova
(Gazprom VNIIGAZ LLC)*

Today, Gazprom PJSC uses a wide range of pipes and fittings produced according to different technologies and different in design.

In recent years, in connection with the implementation of new projects of gas pipelines in Gazprom PJSC, including ones designed for pressure ranges of over 10 MPa, the new types of pipe products with unique parameters (strength classes, wall thickness) have been used. A large-scale reconstruction or modernization of production facilities of most domestic pipe factories and factories producing fittings has been carried out. At metallurgical and pipe enterprises the modern production analysis and quality control systems for manufactured products have been implemented.

However, the trend towards continuous improvement of requirements to pipes and fittings is still a relevant issue, which is reflected in the developed regulatory and technical documentation on pipe products.

Due to the fact, that in January 2016 the industry standard «Specifications for pipes and fittings» will be put into force, the pipeline construction will require the use of only those pipe products manufactured in accordance with technical specifications. This fact is consistent with the introduction of the new version of the «Instruction on using pipes and fittings at the facilities of Gazprom Company» (in September 2015), which doesn't include the lists of pipe products supplied according to state standards. Thus, it is another effective barrier for penetration of low-quality and counterfeiting products to the facilities of Gazprom PJSC.

The report focuses on the crucial aspects of high-strain capacity pipe production development. Some of the problematic issues concerning the regulation and justification of the quality of pipe products, designed for operation at high pressures, are also considered.

Development of quality evaluation standards for ring welded joints for conditions of using automated and mechanized ultrasonic testing methods

*V.M. Silkin, V.M. Kovekh, E.N. Ovsyannikov, I.N. Kurganova
(Gazprom VNIIGAZ LLC)*

The methodology and experience of the practical application of the advanced approach to design-experimental verification of quality evaluation standards for ring welded joints regarding the technical capabilities of non-destructive testing means have been considered.

The primary focus is made on development of quality evaluation standards for welded joints for automated and mechanized ultrasonic testing methods. The adapted proposals on development of quality evaluation standards for conditions of separate and combined application of radiographic and ultrasonic testing methods have been presented.

The design-basis verification of the quality assessment standards of welded joints with defects is performed on the basis of the universal hierarchical structure of computational models and criteria. The extended list of physical and mechanical properties of construction materials is taken into account, the stress-strain state parameters in the area of the welded joint are estimated, the influence of welding technologies on the performance capabilities of welded joints is considered.

When developing the quality evaluation standards, the results of laboratory, bench and field tests, which have been conducted to determine the actual physical and mechanical properties of the base metal and weld metal corresponding to different welding technologies, have been used. The practical application of computational models and criteria of nonlinear fracture mechanics allowed to significantly improve the accuracy of estimates of performance capabilities of welded joints. Previously, this approach had a limited application only for the expert purposes.

The experience of development of quality assessment standards for welded joints, both for the stage of construction of new facilities, and the stage of selective repairing of welded joints, performed at the facilities, the service life of which is more than five years, is described.

HIPER pipes certainly ensure pipeline integrity and save construction costs in harsh environments

*N. Suzuki, T. Arakawa (JFE Steel Corporation),
A. Arabey (Gazprom PJSC),
T. Esiev, V. Cherniy, O. Trifonov, V. Makhanev, I. Sivokhin,
S. Yakovlev (Gazprom VNIIGAZ LLC)*

HIPER PIPES were developed by JFE Steel Corporation and present high strain capacity compared to standard pipes. Therefore a number of HIPER PIPES has been delivered to customers all over the world to ensure pipeline integrity in harsh environments. JFE Steel Corporation received a technical requirement TU 1381-101-JFE-2012 in 2012. Gazprom Recommendations entitled for application of HIPER PIPES with high strain capacity in zones of active tectonic faults, seismic and permafrost regions were published in 2014.

HIPER PIPES present a round-house type stress-strain curve even after conducting anti-corrosion coating at 230 degrees C for 5 minutes for instance. The strain capacity in compression or bending of HIPER PIPES shall be expressed with a stress ratio $\sigma_{2.0}/\sigma_{1.0}$ where $\sigma_{1.0}$ and $\sigma_{2.0}$ express the longitudinal yield strength at total strain of 1.0 and 2.0 %, respectively. The required strain capacity of HIPER PIPES can be satisfied controlling the stress ratio without increasing wall thickness. Standard pipes have a Luders plateau type stress-strain curve and the strain capacity shall be small compared to that of HIPER PIPES.

In order to explain the excellent strain capacity and the cost effectiveness of HIPER PIPES in the harsh environment, a few ground deformation models are assumed and the pipeline integrity is discussed from the viewpoints of the stress-based pipeline design method and the strain-based pipeline design method. Taking into account the effects of the seismic excitation and the increase in temperature of the pipeline, the pipeline integrity using HIPER PIPES or the standard pipes are compared in a Frost-Heave zone, a Slope-Sliding zone, and a Fault zone.

Research of the impact of carbon equivalent on the inclination of high-strength steel grades to form cold cracks during welding

*L.A. Efimenko, O.E. Kapustin, D.E. Vyshemirsky
(Gubkin Oil & Gas University),
E.L. Makarov, S.A. Korolev, D.S. Rozanov,
(Bauman Moscow State Technical University)*

Presentation contains the results of experimental assessment of the impact of the chemical composition of high-strength pipe steel brands on their inclination to form cold cracks during welding. Carbon equivalent (C_{equiv}) was discussed as the criterion contributing to the formation of hardening factors which is the main factor of cold cracks formation. Carbon equivalent varied from 0.35 to 0.54 %.

Test of five batches of specimens was conducted according to the requirements of GOST 26388 at the unit LTP-2-3. Test conditions anticipated a possibility to assess the impact of C_{equiv} only on the formation of cold cracks. Content of diffusion hydrogen and the levels of welding voltage were identical for all the specimens.

Analysis of obtained values of the minimum destruction tensions corresponding to the formation of cold cracks in welded specimens, as well as the research of the destruction micromechanism demonstrated that in the assessment of low-carbon high-strength inclination to form cold cracks during welding it is necessary to consider not only the value of the carbon equivalent but also the content of carbon determining the plasticity of hardening structures being formed. At that C_{equiv} values can be increased in relation to normative parameters of the carbon equivalent assumed for conventional low-alloyed steel grades.

Estimated and metal testing justification of high-reliability characteristics of cold-bended branches with increased bending angle, which are made of pipes with increased strain capacity (for Asia-Pacific region zones)

*I.P. Shabalov, V.Ya. Velikodnev, S.Yu. Nastich, V.S. Kalenskiy
(Pipe Innovation Technologies LLC),
S.A. Chegurov (United Metallurgical Company),
M.A. Bubnov (Vyksa Steel Works)*

Increase in the bending angle of pipe's branches relative to the values regulated in GOST 24950-81 (angle on a single tube of type 1 is not more than 6°, the radius in any part of the branch is not less than 40D), without critical exhaustion of metal plastic properties in the process of bending and subsequent operation, can be achieved by using the pipes of K60 strength class with increased strain capacity (for APR zones).

The FEM procedure has been used to estimate the deformation level and residual stresses in the bends of pipes of Ø1420×21.7 and 25.8 mm for the Asia-Pacific Region zone. The areas of maximum strain and residual stresses for different methods of pipes' bending have been determined. It has been shown that at the initial moment of bending the strain is concentrated on the inner part, and then it moves to the outer part of the pipe. The strain distribution is not symmetrical, and depending on the bending pitch the considerable increase in the level of local deformations is possible. Residual stresses are concentrated in the "neutral" zone and in the region of the longitudinal seam.

The types of structural states of pipe steels K60 and K65, providing increased strain capacity of the metal due to the presence of the structural components with significant differences in the type, morphology and strength characteristics in the steel structure, are considered. The possible technological options of obtaining target structural states and the desired properties of sheets and pipes (with comparable results) in the industrial conditions of Russian and foreign enterprises are presented.

Reduction in strain capacity of the pipe metal K60 by heating it during the coating process is demonstrated.

The development process of metal structure and properties under the influence of the strain hardening processes and aging, depending on the manufacturing processing route of pipes' branch production using pipes with factory-type coating or without it, has been analyzed.

The research experience summary for high-strength steel pipes' resistance to extended destruction (about the development of the field tests Atlas for the pipes of K65 strength class)

*A.B. Arabey (Gazprom PJSC),
A.G. Glebov, L.M. Kaputkina (NUST MISiS),
A.I. Abakumov, A.S. Smirnov (RFNC-VNIIEF),
T.S. Esiev, S.E. Yakovlev (Gazprom VNIIGAZ LLC),
I.U. Pyshmintsev, A.O. Struin (ROSNITI JSC)*

One of the most important tasks at the stage of designing the system of trunk gas pipelines from Yamal Peninsula was to ensure the economic efficiency of the project. The solution to this problem, taking into account the need for the construction of an extended high-pressure gas pipeline from the region with difficult climatic conditions, was found only by using high-strength pipes with high operational reliability and durability parameters.

In order to ensure, verify and confirm the characteristics of the new-generation pipes, Gazprom PJSC together with a number of research teams organized and conducted a complex of laboratory, bench and field tests. Significant importance in this test complex was paid to the field pneumatic tests of the experimental stalks. Conducted between 2008 and 2014, field pneumatic tests of pipes became the final certification stage for the manufactures involved in the supply of pipes for the construction of Bovanenkovo – Ukhta TGP. The test results allowed to develop the requirements for pipes of K65 strength class in the terms of their resistance to extended destructions, specify them in a separate document – Technical requirements, and ensure the launch of these pipes into production, as well as to approve the technical conditions for pipes.

The need for large-scale experiments to simulate the effect of the operational pipeline destruction required the development of new methodological approaches to the organization and technological tooling for tests, the interpretation of their results. The possibility of using K65 strength-class pipes of 1420 mm diameter at the pressure of 11.8 MPa without additional measures aimed at preventing extended destructions (pipes banding, crack dampers installation) was experimentally proved. The analysis of accumulated experimental data from conducted tests was classified in the form of Field tests atlas with characteristics of trial stalks, detailed description of test conditions (temperature, pressure, type of backfilling, etc.), visually observable effects in the case of trial stalks destruction, the analysis of pipes' bent fractures. The Atlas, along with the examples of pipes classified by their ability to inhibit the dynamic crack propagation, also includes the analysis of "abnormal" test cases, in which it was not possible to provide a predetermined trajectory of the crack development. The systematical Atlas material became the basis for the development of a computer model of an extended ductile fracture of the gas pipeline.

About the development of technical requirements to composite pipes

M.V. Simakov, V.A. Egorov (Gazprom VNIIGAZ LLC)

Gazprom VNIIGAZ LLC has conducted works on the development of requirements to pipe products made of polymeric composite materials for the facilities of Gazprom PJSC.

Within the frameworks of this work Gazprom VNIIGAZ LLC has collected data on the international experience of using pipes and pipe products made of composite materials at the natural gas production, processing, transportation and storage facilities.

The practice of manufacturing oil and gas pipelines on the base of composite materials faced a number of technical problems that require scientific study and research.

The disadvantages of polymer composite pipes include:

- very high "gas permeability" of the material, that increases proportionally to the increase of the wall stress in the multi-layered pipe, which may lead to delamination of the inner coating or a layer at depressurization;
- the lack of reliable gas-leakless fittings of the pipe products made of polymer-composite materials;
- the current lack of a common approach to the estimation and justification of performance characteristics and quality assessment methods for multilayer and reinforced pipes made of polymeric composite materials.

The main advantage of polymer-composite pipes if compared to steel pipes is their high corrosion resistance. There is no need to use the system of active corrosion protection of gas pipelines. Also there is no need to apply external anti-corrosion coating on the pipes in factory and field conditions.

The current regulatory-methodical documentation of the Russian Federation does not contain regulatory documents covering the questions of design, construction and operation of polymer composite gas pipelines.

The novelty of this work consists in the proposals on the use of pipes and pipe products made of polymeric composite materials at the facilities of Gazprom PJSC, which have been developed for the first time within the frameworks of the system approach, and the technical performance requirements to pipe products made of polymeric composite materials have been justified.

Development and qualification testing of methods and technologies for welding repair of pipe defects and welded joints of underwater gas pipeline crossings in welding-assembly chambers, caissons and in aqueous medium

*E.M. Vyshemirsky (Gazprom PJSC),
S.P. Sevostyanov, R.O. Ramus (Gazprom VNIIGAZ LLC),
S.G. Parshin (Peter the Great St. Petersburg Polytechnic University)*

The methods and technologies for welding repair in welding-assembly chambers, caissons and in aqueous medium, which are used for repair of underwater gas pipeline crossings, are presented. The factors, affecting the significant changes of thermal-physical properties of arc and shielding gas, the intensification of metallurgical processes of oxidation and hydrogenation, the occurrence of gas pores and nonmetallic inclusions, the degradation in arc stability, microstructure changes in the case of underwater welding, are presented. The report describes the scope of works and the sequence of operations for qualification testing of methods and technologies for welding repair of pipe defects and welded joints of underwater gas pipeline crossings in welding-assembly chambers, caissons and in aqueous medium. The requirements to the process of development of the program on qualification testing of technologies for dry hyperbaric welding repair of pipe defects and welded joints of underwater gas pipeline crossings in caissons and in aqueous medium are presented. The possibility of using facilities, intended for testing of welding equipment and technological processes at industrial pressure up to 60 meters of water column, has been estimated. The use of coated electrodes and flux-cored wires for underwater welding in hyperbaric conditions in caissons and in aqueous medium has been considered.

Strategic approaches to quality assurance of pipe products for advanced projects of Gazprom PJSC

P.P. Stepanov (OMK JSC)

United Metallurgical Company (OMK) is one of the major domestic manufacturers of pipes and connection pieces for trunk pipelines, railway wheels and other metal products for energy, transport and industrial companies. The priority line of activities of the company is provision of projects and enterprises of Gazprom PJSC with high-quality pipe products (pipes and fittings). At present, the company has established an efficient production chain aimed at assurance of high quality of products for the gas industry involving priority use of pipe material (sheet and coiled rolled stock) of the company's own making.

Systematic work with Gazprom PJSC in the area of mastering the manufacture of innovative pipe products is performed within the scope of Technical Cooperation Programs that are updated periodically with regard for results of work and setting new tasks. The Cooperation Program for years 2015–2020 includes joint applied researches involving the potential of Corporate Engineering & Technology Center (ETC) of OMK JSC, the tasks of which include both organization and conduction of research work and engineering follow-up of manufacture. The research is conducted in the Research Laboratories Center (RLC) which is a division of ETC. The RLC complex is provided with unique research equipment and manned with high-class specialists. Implementation of a system approach to pipe products quality assurance is the cause of priority participation of the company in execution of advanced projects of Gazprom PJSC such as Nord Stream, «Turkish Stream», «Strength of Siberia», etc.

Today, the pipe complex of OMK JSC is prepared to supply innovative products complying with the strictest technical requirements for projects of Gazprom PJSC.

**New welding technologies with the application of contact flashing
welding equipment sets development of regulatory documents
for welding and quality control of welds**

*I.G. Samorodov (Gazprom PJSC),
V.I. Khomenko, A.N. Terenin (Pskovelektrosvar CJSC),
V.M. Silkin, S.P. Sevostyanov, Yu.A. Soloviev
(Gazprom VNIIGAZ LLC)*

Works aimed at the implementation of contact butt welding by flashing during the construction of trunk pipelines is a comprehensive project being implemented along two directions.

The first direction being implemented by Pskovelektrosvar CJSC together with MRTS JSC, Stroitransgaz CJSC, NUTsSK Welding & Control at Bauman MGTU is the development of equipment for welding complexes for welding, burr removal, thermal treatment and control of welds.

The second direction being implemented by Gazprom PJSC, Gazprom VNIIGAZ LLC, NUTsSK Welding & Control at Bauman MGTU, ITs Politekhtest (FGAOU VO SPbPU), Pskovelektrosvar CJSC is the development of the necessary regulatory documentation – STO Gazprom «Instruction for automatic contact flashing welding of butt pipe joints for construction of pipelines».

The presentation describes the current status and perspectives of the application of contact butt welding by flashing in the construction of pipelines.

**Application of electromagnetic and thermal process simulation
in induction heating systems when designing equipment
for accelerated thermal treatment of ring weld joints
on high-strength pipes**

A.A. Pismenny (Pskovelektrosvar CJSC)

Automatic contact welding by flashing joints of heavy-walled pipes has proven its high reliability by a long-term operating experience of pipelines of various purposes, including gas pipelines. Reliability of the technology of welding and thermal treatment of ring joints is ensured by a modern level of comprehensive equipment automation in combination with high efficiency. At the same time these welds are characterized by high mechanical properties.

To ensure normative parameters of impact viscosity for joints of pipes made of high-strength steel a post-welding accelerated thermal treatment of weld and near-weld area is used which is implemented using the method of induction heating.

Implementation of the numeric method of end elements for simulation of thermal fields in induction heating by solving the problem of distribution alternating-current electromagnetic fields allows designing, with acceptable accuracy, the induction systems which ensure a localized transfer of thermal power to the object of treatment and minimization of thermal impacts which cause excessive softening of metal outside the area of treatment.

Practical results of measurements of temperature fields during induction treatment of welded abutting joints on pipes have proven the adequacy of models being designed to the actual conditions.

Mastering of production technology for electric-welded pipes of unique standard size for Kirinskoye field

*A.B. Gizatullin, A.A. Fedyaev (ChelPipe JSC),
T.S. Esiev, S.E. Yakovlev (Gazprom VNIIGAZ LLC)*

An important factor in reaching the competitive level for such companies as ChelPipe JSC is its steady development, allowing it to form firm demand for its products.

The Company pays special attention to participation in promising and high-tech pipeline projects, both Russian and foreign ones. One of such innovative directions is the project on development of field electric-welded pipes 508×22.2 mm – SAWL 450 I FD and 508 24.9 mm – X65 with 3-layer outer polyethylene coating for land and underwater pipelines of the Kirinskoye gas-condensate field (GCF).

The Russian pipe companies did not take part in the supply of pipes for the first phase of the Kirinskoye GCF infrastructure development, due to the lack of technical capabilities for manufacturing welded pipes with a diameter of less than 530 mm.

ChelPipe JSC is the only one Russian company, that has decided to master the production of pipes of such «inconvenient» size, starting its works on this project in the spring of 2015. The analysis of the manufacturing process for production of the pipes of the mentioned-above type has shown that the main technical complexity of their production is small internal diameter which, taking into account the tolerances of out-of-roundness, curvature and wall thickness, is at the operational limits of equipment of the electric-weld pipe workshop «Height 239». An additional problem was caused by unfavorable ratio of wall thickness to diameter of the pipes and the expected, due to this fact, change in the metal properties in the process of pipe processing.

Within the shortest possible period of time ChelPipe JSC has developed and implemented a complex program of measures for modernization and updating of equipment in order to manufacture the pipes of that type. And in August 2015, together with the specialists of Gazprom VNIIGAZ LLC the qualification of the processing technology for the manufacture of pipes for Kirinskoye GCF has been carried out, technical specifications on the products have been developed and approved.

Thus, the construction of the second phase of the domestic project of Gazprom PJSC will be carried out using the pipes produced in the Russian Federation.

Evaluation of the defects acceptability for welded joints taking into account the non-destructive testing capabilities

A.S. Kurkin

*(FSAI R&E Center of Welding and Control at Bauman
Moscow State Technical University)*

The technology of automated welding under the factory conditions should theoretically provide the complete absence of defects. Any control method, that detects certain types of defects, can contribute to the process of solving this task. However, manual welding under the site conditions almost inevitably leads to the occurrence of defects. The tendency to eliminate all identified defects leads to the occurrence of other defects during the repairing process. Meanwhile, «completely defect-free» welded joints certainly contain some defects, which haven't been detected by applied testing method.

Existing standards of defects acceptability include the categories of defects, such as cracks, which are considered to be completely unacceptable, regardless of their size. This creates a dead-end situation, in which the opportunity to continue production relies only on the imperfections of control means.

When deciding on the acceptability of the detected defects, the information obtained by using the applicable non-destructive control method is used. This information is always incomplete. X-ray inspection gives a fairly objective view of the shape and size of one of the defect's projection, but does not allow to estimate its location over the wall thickness of the pipe. These ultrasonic testing results are more complete, but require some interpretation, the results of which are not always unambiguous. Almost none of the control methods allows to reliably identify the type of a defect (distinguish incomplete fusion from slag inclusions or pores).

The computer-aided simulation of the pipeline service process makes it possible to evaluate the possibility of destruction caused by various defects taking into account the amplitude value and number of loading cycles. The calculation results have allowed to develop additional requirements to control means and methods, required to assess the strength and service life of the pipelines. First of all, at least approximate data on the defect size regarding the wall thickness parameter (direction of a defect) and its distance from the outer and inner surfaces of the pipe is needed. Upon availability of such information, the permissible size of a defect along and across the weld can be significantly increased.

Some data may be obtained from the information on the welding origin of defects in a welding seam. It can be reasonably expected that the size of defects in the direction across the welding seam does not exceed the cross-sectional area of one bead of a multiple-bead weld.

The question of the mutual influence of neighboring defects is the least studied one. The conditions of defects combination into a single defect are significantly different in various industry standards. The ratio of the amplitude and the number of loading cycles of trunk pipelines is of such value, that significant growth of defects during the service life is only possible in the

conditions of their large sizes (in this regard the largest of three sizes of a defect has the least impact on the durability), as well as the location of the defect near the structural stress concentrators. In this regard, even closely-spaced small defects can be considered to be of a single type, since their coalescence during the service life is unlikely.

It makes sense to introduce such changes in the defects acceptability standards and methods of their application, that will ensure safe operation and reduce over-rejection rate at the same time.

Analysis of the welding technology for large-diameter pipes manufacturing

*A.A. Velichko (Severstal PJSC, Izhora Pipe Mill CJSC),
I.P. Shabalov (Pipe Manufacturers Association)*

1. Review of changes in technical requirements to large-diameter pipes.
The increase of the operational pressure of gas pipelines required the increase of the impact resistance of the base metal to stop the extensional destruction.
2. The main factors of the welded-joint properties of the longitudinal seam of pipes.
3. Dependence of the welded joint impact resistance on the cooling rate after the welding process.
4. Non-uniformity of the mechanical properties of the heat-affected zone depending on the structural state of the metal in this area.
5. Cooling rates for heat-affected zone at the different types of welding.
Multi-arc welding under a protective flux layer, laser arc welding, assembly welding, laser welding.
6. Morphology of various sections of heat-affected zones, depending on the rate of heat input and the properties of the cooling surface.
7. Laser-hybrid welding of large-diameter pipes.
8. Properties of the welded joint of the laser-hybrid welding for large-diameter pipes.
9. Prospects for mastering the production of large-diameter pipes of X100 strength class.

Organization of repair of pipes for repeated application and pipeline fittings using welding and plasma gouging technologies in Gazprom transgaz Tchaikovsky LLC

A.Y. Kotolomov (Gazprom transgaz Tchaikovsky LLC)

The report presents repair performance results for pipes having both corrosion and stress-corrosion defects and for ball valve casings with nominal diameter 400–1000 having welded seam and casting defects discovered during major overhaul of process pipelines on compressor stations and insulation coating overhaul carried out on a linear part of the trunk lines.

The report gives application examples of automatic plasma gouging completed with rectilinear belts having magnetic fastening for defective spots sampling: longitudinal factory welded seams, extended corrosion and stress-corrosion damages on the external surface of pipes.

Peculiarities of manual plasma gouging when sampling local defective spots of welded seams and basic metal defects on the pipes and ball valve casings with the subsequent welding of the sampling spot have been considered.

The report indicates the required procedure to certify repair technologies by basic metal welding and welded seams of pipes and ball valve casings.

The report shows the experience gained last year while repairing 470 pipes with nominal diameter 1400 in accordance with “Temporary Instruction for the Use of Automatic and Manual Air-Plasma Gouging for the sampling of the pipe and pipeline component defects caused by corrosion and stress-corrosion”, approved on July, 31st, 2014, by A.A. Filatov, the Head of Major Overhaul Department, Gazprom PJSC.

The report analyses inspection and repair management details for the pipes with nominal diameter 1400 with stress-corrosion defects for the purpose of their repeated application in the third category areas of a linear part of the trunk line in various conditions: in route pipeline bases, open production sites of trunk gas pipeline production management, as well as in plant conditions of the pre-production shop in the Technology Engineering Centre of the Company. The data on auxiliary equipment and mobile shelters provided for the above-stated production sites have been cited.

**Welding joints diagnostics with radiographic method
of nondestructive inspection under pressure, without gas
transmission interruption in conditions
of Gazprom transgaz Ukhta LLC**

*A.N. Tovstyj, E.A. Dasis, N.K. Kharlampidi
(Gazprom transgaz Ukhta LLC)*

The subject of report is related to necessity of radiographic diagnostics of welding joints of TGP with large diameter and big wall thickness, admitted abnormal by results of ILI under acute gas deficit conditions, when gas transmission interruption is not possible due to commercial, technological or other reasons. With commissioning of TGP facilities designated for continuous gas supply for export, when gas transmission interruption even for several minutes is related to a lot of difficulties, this topic's importance has significantly grown.

The task of radiographic inspection of welding joints of pipes of large diameter and large wall thickness is complicated with presence of water molecules, etc. together with mechanical impurities in a gas pipeline body, that diverge Roentgen rays. Therefore, radiographic images are blurred, not clear and low in contrast, and their quality in these conditions do not correspond with RD.

Method of radiographic inspection of pipes of large diameter (DN 1400) and large wall thickness (over 20 mm) under pressure, without gas transmission interruption.

The results were provided for radiographic inspection of welding joints conducted under conditions of uninterrupted gas transmission.

A conclusion was made, that thick-wall welding joints of large diameter pipes diagnostics with radiographic method of nondestructive inspection without gas transmission interruption is possible upon application of according materials, conditions, equipment and correctly developed inspection process.

Practical application of piping products with high strain capacity in Gazprom PJSC gas pipelines design

S.N. Aleksandrov, O.A. Mayorova (Giprospetsgaz JSC)

Contemporary standards of pipelines design assume calculation by the first and the second limit state – by destruction and deformations limit. Therewith, both are expressed through tensions limiting conditions appearing in the pipes material, in particular – tensions shall not exceed some part of standard yield strength of a pipe. Such is a classic design approach to main trunk pipelines that found its reflection in regulatory documentation of the Russian Federation.

Recently, Giprospetsgaz JSC specialists often face information about performance of research in the field of application of piping products having high strain capacity. Standardised characteristics of these piping products (ultimate strength, yield strength, etc.) do not differ from «normal» pipes, and it does not allow to obtain any benefits using them with application of a classic pipelines design approach. Such pipes can undergo deformations exceeding «yield strength» deformations without loss of normal operational capacity. It makes us consider rethinking the «classic» approach to design of main trunk pipelines, with account of modern technologies development.

The first step on the way to creation of design standards based on pipeline ultimate deformations limit, and allowing to use the advantages of highly deformable piping products to full extent, is «Recommendations to application of HIPER pipes with high strain capacity within the areas of active tectonic faults, in the areas of high seismic activity and permafrost».

The most relevant in our opinion is application of «highly deformable» pipes at facilities with complicated construction conditions. The moment has come when it is necessary to create a «mechanism» for their practical application, therefore it will give a push to further improvement of piping products characteristics and Russian piping transport reliability.

Interrelation between the carbon equivalent of high-strength pipe steel grades and their response to thermal cycle of welding

*L.A. Efimenko, A.A. Ramus, D.E. Vyshemirsky
(Gubkin Oil & Gas University)*

Response of steel grades to the thermal cycle of welding is one of the key parameters of weldability. It is expressed in the specifics of structure-phasic conversions and changes of the complex of their properties.

The objective of this work was the research of the impact of the chemical composition on their response to the thermal cycle of welding.

The research was performed on low-carbon high-strength pipe steel grades micro-alloyed by strong carbide-forming elements. Their characteristic feature is a low carbon content and presence of such carbide-forming elements as Nb, V, Ti. The value of carbon equivalent varied from 0.35 to 0.54 %.

External pipes factory-applied polyethylene coatings

*A.P. Sazonov, V.V. Lihatsky, A.V. Latyshev, E.V. Petrusenko
(Gazprom VNIIGAZ LLC)*

The report provides information about currently used factory-applied pipes external polyethylene coatings used on Gazprom PJSC facilities is presented at construction and renovation of gas pipelines.

Sectorial standards and changes thereof representing main requirements to certification and application of polyethylene coatings in factory conditions are provided.

On the basis of R&Ds and tests of materials properties, designs of new types of polyethylene coatings for pipes have been developed.

Using pipes with polyethylene coating for application of internal anti-friction and external hydro/thermal insulation coatings has been considered.

Perspective materials of local manufacturers for anticorrosive polyethylene coatings for protecting pipes from corrosion in factory conditions and their application technologies have been reviewed.

Strain diagram and fracture development process for drop-weight tests

*A.B. Arabey (Gazprom PJSC),
A.G. Glebov, L.M. Kaputkina (NUST MISiS),
T.S. Esiev (Gazprom VNIIGAZ LLC),
A.I. Abakumov (FSUE RFNC-VNIIEF),
I.Yu. Pyshmintsev (RosNITI),
B.A. Sarychev (MMK OJSC)*

Among the most important parameters evaluated during the acceptance tests of large-diameter pipes there are stress-to-rupture tests of pipe metal samples using drop-weight testing (DWT) method. In accordance with regulatory requirements, «the amount of the viscous component» in the fracture of samples should not be less than 85 %. However, the specific character and variety of fracture structures of DWT samples, especially when testing high-strength high-viscous steels, often make the results of evaluation very subjective and controversial, which significantly reduces the potential capabilities of this type of testing.

In recent years, researchers pay a lot of attention to the use of instrumented DWT methods with strain (destruction) diagrams plotting in the coordinates of «force – distance» or «force – time». The prospective of using deformation (strain) diagrams during DWT of high-viscous steels of a new generation is the ability to:

- separate the processes of crack origin and crack development;
- match the topographic and energy parameters of the test to specific areas of destruction;
- estimate the steel viscous operation capability without using data on the amount of viscous component in the fracture.

Extensive researches were carried out in the Central Laboratory of MMK OJSC at the instrumented impact tester DWT40 IMATEK on the samples of steel of K65 strength class of 27.7 mm thickness, which have been taken from the metal sheets of MMK OJSC and from the pipes produced by ChelPipe OJSC. The tests have been conducted within a temperature range from plus 20 to minus 80 °C with an increment of 10 °C.

Previously unknown correlations between topographic, geometric and energy parameters of the samples, destroyed during DWT with the topography of different zones (areas) on the surface of fractures, resulting from the propagation of destruction, have been determined. The correlation of the studied parameters with strain diagrams, obtained in the course of DWT, is shown.

Split tees production project in Russia

O.V. Kondratyeva (TDW Eurasia LLC)

Gazprom PJSC pays particular attention to the matters of import substitution and conducts a methodical work on arrangement of import substituting products manufacture at domestic enterprises. Under implementation of import substitution program, jointly with Gazprom VNIIGAZ LLC, T.D. Williamson Company in 2015 localised production of new generation split tees LOCK-O-RING® PLUS at the territory of the Russian Federation. Production is a part of TDW Eurasia LLC. By 2017, all nominal sizes of tees with diameters up to DN 1,400 mm will be produced at a Russian plant; therewith 100 % of consumables and component units will be substituted by components produced in Russia.

Report considers in detail all the stages of production arrangement in Russia, provides production organization structure and level of localization from 2015 to 2017 with yearly breakdown.

Anisotropy of pipe steels mechanical properties after thermo-mechanical controlled treatment

*I.Yu. Pyshmintsev, A.O. Struin, V.D. Kvashnin
(RosNITI JSC),*

*A.M. Gervasyev, R.Kh. Petrov
(Ghent University, Belgium)*

The article provides research of anisotropy of strength, plastic and viscous properties of ferrite-bainitic pipe steels K65 with different structure parameters. It was determined that strength properties are minimal in longitudinal (L) direction, mediocre – in thickness direction (Z direction) and are at maximum in transverse (T) direction in relation to the direction of sheet rolling (pipe axis). Therewith anisotropy of strength properties is not big, it actually changes with reduction of testing temperature and reaches 100 MPa by yield limit and 50 MPa by temporary resistance.

Anisotropy of viscous properties is expressed significantly stronger that strength properties'. Impact strength in T and L directions amounts minimum 250 J/cm² at minus 20 °C, and in Z -direction – 30 J/cm² maximum at the same testing temperature. Low viscosity in Z direction determines inclination of the researched steels to formation of splits at expansion of ductile fracture (brittle cracks parallel to sheet rolling plane). Analysis of the considered steels' micro-structure and crystallographic texture has shown that inclination to formation of splits is determined by a number of micro-structural factors, including predominant position of split planes {001} in parallel with the rolling plane, morphology of micro-structure elements and size and type of MA-component distribution.

Laws of stress corrosion cracks development in pipe steels of X70 strength class in model ground electrolytes with pH close to neutral

I.V. Ryakhovskikh, R.I. Bogdanov (Gazprom VNIIGAZ LLC)

The results of diagnostic tests of pipelines' sections in Russia and abroad have shown that regardless of the manufacturer of pipes and pipelines operating modes the stress-corrosion cracking defects (SCCD) occur only when the metal surface is in contact with a ground electrolyte in the areas of protection coating delamination and damage.

The work is based on the results of corrosion and mechanical tests of samples made of steel of X70 strength class. To study the stage of forming colonies of cracks, the cyclic tests on full-thickness samples of pipes' metal with maintenance of their original degree of curvature have been conducted. The rate of cracks development into the metal depth was determined on the girder-type samples under static and cyclic loads. The citrate buffer (pH 5.5) and the solution mixture of NS_4 and borate buffer (pH 7.0) have been used as the background mediums modeling the ground electrolyte. The background mediums have been added with substances which are components of the natural ground electrolyte, as well as with known corrosion inhibitors and hydrogenation promoters (HG) of the metal.

The development of cracks was found to occur on local metal damages formed during the manufacture of pipes or steel production. Non-metallic inclusions have a significant impact on the SCCD steel resistivity characteristics. A negative effect of increased content of polygonal ferrite in the case of structural banding on steel resistance against SCCD has been proved. The metal anodic dissolution (AD) activators (sulphide, carbonate ions) accelerate the cracks' development process into the metal and AD inhibitors (benzotriazole, catamine AB) decrease its rate. HG steel promoters have no influence on SCCD (iodide ions). Cathodic polarization of the pipe steel inhibits the cracks' development rate under static and relatively-small cyclic loads.

The results of these works are included in the current regulatory documents of Gazprom PJSC in the field of laboratory testing of pipe steels on its SCCD resistance and ground-based diagnostic tests of gas pipeline sections.

Study of metallurgical factors influence on corrosion-cracking resistance parameter of modern pipe steels

*K.A. Udod, I.G. Rodionova, O.N. Baklanova, A.Yu. Kazankov
(FSUE I.P. Bardin Central Research Institute for Ferrous Metallurgy)*

Modern pipe steels, used for manufacturing of large-diameter pipes, are significantly different from the steels of previous generations. These steels with high carbon content are characterized by high stability of their chemical composition, higher purity regarding harmful impurities and non-metallic inclusions, as well as more homogeneous macro- and micro-structure characteristics. At the same time, since modern gas steels have been operated only for a short period of time, there is no data on their resistance to local types of corrosion, especially to the stress-corrosion cracking.

Most studies dedicated to the stress-corrosion cracking of metal pipes, consider local corrosion damage or localized electrochemical corrosion as the first or initial stage of stress-corrosion cracking process. The direct cause of local steel corrosion is the presence of non-metallic inclusions breaking to the pipe surface.

The objective of this work is to estimate the influence of metallurgical factors on corrosion-cracking resistance parameter of modern pipe steels.

Special features of the welding process for dissimilar steels of the different structural classes with regard to process support pipelines

*V.V. Brovko, N.V. Kobernik
(FGAU R&E Center of Welding and Control at Bauman
Moscow State Technical University)*

The main features of the welded joints of process support pipelines are a wide variety of steels welded together and the high quality requirements set for welded joints. For process pipelines a non-consumable electrode welding in inert gas medium is used, of both types: manual and automated orbital welding. This welding method is the most universal and provides the maximum quality of welded joints that can be achieved. For welding process pipelines, used for support and maintenance purposes, dissimilar joints welding is often needed. For example, it is often necessary to weld stainless steels of the austenitic class with pearlite-class heat-resistant steels, because valves are usually made of stainless austenitic steel, and a pipeline – of pearlitic steel. Composition of steels of different structural classes sets certain restrictions on the welding technology in terms of heat input.

Nowadays, the impulse technologies are widely used, especially for automated orbital welding. These technologies allow to form a high-quality weld in «suspended» mode in different positions, but the heat input can be different (compared with continuous processes). Therefore, this work is aimed to study the peculiarities of the automated non-consumable electrode impulse arc welding in inert gas medium of corrosion-resistant austenitic steels and pearlitic heat-resistant steels. The possibility of obtaining a welded joint with the desired mechanical properties without its preheating and subsequent heat treatment is considered.

**Present-day lines of training of welding production,
non-destructive testing and construction inspection specialists
involved in construction, repair and operation
of gas transport system facilities**

*N.A. Anisimova, S.P. Sevostyanov, Yu.A. Solovyev, O.V. Chikhanova
(Gazprom VNIIGAZ LLC)*

The paper presents experience of Gazprom VNIIGAZ LLC in organization of comprehensive training of specialists in welding production and non-destructive testing of Gazprom PJSC subsidiary companies and contractor organizations for mastering of up-to-date methods and processes used in construction, operation and repair of gas transport system facilities.

In view of implementation of Gazprom PJSC's investment projects, development of high-end technologies ensuring good quality of work in the area of welding and welded joints inspection, improvement of regulative and technical documentation of Gazprom PJSC, one of important lines of activities is forward-looking, comprehensive training of highly skilled personnel.

The specific feature of training is implementation of joint educational projects coordinated by a scientific organization (Gazprom VNIIGAZ LLC). Joint participants are producers of welding and non-destructive testing technologies, leading research centers and educational organizations. The paper presents examples of joint educational projects of years 2014–2015:

- training of welding specialists in application of manual and machine welding technologies (Gazprom VNIIGAZ LLC – St. Petersburg Peter-the-Great Polytechnical University); training of non-destructive testing specialists in application of new methods of non-destructive testing: automated ultrasonic testing (Gazprom VNIIGAZ LLC - ANO UIC RONKTD Spektr of academician V.V. Kluyev);

- mechanized ultrasonic testing (Gazprom VNIIGAZ LLC – Altes LLC).

The paper presents also a review of professional development programs for specialists in radiographic inspection: using radiographies digitizing and archiving systems, digital and computerized radiography systems developed by Gazprom VNIIGAZ LLC.

Innovative solutions of GE Inspection Technologies for gas transmission facilities productivity and operation reliability improvement

*A.A. Ustinov, A.L. Stepchikov
(GE Inspection Technologies)*

The report presents information on equipment in the field of nondestructive inspection. Ultrasound, radiographic, eddy-current, video-endoscopic equipment of GE Inspection Technologies used for improvement of productivity and reliability of gas transmission system facilities operation.

Unique properties and parameters will be demonstrated, proved by obtained experimental and practical results.

Flat detectors DXR250C-W, DXR250U-W enable obtaining results of high class in the most severe conditions. Memory plates based scanner CRxVision equipped with innovative functions for productivity improvement, plate life extension and assurance of great image quality, CRxVision was developed for welding joints inspection in particular. The scanner was developed covering the strictest requirements

X-ray tube ERESKO300MF4 reduces exposure time by 3-5 times at radiographic inspection in the field of CR/film application, where geometric enlargement is especially required.

MMK OJSC is a reliable supplier of rolled metal products for gas production industry

S.V. Denisov, P.A. Stekanov (MMK OJSC)

In 2009 MMK OJSC put into operation the unique Russian production complex, that includes units for steel smelting, finishing and casting, block 5000 with the rolling force of 12 thousand tons, and a heat-treatment facility, and has no analogues in the domestic industry. This complex allows to produce the hot-rolled plate not only for pipe industry, but also for bridge and ship construction, both for above-water and underwater products.

In 2014, the Government approved the national program on development of the Arctic zone of the Russian Federation. One of the objectives of this Program is to expand the base of raw materials in the Arctic Region. This area will require the development of new areas of mineral resources, the construction of gas and oil pipelines, gas treatment facilities, liquefaction plants and terminals for transferring the liquefied natural gas. The implementation of this Program will also help to develop the area of civilian shipbuilding, in particular through the production of gas transportation ships with innovative technologies for domestic marine field for transferring liquefied natural gas and the tankers for transportation of high ice-class oil for operation in the Arctic Region and the Far East. In addition, the introduction of «breakthrough» technologies, such as the development of advanced manned underwater technical means as part of a technology platform «Ocean development» is planned.

Implementation of all projects in this area will require the use of unique high-strength cold- and corrosion-resistant metal units, operating in extreme climatic conditions. This complex of steel properties is provided by the optimal steel purity and formation of the required microstructure of rolled metal products.

The existing complex of processing equipment of MMK OJSC will allow to produce advanced rolled metal products without additional costs and/or increase production volumes of cold- and corrosion-resistant rolled metal being produced nowadays.

Experience in application of automated ultrasonic testing method for international projects

V.V. Pankov, D.S. Pomerantsev (Olympus Moscow LLC)

Olympus Company is the recognized worldwide leader in the production of automatic ultrasonic testing (hereinafter – AUST) systems that fully comply with the requirements of international standards in the field of pipelines construction and control, such as DNV-OS-F-101 «Submarine Pipeline Systems. Offshore Standard», DNV-RP-F118 «Pipe Girth weld AUT system qualification and project specific procedure validation. Recommended Practice», ASTM E-1961 «Standard Practice for Mechanized Ultrasonic Testing of Girth Welds Using Zonal Discrimination with Focused Search Units» and API 1104 «Welding of Pipelines and Related Facilities».

In our report we would like to tell about the experience in application of AUST systems in the process of trunk gas pipelines construction by our key partners, construction and contracting organizations: Oceaneering, Saipem, RTD APPlus and others. Show main advantages of AUST method, statistical calculations, and give an estimate to the method effectiveness on the basis of international experience.

Automated ultrasonic testing instead of radiographic testing

*V.G. Badalyan, A.Kh. Vopilkin
(Scientific-production center «ECHO+» LLC)*

The advantages and disadvantages of radiography and automated ultrasonic testing with coherent data processing (AUT) are considered. The information content and the sensitivity of these methods are compared. The possibilities of measuring the size of defects in radiography and AUT are analyzed. It is claimed that detectability and the error in determining the geometric dimensions of the defects using AUT method with coherent data processing is sufficient for practical purposes.

An example of the application of the system with coherent data processing for testing austenitic welded joints of thick pipelines (up to 45 mm) is given. The pipelines are used for catalytic cracking complex construction. The works timing report showed that the period of AUT of one welded joint of 508×34 mm did not exceed 60 minutes, with the possibility to conduct other installation works at the same time.

Program on development of the import-substituting production capacities for welding equipment

I.E. Voronin (VELDER LLC)

Our company operates in the market of welding equipment since 1998. At that time our company was named Inverter Plus LLC and began its operation together with EWM Company. The objective of this period is to study the products and bring EWM products to the Russian market.

In 2003 our company was renamed as VELDER Company. The main direction of our activities is to develop our own production of competitive, import-substituting welding equipment.

At the moment, we continue to cooperate with EWM Company and provide technical support to their equipment in the Russian Federation. There are some other partners among European companies: SELCO, TBI, Scomes, Fortrans, etc. But they are the suppliers of components for our production.

Nowadays, the main part of our business is the equipment that we produce ourselves:

- our own developments: equipment for mechanized MIG/MAG welding; control systems of welding machines; wire-feeding units for TIG and MIG/MAG welding;
- the projects on joint production of inverter units for MIG/MAG and MMA welding within the frameworks of cooperation with European companies;
- cooperation with the Russian developers of power inverter modules and digital control systems.

Planning our works, we rely on the results of meetings with the consumers of our products. For us the experience of cooperation with Gazprom OJSC for more than 15 years is invaluable.

At the previous conference I reported about our new product – VULCAN 315. We consider this device to be an alternative to our well-advertised welding power source PICO 300 (EWM).

Today, we can say that VULCAN proved not only its competitive technical parameters, but also its high reliability during operation in the real field conditions. Out of the several hundreds of products manufactured in our Company, more than 250 of them go through periodical maintenance in our Company. Assessing their state, we make conclusions about the reliability of these devices.

We are currently working on a new version of this product and we hope that in the nearest future we will be able to offer it for testing to our partners. We plan to decrease two parameters – weight and price.

This year we have started mass production of Converter power source SCAT 520 – it's an extension of the product range of Scat Series.

Recently, on the basis of power sources of SCAT Series we have launched full-scale production of a more powerful model SKAT 520N3. This is a special model of the source, which will be used in automated welding and surfacing units.

The product has excellent power characteristics: 100 % DC at 400 A load. The use of the electronic choke developed by our Company simplifies

unit's adjustment and allows to obtain excellent results for automatic and mechanized welding in the conditions of shielding gases and their mixtures, self-shielded wire welding, welding and surfacing under the flux layer. The device has a function of MMA welding.

This is only a part of our plans on developing new products for the nearest future. At the present time, we are conducting negotiations with the well-known European company for implementation of the following project: «Present-day production of inverter welding power sources at VELDER LLC premises».

In this regard, I would like to bring up the problem that concerns the issues of developing our own production capacities. The market is extensively saturated with equipment produced abroad under the brand name of the Russian company. These companies are registered as domestic producers. Thus, in violation of the Presidential Decree of 23.01.2015 No. 31 «On additional measures against illicit turnover of industrial products», the interests of the Russian producers and consumers of welding equipment, our market opens its doors to unscrupulous suppliers. Under the conditions of an expensive dollar, to remain competitive, unscrupulous producers neglect quality, reliability and safety characteristics.

I believe that producers and consumers should consolidate their efforts to react against this situation. The specialists involved in equipment certification should act in the interests of our country.

Inductive-heating equipment

S.A. Rachkov

(Research and Development Enterprise «ELTERM-S» LLC)

The report presents a series of medium-frequency inductive-heating equipment produced by R&D Enterprise «ELTERM-S».

The equipment is used for pre-heating and additional heating of welded joints during construction and repair of pipelines, including pressure tapping on existing trunk gas pipelines without interrupting the gas transmission process.

In addition, the equipment can be used for post-welding heat treatment, and also for heating the outer surface of the pipe prior to applying to it the protective coating.

The manufactured equipment range includes units' power values from 16 to 630 kW at the frequencies from 250 Hz to 10 kHz. It is operated in field conditions, at factory workshops, at line operation sections and combined heat and power plants.

Most units with the power from 30 to 50 kW are used for heating and heat treatment for pipe welding processes. More powerful units (160–630 kW) are used for tapping on gas pipelines without interrupting the gas transmission process and for re-insulation of pipelines. The report presents some innovations.

The company develops and manufactures inductive-heating equipment for various technological purposes, which is designed for hardening, soldering, deposit welding and heating with further mechanical deformation.

Prospects for Equipment: expanding the size range in the terms of power, development of specific powerful and reliable heating units, increasing the units' automation level, flexibility in operation, the replacement of similar imported equipment by the units produced by Research and Development Enterprise «ELTERM-S».

Application of induction heating method in oil and gas industry

N.I. Petridi, D.I. Kurtua (KATRAN LLC)

KATRAN Company, being a part of TD KURAY Corporation, is a developer and manufacturer of heat-treatment equipment. It provides services for heat treatment of welded joints, and also provides training and certification for "heat treatment operators".

Most of the products manufactured by KATRAN Company are designed for oil and gas industry:

- compact and reliable units PPCh-20-10 and Interm-63 for pre-heating and concurrent heating of welded joints with unique inductors;
- powerful and multipurpose units of Interm and TP6 Series for heat treatment of welded joints both in shop and highway conditions;
- induction complexes of PPCh Series, solving the problem of heating before insulation coating, pipe bending, production of sharply-bent branches and necks drawing, production of T-shape bends;
- steel-making and hardening complexes for shafts and gears.

In 2015, the products of KATRAN Company are included in the «Register of auxiliary equipment and materials for welding and installation works» of Gazprom PJSC.

Cooperation with KATRAN Company allows you to get a full range of equipment, consumable materials and services for heat treatment in one place.

SESSION E

**CONSTRUCTION, REPAIR AND CORROSION PROTECTION
OF GAS TRANSPORTATION FACILITIES**

28–29 October 2015

Practical experience of microturbines operation at gas pipelines facilities and new sterling engine-based solutions

A.A. Skorokhodov, S.E. Grechkin (BPC Engineering LLC)

1. Experience in the application of ENEX microturbine power plants on gas pipelines infrastructure facilities in Russia and Kazakhstan.
2. Uninterruptible power supply at strategic locations.
3. Advantages of microturbines at remote sites. Reliable unmanned operation with remote control and monitoring.
4. New solutions of reliable and efficient power supply for gas transmission infrastructure with the use of new power plants ENEX 7.5 based on free piston Stirling engines with a unit power output of 7.5 kW and flexible scalability.

Pipes re-insulation technologies in depot and field conditions

*A.P. Sazonov, V.V. Lihatsky, A.V. Latyshev
(Gazprom VNIIGAZ LLC)*

The report provides information about corrosion protection coatings currently used on Gazprom PJSC facilities in depot and field conditions.

Sectorial standards and changes thereof representing main requirements to certification and coatings application in depot and field conditions are provided.

On the basis of R&Ds and property tests of primers, mastics, reinforcing and wrapping materials, equipment for hot and cold application of coatings used now for gas mains re-insulation in field conditions has been developed.

Perspective materials and structures of coatings on their basis for protection against corrosion of connecting elements, assembly units and valves in depot and field conditions have been considered.

Perspective anticorrosive coatings for protecting pipes against corrosion in depot conditions and their application technologies have been also considered.

Determination of optimum process parameters for manufacture of cold-bent curves

K.V. Polikarpov, Yu.A. Mayants (Gazprom VNIIGAZ LLC)

At present, the basic normative documents regulating manufacture of cold-formed bends in Russia are GOST 24950-81 and SP 86.13330.2012 (SNIIP III-42-80*). In elaboration of said normative documents, Gazprom VNIIGAZ LLC, by order of Gazprom PJSC, conducts development of Gazprom standard «Instruction for manufacture of cold-formed bends in factory and field conditions».

The paper:

- considers the issues of development of mathematical models for the cold-formed bends manufacture process with regard for their processability features;
- proposes a procedure for calculation of main process parameters of cold bending;
- presents results of field and laboratory tests conducted together with Trubodetal OJSC;
- shows the ways to increasing bend angles.

Development of algorithmic support for ultrasonic corrosion rate evaluation device

S.V. Savchenkov, E.A. Spiridovich (Giprogazcentr JSC)

Using results of earlier research, a concept was proposed for an ultrasonic corrosion rate evaluation device that has broad prospects of application in remote corrosion monitoring systems as a stationary meter, and prototypes of the device were manufactured.

Specific features of the device are inclusion of ultrasonic transducers of various types as well as development and implementation of a unique algorithm that allows not only highly accurate determination of the corrosion process development rate but also identification of its type.

Said algorithm is based on the use of individual features of various types of ultrasonic transducers and on original experimental models using the data obtained in the course of specially conducted research.

In the course of the above-mentioned research, the following results were obtained:

- the value of the first bottom echo signal of a combined-type transducer can be used as a quantitative characteristic in corrosive damage identification;
- influence of various factors on bottom echo signal amplitude variation in the stationary measurement mode have been studied (the sensor design does not allow movement of transducers);
- experimental relationships have been obtained that allow estimation of influence of various factors;
- models have been developed for evaluation of geometric parameters of local corrosion defects positioned in the acoustic field of the transducer, and their adequacy has been estimated using statistical criteria.

Russian innovative technology protection of pipes and pipeline components ZUB-Kompozit

A.V. Plavin (BT SVAP LLC)

In 2014 specialists of SVAP LLC developed an innovative Russian technology ZUB-Kompozit for protection of pipes and pipeline elements from alternately directed impacts and loads of various natures at the stages of transportation, construction and operation.

ZUB-Kompozit coating assures protection from mechanical damage of anti-corrosion coating of steel pipes, pipeline components and joints, protection of thermal insulation and waterproof coating of pipes, protection of polymeric and composite pipes and pipeline components.

Application of ZUB-Kompozit coating for protection of pipelines which are being constructed by horizontal directional drilling is an efficient technical solution. Absolute absence of risks related to the damage of anti-corrosion pipe protection, reduction of anti-corrosion protection coating, absence of necessity to use costly protective sleeves, savings related to pilot pipes and other aspects ensure a high level of economic efficiency and allow reducing the duration of construction period.

ZUB-Kompozit coating can be used for pipeline lining when using suspended ballasting systems (UChK, UTK, UBO, etc.).

Areas of above-normative proximities of pipelines to hazardous production facilities and residential developments represent a promising field of innovative coating application. In such a case ZUB-Kompozit coating is successfully used as a compensating measure in the development of Special Specification.

As of today, a complete complex of ZUB-Kompozit coating tests has been completed in compliance with the Program and Procedure developed by Gazprom VNIIGAZ LLC. Test results have demonstrated a high level of coating strength. For instance, impact energy below the damage of the pipe anti-corrosion protection by a steel sheet is 50 J, and the impact energy withstood by ZUB-Kompozit without ACC is 5,500 J.

By now SVAP LLC has prepared standard technical solutions for application of ZUB-Kompozit coating taking into account different construction conditions.

Application of the innovative coating will allow increasing the level of industrial and environmental safety of Gazprom PJSC.

Limit tolerance states of cold bending branches made of pipes with high strain capacity

*I.P. Shabalov, V.Ya. Velikodnev, V.S. Kalensky
(Pipe Innovation Technologies LLC)*

For trunk pipelines construction in the areas with compound relief form the cold bending branches of $40D$ radius are used. The pipe branch parameters depend mainly on the size of the pipes and the technological capabilities of machines of different manufacturers, and the mechanical, geometric characteristics and reliability characteristics of a pipe branch are currently controlled after its manufacture. The use of pipes with high strain capacity in the production process makes it possible to manufacture cold bending pipe branches of the smaller radius due to the toleration of higher plastic deformations of the metal. In this case the distribution of metal elastic and plastic deformation values in the course of bend manufacture, the superposition of deformed zones at the several steps of bending, etc. become very important factors. To analyze these factors, mathematical simulation of metal deformation in the course of manufacturing the branch using the coated pipe of K60 strength class for the Asia-Pacific Region zones has been performed. The numerical model takes into account the physical and geometric non-linear properties of the pipe coating, as well as the formation of the corrugations in the compression zone during the pipe branch manufacturing process.

The simulation results allowed to determine geometrical changes during pipe branch manufacturing process, the area size and the level of plastic deformation, the level of residual stresses. The dependences of the plastic deformation values, residual stresses, as well as the size of the corrugation from the single bend size are presented.

The results of this study allow to identify the critical areas and determine their parameters, to justify the optimal technological mode of pipe branch production. Based on the simulation results, that have been obtained during the study, the preliminary conclusions on the possibility of manufacturing cold bending branches using the pipes with high strain capacity have been made, and the conditions of their reliable use in the gas pipeline have been determined.

Design analysis of the strain state of cold bending branches in the pipeline during its operation

V. Ya. Velikodnev

(Pipe Innovation Technologies LLC),

R. V. Unesikhin

(Center of Expertise of Pipeline Systems and Engineering LLC)

The objective of this work is to analyze the value of extreme internal forces and deformations occurring in the cold bending curves at various stages of operation under the influence of permanent, temporary and special loads (in particular, the seismic forces for high-seismic activity and active tectonic fractions areas).

To reach this objective, a pipe of 1420 mm diameter and 25.8 mm thickness of K60 strength class ($R_{1H} = 590$ MPa and $R_{2H} = 480$ MPa) has been studied. As a primary design model, a Z-shaped linear pipeline with turns from 3 to 18° formed of cold bending curves with radius of 40 to 60 m has been considered.

The options of design models with turns in the vertical and horizontal planes have been considered. For all design cases the following parameters have been varied: radius and angle of cold bending curves, various types of ground content for pipe laying (from sands to clay soils).

The analysis of the results, obtained in the course of design calculations, allowed to determine dependencies between the stress-strain state in the wall metal of cold bending curves and the parameters, which have been varied in the course of developing the final types of design models.

During this analysis a parabola strain dependence on the turning angle at a fixed bending radius with a prominent extremum, in contrast to the expected monotonic strain decrease with increase of the radius, has been determined.

The work includes the comparison of the stress-strain state of cold bending curves and the curves formed with induction heating.

The conclusion considers the stress-strain state in the pipeline, taking into account the residual longitudinal stresses typical for the cold bending pipe branches.

Choosing method of gas pipelines repair. Equipment applicability depending on selected method

*A.S. Panov, V.V. Susanin, A.I. Zenkin
(Kropotkin Engineering Plant (KrEMZ JSC))*

The main methods of trunk gas pipelines are regulated by Gazprom PJSC standard (Gazprom STO 2-2.3-231–2008 «Rules of works execution at trunk gas pipelines line part overhaul»). Methods selection depends on pipeline state and is justified with the data of diagnostic survey.

For each of the regulated STO methods, Kropotkin Engineering Plant produces required hardware, machines and devices, as well as stationary lines for pipelines cleaning and insulation, pipes repair bases.

Special attention is paid to cleaning machines, because quality of piping corrosion-proof coating recovery significantly depends on quality of pipe cleaning from damaged insulation coating and surface preparation for application of new insulation.

It was determined that re-insulation works cost, including earthworks, clearing from old insulation and application of new insulation amounts to the most part of repair estimate cost. Then goes insulation materials cost and only then – cost of cleaning and insulation machines. Economically it is better to use more reliable and automated modern machines enabling to reduce the influence of human factor.

Currently at the stage of completion, the Plant has a project of portable Bases for repair of pipes insulation with application of extruded polyethylene or polyurethane coating. Under condition of such Bases placement in direct proximity of the repair facilities, places of pipes storage, etc., positive sides of their application are obvious – such as reduction of transportation costs, relatively low power consumption, variability, capability of swift use of recovered pipes at gas pipelines repair.

On the use of composite bandages for increasing the strength of main gas pipelines at crossings of active tectonic faults

*M.A. Kurganova, E.S. Nosova, O.V. Trifonov, V.P. Cherniy
(Gazprom VNIIGAZ LLC)*

Analysis of efficiency of strengthening of underground steel pipelines by composite bandages under active tectonic fault effects has been performed. In the developed 3D model, pipeline was regarded as a elasto-plastic steel shell with bandage represented as the orthotropic elastic shell, and surrounding soil was simulated as a continuous medium. The model accounted for elasto-plastic soil behavior, contact interaction between soil and pipeline, considerable non-elastic deformations, pipe section deformations and possibility of local stability loss.

Efficiency of using composite bandages for pipelines strengthening have been analyzed on the basis of limiting conditions criteria. It has been demonstrated that the use of bandages in highly loaded pipeline areas result in essential decrease of pressure and pipe wall deformations. Bandage thickness, its position in relation to the fault plane and the length of strengthened part on maximum permissible soil displacements in the fault have been investigated.

Calculation of strength characteristics of the heat-insulation layer for pipes with ballast coating

*E.V. Petrusenko (Gazprom VNIIGAZ LLC),
S.V. Melikhov (BT SVAP LLC)*

The report presents information about the development of normative requirements to thermal isolation of pipes and the connecting parts applied in factory and field conditions.

Pipes and connecting elements intended for application of thermal isolation should have a corrosion protection coating.

Requirements to thermal insulation materials and the coatings intended for thermal isolation to be applied in field conditions at execution of construction and repair works on facilities of Gazprom PJSC 1420 mm pipelines with operation temperatures minus 40 °C to plus 140 °C are formalized in temporary technical requirements approved in 2014.

In factory conditions, thermal isolation consists of a polyurethane heat-insulation layer enclosed in protective polyethylene or zinc-plated steel cover. In total, as per 01.09.2015, nine factories passed certification and have specifications on pipe products with thermal isolation approved by Gazprom PJSC.

To check a possibility of applying ballast coatings on pipes with anti-corrosion coating and thermal isolation, strength characteristics of pipes heat-insulation layer with a ballast coating have been estimated. Calculations estimated the reserve strength ratios of different-diameter pipes with thermal-insulation layers at different schemes of loading. Specifically, potential lifting options of pipes with coatings and thus occurring stresses have been reviewed, and most critical stress zones at different methods of structures slinging the control of which will provide safe pipes handling at all stages of production and construction works have been defined.

New opportunities and approaches in designing and manufacturing of mobile technological complexes in the interests of Gazprom PJSC

A.V. Gerasimov, A.A. Makarov (TechProm LLC)

The report presents new and innovative approaches to the design and manufacture of mobile workshops, laboratories, crew buses and other mobile facilities to support ever-increasing complexity of technical tasks.

A number of specific standards to mobile technical facilities, developed in compliance with requirements of Gazprom PJSC, and the practical solution approaches are proposed.

The results of studies of the functional characteristics of all types of mobile technological complexes in the field conditions are presented.

The necessity of a scientific approach to design and manufacture processes of mobile workshops, laboratories and other facilities ensuring maximum efficiency of regular technological equipment in the field conditions is verified.

The developments of TechProm LLC are described, in particular: innovative technical solutions and the materials used in design and manufacture of mobile technological complexes, which are supplied to a number of subsidiaries of Gazprom PJSC.

The key points of the report verify a new approach to the issues on development, production and use of mobile process components (workshops, laboratories, etc.) of high technical level, that ensures the efficient operation of these special machines, efficient use of the existing technological equipment, reasonable financial support for this issue.

Split tees production project in Russia

O.V. Kondratyeva (TDW Eurasia LLC)

Gazprom PJSC pays particular attention to the matters of import substitution and conducts a methodical work on arrangement of import substituting products manufacture at domestic enterprises. In 2015, within the framework of import substitution program implementation, jointly with Gazprom VNIIGAZ LLC, the company T.D. Williamson, a production of new generation of split tees LOCK-O-RING[®] PLUS was localized on the territory of the Russian Federation. Production facility is a part of TDW Eurasia LLC. By 2017, all nominal sizes of tees with diameters up to DN 1,400 mm will be produced at a Russian plant; therewith 100 % of consumables and component units will be substituted by components produced in Russia.

The paper presents in detail all the stages of production arrangement in Russia, describes the organizational structure of production and localization degree from 2015 to 2017 with a breakdown by years.

New approaches to certification of products – as an efficiency improvement point of Gazprom PJSC companies

E.G. Chekalev (SC Intra LLC)

In the current situation of sanctions and unpredictable behavior of foreign partners the question of technological independence of the Russian companies becomes of great importance. Gazprom PJSC, as one of the most important elements of the Russian economy, is obliged without doubt to have an easy opportunity to quickly switch from foreign suppliers of goods and services to the Russian ones. Among the obstacles to the technological independence there seems to be the process of new products' certification.

The procedure, approved by Gazprom PJSC, implies the existence of internal technical regulations. However, due to its novelty a new product is not always described in the standards of the company and has to pass a very long way from the development of internal regulations of Gazprom PJSC to pilot works on the new product. This can take several years.

One of the ways to overcome bureaucratic barriers and speed up the certification process is to use the pilot operation procedure, that has been already tested at other major Russian oil and gas companies (Rosneft, Lukoil, Bashneft, Tatneft).

The report describes the main stages of the certification process. Ways to maintain operational safety of products, which have been certified according to the updated certification procedure. Experience of these procedures application.

The proposed certification scheme allows Gazprom PJSC to achieve the following important goals:

1. Instant savings by switching to Russian components.
2. Technological independence from foreign suppliers.
3. The speed of response to market challenges.
4. Decision-making flexibility.

Application of textile materials on gas transmission construction facilities. Stages and development prospects

G.R. Gabelaya (Gazprom StroyTEK Salavat CJSC)

Experience in textile materials application in gas transmission systems construction in Russia to date has history of over thirty years. At present textile materials are actively applied virtually in all conditions of pipelines construction. At that, their scope in the overall share of applied materials is on a constant rise.

The main fields of textile materials application are:

- pipelines ballasting;
- erosion-preventive systems;
- road and site foundations.

In the initial period of textile materials implementation, the technical requirements were forming on the basis of already existing materials being applied in other industries. A broad complex of research conducted in the eighties of the 20th century by leading institutes enabled creation of new for that moment in time materials for oil and gas industry in particular.

As of today, the main characteristics of textile materials are strength, ultimate elongation, climatic and chemical resistance. Applicable to date regulatory requirements allow producing durable and reliable products.

Until recently, mostly imported raw materials were used for textile materials manufacturing. In the modern economic conditions a trend has occurred for development of domestic productions.

The conducted analysis demonstrated that the most efficient way to organize manufacturing of products of textile materials ensuring the maximum products quality is arrangement of full production cycle from a fibre to complete product.

Gazprom StroyTEK Salavat CJSC being a manufacturer and supplier of a wide range of specialized products of textile materials is carrying out constant work in engaging domestic materials in production.

Improvement in application procedures of pipeline pigs for trunk gas pipelines

*S.V. Karpov, A.S. Alikhashkin, D.I. Shiryapov,
A.Yu. Rakitin, A.V. Elfimov (Gazprom VNIIGAZ LLC),
K.A. Fazletdinov, A.K. Fazletdinov, E.K. Shakirov (Semigorje LLC)*

During the pre-commissioning operations on trunk gas pipelines a broad range of pipeline pigs is used for pipeline interior cleaning, for separation of liquid and gaseous media during filling of pipeline sections for hydraulic tests and test medium removal after testing, for removal and spreading of remaining moisture over internal pipe surface in the course of drying, and for estimation of pipe geometry in the constructed section using gauging disks.

Unification of technical requirements for pipeline pig materials and design makes it possible to increase efficiency of their use, to improve the approach to selection of particular pig types and designs for performing some or other process operations, and to mitigate risks of pig seizure, incomplete contamination removal, damage of internal anti-friction coating of pipes or destruction of pigs during pigging.

In view of the above, Gazprom VNIIGAZ LLC in cooperation with Semigorje LLC have developed technical requirements for pigs used for cleaning and drying of trunk pipeline cavities, and recommendations for pig using in construction and repair of linear portions of Gazprom PJSC's trunk gas pipelines.

In the course of development of technical requirements for pipeline pigs, we analyzed physical and chemical properties of polyurethanes used for manufacture of disks and cups mounted on pigs; as a result, requirements for physical and chemical properties of components were developed. In addition, requirements for pigs of various types, designs and modifications were established including maximum movement speed, minimum pig running life until unacceptable wear, and working pressure difference at pigs during their movement.

Recommendations for pigs application were developed in elaboration of the technical requirements; they take account of various conditions of pre-commissioning operations and stage-by-stage manner of strength tests of different gas line sections.

Normative aspects of quality control for trunk gas pipeline interior drying

*D.I. Shiryapov, S.V. Karpov, A.S. Alikhashkin, A.V. Elfimov,
A.Yu. Rakitin (Gazprom VNIIGAZ LLC)*

One of the most important quality criteria for pre-commissioning operations performed on trunk gas pipeline is the condition inside pipelines, process vessels and apparatus. This is understood as both the absence of contamination or foreign objects and a low moisture content of the medium that fills pipelines and equipment.

Development of requirements aimed at standardization of the pipeline drying technology as applied to specific natural and engineering-geological conditions characteristic for various sections of trunk pipelines makes it possible to optimize the process of pipeline preparation for natural gas transportation and to improve its efficiency, thereby shortening the time of putting constructed or repaired trunk pipeline facilities into operation.

In this connection, Gazprom VNIIGAZ LLC has developed a procedure for conduction of trunk pipeline drying under various natural and climatic conditions; the procedure establishes requirements both for the order of drying of cavities in trunk pipeline facilities and for measures aimed at improvement of drying efficiency. Said measures take account of conditions under which the work is performed and technical data of the equipment used.

Special attention is given to performance of inspection procedures in conduction of drying; among other things, sampling points on the pipeline are indicated, and measures for elimination of influence of external factors on measurement accuracy are established. In addition, duration of the holding period for the dried pipeline section is defined, and the procedure for dried gas line section testing for the absence of remaining moisture is prescribed. Pressure ranges at which pipelines dried by vacuuming must be held for testing their tightness and during final inspection of drying quality are established. The necessary plots illustrating the physical essence of the drying process, and computational relationships for calculation of various drying process parameters are presented.

Application of protective and repair-recovery coatings using technology of thermal spraying and surfacing in the organizations of oil and gas industry

A.V. Kalachikhin (Plackart CJSC)

Plackart CJSC is a leading Russian R&D and manufacturing organization, by own efforts developing and applying technologies of thermal spraying (TS) and surfacing for protection from corrosion and wear and tear, based on conditions of equipment operation, for oil and gas extraction, transport, storage and refining. The company performs optimized selection of materials, application modes and equipment for spraying and surfacing.

We help our partners:

- to increase parts life span by improving operation properties;
- to increase parts reliability, reduce prime cost of their manufacturing and maintenance;
- to reduce products' resource and power consumption;
- to reduce costs for repair and procurement of expensive components, including imported ones;
- to reduce equipment downtime in repair;
- to replace expensive structural materials with cheaper ones, with coatings that are easier to treat.

Gates and seats of gate valves with sprayed coatings under import substitution program successfully substitute imported analogues in well-control equipment since 2007. During this period, Astrakhanskoye gas & condensate field was supplied with about 150 gates, 300 gate seats, 250 seat rings with sealing surface reinforced with tungsten carbide applied using method of high-speed thermal spraying.

No cases of malfunction were registered.

One of the most important issues of import substitution is ball valves manufacturing with «metal-over-metal» packing. Plackart CJSC possesses technologies of application and packing of coatings based on tungsten carbide, stellite, inconel and nickel-based materials.

Experience of MIC materials and technologies application in compressor manufacturing:

- manufacturing piston rods and plunger pistons with reinforcing coatings (piston rods of 5G600 compressor have worked for over 20 000 hours at Omsk Refinery);
- manufacturing parts of flow part with flow anti-adhesion coatings;
- application of seal running-in coatings;
- recovery and reinforcement of seal housings of rotors, shafts, bearings;
- electrolytic coatings replacement;
- corrosion protection in the presence of hydrogen sulfide, carbon dioxide;
- erosion protection.

Using additive technology enables production of complex parts with inside curve-linear holes, not available for production with other methods of

treatment. Direct CAD manufacturing and no need for great many re-installations of a part on a bench enables to obtain micron-accurate product

«Spramet» protection system is a registered trademark of Plackart CJSC and consists of multi-layer coating of thermally applied metal on the basis of Al, Mg, Zn alloys; impregnating compound, primer and finishing coat. «Spramet» protection system is an economically justified alternative to paint-and-lacquer coatings and has a significant advantage in thermal and mechanical properties, as well as in service life span. «Spramet» protection system, by the virtue of protective properties, protects the surface of a metal structure even at mechanical damage to the coating.

Thermal spraying technology of «Spramet» protection system does not lead to metal structure heating over 150 °C, which in turn does not result in thermal warp distortions, adhesion indicator is 50 MPa.

Since 2010–2014, «Spramet 114» protection system has started being applied onto parts of exhaust line (GPU exhaust shafts, GPU muffling chambers, flare tips, fire tubes) in 8 gas transmission and gas extraction organizations of Gazprom PJSC.

Successful experience in application of metal-sprayed coatings at Astrakhan gas complex was awarded with Gazprom award in the field of science and engineering for 2012.

Overhaul Department of Gazprom PJSC extended duration of expert opinion on Plackart CJSC readiness for execution of works in UGSS facilities repair and maintenance, and also pronouncement of organizational and technical readiness for works execution was received from Gazprom Gaznadzor JSC.

Automation of pipe welds insulation methods in field conditions

E.V. Petrusenko, N.I. Savostina (Gazprom VNIIGAZ LLC)

Technical requirements to coatings for insulation of pipelines welded connections are specified in STO Gazprom 9.1-017-2012 «External protective coatings for ring welded connections of pipelines. Technical requirements» and provide a possibility of using different types of coatings depending on requirements of pipelines operation conditions. At that, the main type of coatings used for corrosion protection of gas pipelines welded joints are thermosetting materials (TSM) – collars or sleeves.

In the course of applying on welded joint TSM intended for operation at temperatures up to +60 °C, shotblasting treatment and heating of metal in the weld zone to temperature of at least +90 °C should be provided. Recommendations concerning heating temperatures for all TSM, supplied by specifications approved by Gazprom PJSC have been considered. TSM application techniques in field conditions is a labor-consuming problem, and violation of technology results in considerable loss of quality of welds corrosion protection.

To increase insulation application efficiency on welded joints, different proposal for automation of technology of works in field conditions have been considered, among which are:

- induction heating of the welded connection zone;
- using coating infra-red heating equipment;
- using mobile coatings extrusion equipment;
- using shot-blasting treatment.

Development of inhibited polymeric compounds to prevent a risk of stress-corrosion cracking on trunk gas pipelines

*A.B. Arabei (Gazprom PJSC),
V.E. Ignatenko, Yu.I. Kuznetsov, A.I. Marshakov,
M.A. Petrunin, Vo Thanj Tien (IFHE RAS),
R.I. Bogdanov (Gazprom VNIIGAZ LLC)*

Statistics of incidents in the gas transportation system Gazprom PJSC and the world experience of high-pressure gas pipelines operation have shown that the problem of stress-corrosion cracking (SCC) prevention still represents a concern. Due to the above, together with the implementation of measures aimed at the improvement of repair work quality, a task of creating protective coatings looks promising. These coatings must not only insulate metal from the exposure to aggressive environment but contribute to the prevention of repetitive development of SCC-related defects.

The purpose of this work is the development of the method aimed at the modification of the protective coating which will ensure a slowdown of pipe steel SCC process and, at the same time, preserve high adhesion, water resistance and resistance to the cathodic disbandment of coating.

In the course of the work bituminous polymeric coating was modified by the introduction in its primer of inhibiting compounds (IC) based on nitrogen-containing compounds, carboxylates, polymolybdenum acids and organosilicone compounds in quantity amounting from 1 to 4 weight %. Comparative laboratory tests of adhesive strength, water resistance and resistance to the cathodic disbandment of protective coating used in gas pipeline insulation in field conditions, as well as of experimental (modified) protective coating, were conducted. Separately the impact of IC on the rate of expansion of already existing crack with a static load of a specimen, as well as the resistance of steel to cracking under slow stretching of specimens, were researched. Tests were conducted in model ground electrolytes with pH = 5.5 and pH = 7.0 which did not and did contain hydrogen sulfide.

Based on the results of mechanical corrosion tests the tested ICs were ranged based on their ability to reduce the time till the formation of microcracks on the steel surface and decelerate the expansion of already existing crack. It is demonstrated that the best adhesive characteristics in the coating are achieved by the compound containing the inhibitor IFHAN-29-ACh and organosilicon compounds. Based on the results of comprehensive laboratory tests inhibited bituminous polymeric coating is recommended for pilot plant tests.

Identification criteria for geomagnetic stray current sources

*A.A. Zubkov (Stroygazmontazh LLC),
R.V. Aginey (Giprogazcentr JSC)*

A geomagnetically induced current is a varying in time electric current generated in soil as well as in subsurface steel pipelines and other extended in space conductors under influence of geomagnetic field variations and associated variations of electric field on the Earth surface. The presence of a geomagnetically induced current leads to variations of the pipeline polarization potential in time. This effect was observed on pipelines located in Europe, North America, Australia. The effect of geomagnetically induced current on a pipeline may lead, in a number of cases, to the pipeline lower operating reliability and to occurrence of interference that hamper polarization potential measurement and do not allow accurate determination of the degree of pipeline protection by electrochemical protection equipment. For the domestic practice, the processes of geomagnetically induced current generation in subsurface pipelines are relatively new and understudied, since they manifest themselves mainly in line portions of trunk gas pipelines with a high transfer resistance of the insulation coating, the line being galvanically isolated from other lines. When studying stray currents, it is extremely important to ascertain their geomagnetic nature for making correct decisions during subsequent operation.

The relevant technical literature presents information on identification of non-classical geomagnetic stray current sources on the basis of the following features: singleness of the stray current source, the absence of current leakage in/out at the area boundaries, the absence of a variable component of frequencies multiple to the commercial frequency in the pipe-ground potential difference; however, these criteria are insufficient for reliable identification of the source.

As a result of studies conducted on a pipeline susceptible to influence of stray currents of geomagnetic nature, criteria have been developed for more precise identification of such sources, including results of analysis of pipeline polarization extremums dependence on potential difference buildup speed, frequency spectrum of variation of the potential and other properties.

About the revision of requirements to polarization potential monitoring for underground steel constructions

*N.A. Petrov, N.N. Glazov, D.N. Zapevalov (Gazprom VNIIGAZ LLC),
A.V. Goncharov (Transneft R&D LLC),
M.A. Bashaev (VNIIST OJSC)*

The existing requirements and practice of using the polarization potential as a standard parameter for the evaluation of electrochemical protection against corrosion of underground constructions have been studied. The analysis of polarization potential measuring methods, applied tools and equipment, main methodological and instrumental measurement errors has been conducted. The limitations of measurement methods and applied measurement tools and devices, the errors in the course of practical inspection significantly limit the information content and reliability of the results and results-based conclusions about the state of electrochemical protection. The state estimation of corrosion protection systems for new trunk pipelines with high-quality protective coating and a minimum amount of through defects can be carried out without the polarization potential control. At the same time, the control of the polarization potential at the points of formation and development of corrosion defects, which is performed by special inspection organizations, allows to evaluate the intensity and the hazard of corrosion effects and reasonably and rationally adjust the solutions to protect against corrosion.

The accumulated contradictions require a revision of the practical methods of polarization potential measurements. The necessity of updating the regulatory requirements for evaluation and control of electrochemical protection systems of trunk pipelines has been explained, the proposals of updating documents at corporate and federal levels have been developed.

The analysis of laboratory methods for polarization potential measurements in modelling environments

I.U. Kopyev, A.M. Pushkarev, N.N. Glazov (Gazprom VNIIGAZ LLC)

The effectiveness control of the corrosion protection system, in particular – the measurement of the polarization potential is of great importance for ensuring reliability of underground facilities operation. One of the methods of measuring the polarization potential of underground constructions is to measure the potential of the auxiliary electrode when switching off its polarization current. However, this method may have certain limitations that may cause incorrect evaluation of construction's protection level during electrometric measurements in field conditions.

The report presents the results of laboratory tests on the relation between the measured value of the polarization potential and various combinations of soil resistivity and protective current density values, as well as measuring methods and individual characteristics of various measuring tools.

The analysis of test results has showed that in the case of soil resistivity of more than 200–300 Ohm·m (and/or in the presence of cathode deposits on the auxiliary electrode) and the polarization current density of more than 0.5 mA/cm², the results of measurements of the polarization potential using the method of disconnecting the auxiliary electrode can significantly differ from actual values, depending on the measuring equipment being used in the particular case.

New developments of equipment for anti-corrosion protection by the company Chemservice

D.V. Savenkov, V.V. Pershukov (Chemservice CJSC)

The company Chemservice, being one of the leaders in the field of manufacturing of equipment for anti-corrosion protection of underground structures, has been continuously working on the improvement of manufactured products and development of new types of equipment.

The presentation contains information about new developments of the company Chemservice in the field of pipeline protection from corrosion. It provides a description of new models of monitoring and measuring instruments with built-in blocks of joint protection, corrosion rate sensors DSK-1 Mendeleyevets and exploitation time meters SVNE-2.

New variations of well-known anode grounding devices are presented which have been already manufactured for more than 20 years. Advantages and specific features of application of marginally soluble grounding devices Mendeleyevets-MR and extended grounding devices Mendeleyevets-MP are described which are manufactured on the basis of mixed metallic oxides. Optimum variants of application of new anode grounding devices are proposed in the most «problematic» areas of pipeline anti-corrosion protection system.

Cathode CJSC: electrometric potential measuring device DIABAZ

M.F. Khakamov (Cathode CJSC)

It is well known that high quality diagnostics of anti-corrosion protection condition is one of the most efficient tools for accident prevention at facilities of oil and gas industry, which are due to destructive power of corrosion. Cathode CJSC, manufacturer of high efficiency systems for electrochemical protection, proposes a new diagnostic tool – electrometric potential measuring device DIABAZ.

The device is designed for determination of structure-earth potentials characterizing protection level of underground infrastructure facilities using electrochemical protection means and insulation coating condition for these facilities.

Potential measuring is provided in versions of outer electrode and according to so called «intensive» technology with cathodic protection current interruption.

Measuring device enclosure is designed as a compact monoblock made of impact-resistant plastic with fastening of belts for chest carrying. Front panel comprises graphic LCD display with resolution of 128×64 pixels and a keyboard (12 keys) with digital and symbol keys.

Rear panel is a switchboard which serves for connection of measuring electrodes and remote GPS antenna.

Distinctive features of DIABAZ: light weight, low power consumption, interface simplicity, service solutions, availability of low frequency oscillograph channel, integrated GPS system.

Electrometric inspection using specified methods is performed in one electrode and three electrode versions. Several mathematical algorithms and GPS bit synchronizing are realized in order to synchronize operation of interrupters and measuring device in case of «intensive measuring». Measuring unit comprises three channel (with common earth – GND) microprocessor measuring and recording device, copper-sulphate non-polarizable electrodes and coil with a wire in order to provide continuous contact with the structure. When performing three electrode measuring using DIABAZ, positive values of lateral gradients are considered as normal, while negative values can indicate current running-off the pipeline and corrosion hazard of the defect.

The new device has an individual channel for oscillographic record of structure-earth signal form which provides as follows:

- to diagnose technical condition of cathodic protection stations (diode and thyristor converters);
- to evaluate technical condition of foot walks and electric insulation joints;
- to evaluate effect from intersecting pipelines and power transmission lines;
- to take measures for provision of required quality for measuring on AC.

Testing of anode ground beds made of low-solubility alloy CHS 15 at the experimental facilities of Gazprom VNIIGAZ LLC

*A.M. Pushkarev, N.N. Glazov, I.U. Kopyev
(Gazprom VNIIGAZ LLC)*

Anode grounding of cathodic protection units is one of the main elements of the electrochemical protection system, and its reliability determines the stability of the anti-corrosive protection of underground pipelines in general. As a result, reliability estimation for anode ground beds is an important task, which requires the conduction of endurance tests.

The report presents the testing results of finished anode ground beds made of corrosion-resistant iron-silicon alloy ChS 15 according to GOST 7769-82.

Initially, the fragments of anode ground beds were tested in NaCl water solution in laboratory conditions, which showed the influence of chrome content on the anodic ferrosilid dissolution. Fragments testing allowed to calculate the electrochemical equivalent for each sample.

To estimate the reliability of end products in general (including the contact unit and the conductive wire) the bench tests have been conducted for one year at different anode current densities.

The analysis of test results allowed us to perform:

- verification of the electrochemical equivalent for its compliance with the manufacturer's specifications;
- reliability estimation for the contact unit and the conductive wire;
- uniform alloy dissolution evaluation for an anode ground bed.

POSTER SESSIONS

28–29 October 2015

On formulation of criteria basis for evaluation of corrosion hazard under effect of alternating current

Yu.G. Petrova (Gazprom VNIIGAZ LLC)

With development of pipeline transport networks and high-voltage power transmission lines, the number of areas where trunk pipelines (TPL) and high-voltage power transmission lines (HVL) are located rather close to each other (parallel laying, crossings, approaching) is increasing. As a result of induction processes, alternating current is generated in the circuit «TPL – surrounding soil». Depending on a number of parameters (mutual position, pipeline insulation quality, HVL operating parameters, soil electric resistivity, etc.), the magnitude of the induced current can reach values that are hazardous in terms of development of corrosion processes in the pipeline.

It is known from the literature that the cause of the corrosive effect of alternating current lies in asymmetry of cathode and anode characteristics of steel, which leads to appearance of a direct component of current and displacement of the pipeline potential. On the basis of fundamental research and experiments, two criteria were formulated: by alternating current density that must not exceed 10 A/m^2 , and by potential displacement – not more than 10 mV. Several additional criteria were developed also for practical use: AC voltage «pipe-ground», relationship of AC and DC current density, critical length of parallel running of TPL and HVL. A direct criterion is directly measured corrosion rate (corrosion depth index) that must not exceed acceptable values of about 0.1 mm/year. In the absence of reliable data on corrosion rate, the remaining criteria should be used.

By optimum designing of the pipeline route near high-voltage lines, the magnitude of current induced in the pipeline can be reduced significantly. For pipelines operating near high-voltage lines, estimation of hazard of corrosion process manifestation must be performed. Application of several criteria allows more reliable estimation of the corrosive effect of alternating current. In case the criteria are not met, measures for reduction of alternating current influence must be taken.

Simulation of conditions of marine environment corrosive effect on pipeline steel

*S.N. Asharin, D.S. Sirota, A.N. Ulikhin, D.N. Zapevalov
(Gazprom VNIIGAZ LLC)*

Corrosion electrochemical behavior of St 3 steel in model marine environment was studied under effect of four factors: temperature, flow velocity, seawater salinity and tensioning stresses. A facility was designed and tried for studies of electrochemical properties of steel in moving media with simultaneous application of a load (in the elastic deformation area) to the working electrode. The significance of factors influencing the corrosion rate, stationary potential and corrosion potential of St 3 steel in model seawater has been revealed. The results obtained show intensification of running of corrosion process with maximum significance of the medium movement velocity under otherwise equal conditions. It has been found that the stressed condition of St 3 leads to de-enobling of the corrosion potential with intensification of corrosion processes running on the steel surface, and to an increase in corrosion rate.

Coatings for connections

*A.V. Latyshev, V.V. Lihatsky, A.P. Sazonov,
N.I. Savostina (Gazprom VNIIGAZ LLC)*

This report provides information about external protection coatings on the basis of thermosetting materials (polyurethane- and/or epoxy-based, powder melted epoxy compounds, etc.) for connecting parts used at present on Gazprom PJSC facilities.

We have developed the company standard of Gazprom PJSC STO Gazprom 9.1-018-2012, which establishes the necessary level of technical requirements to manufactured thermosetting materials and coatings produced on their basis, which are used for corrosion protection of connecting elements depending upon their operation conditions.

This standard regulates the maximum thickness of connecting parts protective coatings which should not exceed 4 mm. Limiting of the maximum thickness is necessary for successful application of coatings in conditions of the Far North where cracking of coatings produced on the basis of thermosetting materials it can be observed.

In the laboratory of protection coatings, expertize of specifications for new protection coatings of connecting parts, acceptance tests of insulation materials and attestation of their application technologies have been carried out.

It has been noticed that protective properties and service life of connecting parts coatings are defined not only by initial materials characteristics, but to a great degree depend on compliance with technological requirements at their application and pipelines operation conditions. Properties of thermosetting materials and coatings on their basis, and also their application technologies define the field of their use for protection of gas pipelines from corrosion in different soil/climatic conditions, and their maximal permissible operation temperature.

Repair of factory polyethylene coating of pipes

*V.V. Lihatsky, A.P. Sazonov, E.V. Petrusenko
(Gazprom VNIIGAZ LLC)*

The report presents information about the technology for repair of damaged areas of pipes factory-applied polyethylene (PE) coatings in shop and field conditions.

Factory application of three-layer PE coatings on pipes is a highly-automated process, which is equipped with multilevel diagnostics and troubleshooting systems, thus minimizing the probability of defects. However, complete avoidance of products quality gaps is impossible.

In Russia, experience of large manufacturers of pipes with PE coatings shows that the number of rejected pipes with such coating (which are to be re-insulated) is about 0.3–0.5 %, and the number of pipes subject to local repairs is from 0.5 to 1.5 % of the total quantity of insulated pipes.

Basic regulatory document for repair of pipes external PE coatings – RD 1390-001-2001 has been reviewed.

The following PE coatings repair technologies of have been analyzed:

- technology of repair of insignificant coating defects;
- repair technology of through and considerable defects up to the epoxy grout layer;
- repair technology of peeling adhesive and PE coating layers, and laminations in PE layer;
- repair technology by repeated application of adhesive and PE layers;
- repair technology of considerable by area non-through defects of PE coating layer.

It has been demonstrated that main causes of quality gaps at repairing the defects of PE coatings are the errors in choosing repair materials and violations of their application technology, among which violation of temperature modes is the most widespread.

Optimum regulation of electrochemical protection equipment working modes at gas transport facilities

S.A. Nikulin, E.L. Karnavsky (Giprogazcentr JSC)

At present, one of the main and pressing tasks for major gas transport operating organizations is corrosion monitoring. Corrosion monitoring is included in the anti-corrosion protection system and constitutes a part of the system of technical condition and integrity management of the gas transport system and of the decision-making preparation system. Corrosion monitoring requirements are set forth in STO Gazprom 9.4-023-2013 «Monitoring and prediction of corrosion state of facilities and equipment. Data collection, processing and analysis system. Main requirements».

The tasks allotted to the corrosion monitoring system are collection, accumulation and computational-analytical processing of information on corrosion condition of the protected facility and anti-corrosion protection equipment.

For solving the computational-analytical problem of optimum regulation of electrochemical protection equipment working modes at gas transport facilities, Giprogazcentr JSC conducted a number of research works, which resulted in improvement of protective potentials distribution models for gas transport facilities, development of basic optimization algorithms, development of solution procedures for the multi-criterion problem of finding optimum parameters using structural optimization principles.

For solution of the issue of automation of the required optimum CPE mode calculation process, by order of Gas Transport, Subsurface Storage and Use Department of Gazprom PJSC, specialists of Giprogazcentr JSC, together with Gazprom transgaz Nizhny Novgorod LLC, conducted a number of experimental works on operating gas transport system facilities such as a section of a trunk pipeline and an industrial site of a compressor station.

The results of the work were proposals for changing the electrochemical protection means working modes, which resulted in a 4-fold decrease in total power output of the equipment, which would lead to a proportional increase in the service life of electrochemical protection equipment (anode groundings). In addition, a part of the equipment was decommissioned. Therefore, the main result of the work for optimum regulation of electrochemical protection means operating modes is a significant reduction in operating costs of anti-corrosion protection of gas transport facilities.

Improvement of requirements to trunk gas pipelines with stress corrosion cracking defects

A.V. Melnikova, I.V. Ryakhovskikh (Gazprom VNIIGAZ LLC)

Among many surface defects of trunk gas pipelines (TGP) pipes, it is the stress corrosion cracking (SCC) defects that pose the biggest danger for the pipeline reliability point of view.

Majority of pipe steels SCC phenomenon researchers believe that stress corrosion cracks colonies at their early stage of development can be divided into two conditional groups: growing with at a constant rate and «stabilized» defects. Therewith, share of «stabilized» SCC defects of pipe metal among long-term operated TGP is quite high (over 90 %), and that is confirmed by stress corrosion damage rate analysis of gas pipelines of Russia and Canada.

The existing methods of TGP diagnostics with use of in-line defect detectors allow identification of a fracture with depth over 20 % of pipe wall thickness with acceptable probability, and external defect scanner provide detection of the above defects with depth from 10 % and more. Therefore, the main part of shallow SCC fractures cannot be identified by the results of diagnostic inspections of TGP sections, and thus stays in operation after re-insulation.

Due to that, justification of pipes operation capacity and possibility of long-term preservation of SCC defects with depth under 10 % of wall thickness and upon condition of ground electrolytic conductor access exception the pipe steel surface is an objective important to Gazprom PJSC.

Operation capacity assessment of pipes with SCC defects was conducted by the method R Gazprom 9.4-030-2014 of stress corrosion defects classification by grade of hazard, based on pipes strength assessment with account of defect's geometric shape, its development stage and pipes metal properties.

In order to confirm the performed calculations, a complex test program was carried out, and its results experimentally proved absence of development of cracks with depth under 10 % of pipe wall thickness at mechanical stress exceeding operational, under condition of exception of electrochemical component of SCC process, even with account of significant variable loads.

Full-scale pilot testing of SCC defects preservation possibility at TGP sections was supported by Gazprom transgaz Chaykovskiy LLC, Gazprom transgaz Ukhta LLC, Gazprom transgaz Yugorsk LLC.

Comparison of descriptive methods of underground trunk gas pipelines interaction with the soil in the domestic and foreign practice

E.S. Nosova (Gazprom VNIIGAZ LLC)

Numerical simulation and analysis of the strength of underground pipelines, laid in the areas with difficult climatic and geotectonic conditions, is not an easy task. It includes both the difficult-to-formalize nature of the pipeline interaction with the soil, and computational difficulties themselves, which are associated with spatial geometries, large deformations, the need to adequately simulate the mechanisms of local and overall buckling of the pipeline in the conditions of its non-linear contact with the soil.

The main engineering model for the calculation of pipeline sections in the terms of interaction with the soil is nowadays a beam model of finite elements method, which allows to take into account large displacements and plastic deformations of the system. Mechanical interaction of the pipeline with the surrounding soil is described using nonlinear couplings (soil-springs), which, depending on their orientation, transmit interaction of a pipeline with the soil in three orthogonal directions.

The key moment in the numerical analysis is the selection of proper pipeline-soil interaction diagrams' parameters. This paper considers the calculation methods for soil-spring diagrams' parameters, which are commonly used in domestic and foreign practice. The comparison of the calculation results using two methods for different types of soils is presented in the form of tables and graphs.

To estimate the impact of differences in the methods of determining the soil-springs' parameters on the stress-strain state of the pipeline, the model calculations of the underground gas pipeline's transition sections through an active tectonic zone of the fault type have been performed. On the basis of the analysis of obtained numerical results the conclusions about the special features of models application for estimation of the interaction of underground pipelines with the soil have been made.

**Automated non-destructive testing of pipelines' base metal
and welded joints of trunk gas pipelines
during overhaul operations using external flaw detectors-scanners**

*O.N. Melekhin (Gazprom PJSC),
I.L. Vyalych, D.A. Zotov, A.E. Lipovik, A.E. Remizov,
I.G. Petukhov (Gazprom VNIIGAZ LLC)*

Automated non-destructive testing using external flaw detectors-scanners is the main diagnostic method, ensuring required performance and reliability of testing pipelines' base metal and welded joints during overhaul of the linear part of trunk gas pipelines (LP of TGP).

Qualification tests of external flaw detectors-scanners showed their flaw-detection properties, as well as the advantages and disadvantages of each individual scanner. The result of conducted tests is a list of external flaw detectors-scanners for automated non-destructive testing of pipelines and welded joints during overhaul of LP of TGP, the technical specifications of which meet the requirements of Gazprom PJSC.

Further development of external flaw detectors-scanners is based on the realization of new design solutions, improvement of the monitoring methodological support, optimization of processing algorithms for diagnostic results.

This report shows:

- the current development state of external flaw detectors-scanners, which are used for diagnostics of LP of TGP of Gazprom PJSC;
- new advanced developments in the area of automated non-destructive testing of LP of TGP using external flaw detectors-scanners;
- principal directions of improving quality and informational content of test results obtained with external flaw detectors-scanners.

Electrolyte-free reference electrodes and perspectives of using them in ECP efficiency control systems

*Yu.A. Ivanov, B.F. Nazarov, A.V. Korshunov
(NPP ElectroKhimZaschita LLC, Tomsk Polytechnic University)*

NPP ElectroKhimZaschita LLC (Tomsk) develops alternative copper-copper sulfate electrolyte-free reference electrodes of the «dry» type, which comply with the requirements for their wide use at pipelines regarding the compatibility with the principle of electrochemical protection (ECP), long service life, ease of installation in the ground without using sophisticated techniques, their costs and dimensions.

The reference electrode SES-1 («dry» electrode) is improved and supplemented with a porous ceramic cone-shaped container (Ø30 and 50) with special composition on the base of bentonite clay. This almost allowed to eliminate the risks associated with its haphazard installation in preliminary prepared pit and minimize the impact of moisture, acidity, temperature, and the content of copper ions in the ground on the stability of the electrode's base potential.

The electrodes are placed in the ground by forcing them with tools in the bottom of the pit, drilled by a moto-driven auger or prepared using special tools. After drying or freezing in the ground the electrode performance characteristics are restored.

An adapter is also designed allowing to bring automatically the results, which have been obtained using electrodes with different base potentials, in the compliance with a common scale of the copper-sulfate electrode.

Electrolyte-free mono- and bimetallic reference electrodes with high stability of their base potentials, designed in the protective container with solid filler and operating by their contact with wet ground, are being developed. Solid-type electrodes allow to eliminate the impact of sharp fluctuations in the parameters of humidity, pH, corrosive ions content in the soil. After ground drying or freezing and its further moisturization the electrode performance characteristics are also self-restored.

The proposed electrodes are economically efficient for manufacture and require no special maintenance or repairing during their operation.

Multifunctional Cortes devices of intensive monitoring of the corrosion state of gas transportation facilities

*Yu.A. Ivanov, S.M. Chukhlantsev, B.F. Nazarov, V.A. Popugin
(NPP ElectroKhimZashita LLC, Tomsk Polytechnic University)*

Prevention of origin and limitation of development of the different kinds of corrosion damages at designing, construction (repairing) and long-term (over 50 years) operation stages of TGP is the main task of Gazprom PJSC.

The methods specified in valid GOST 51164-98, GOST 9.602-2005 in the conditions of the complex influence of corrosion factors typical for the regions of Western Siberia, the Far North and the Far East are not sufficient to ensure the necessary effectiveness of ECP of pipelines, forming a complex heterogeneous corrosion system with the parameters varying over the pipe's length and over time.

To develop the methods of preventing corrosion damages to pipelines in these conditions, Cortes Series devices, which are equipped with a signs-characters indicator, functional control keys and the connectors for probes, which are installed at the depth of pipelines laying, and measuring cables to connect the device to control and measuring equipment, have been developed.

The device «Cortes-Duo» is designed to measure and record all normalized ECP parameters, ground currents, electrical resistivity and acidity of the soil, as well as oxygen and hydrogen currents, and other parameters directly at the depth of pipeline laying. The State acceptance tests of this device have been conducted to approve it as the measuring tool. The planned production – the beginning of 2016.

The device «Cortes-ION» has additional features – measurement of water-soluble salts content in the soil in the mobile mode.

The devices are controlled by the software, including the remote control method, for example from the cab of the operated vehicle by a tablet PC, which extends the functionality of the device and allows to perform measurements in any weather conditions. Moreover, the following features are provided automatically: routing to the control and measuring unit, reference to the map, the calculation of the coordinates by GPS, identification of a control and measuring unit, data measurement and its recording in the measurement protocol. This allows to eliminate the impact of human factors on the accuracy of measurements.

Management of technical condition of gas pipelines subject to stress-corrosion cracking using automation systems

*S.N. Kuimov, S.V. Bausov, A.I. Istomin, V.V. Podolskaya
(Gazprom transgaz Yekaterinburg LLC)*

Specifics of management of the technical condition (TC) of gas pipelines subject to stress-corrosion cracking (SCC) are related to the presence of:

- inadequate reliability of in-line inspection in revealing and identification of various types of crack-alike defects;
- inadequate validity of prognostic technologies in revealing of SCC;
- occurrence of cracking areas of specific morphology angled, longitudinal and lateral in relation to pipes subject to SCC.

It is necessary to develop such processes of TC management that will be justify the minimum summarized costs by the development of repair programs and schedules adequate to TC, reduction of their preparation period, ensuring that planned repair parameters match the actual ones. In order to achieve this target the problems of building a specialized algorithm and information model of the system for TC assessment and planning of repairs of gas pipelines subject to SCC were solved, application software was developed and tested in the course of detailed planning of preventive maintenance and comprehensive repairs. The developed information model allows assessing TC and repair planning based on the results of in-line inspection, instrumental ground diagnostics, technical diagnostics in test pits using the information about the location and length of the areas where natural and technical conditions for SCC development were present.

In order to monitor technical diagnostics in test pits and eliminate the defects on a scale of a gas transportation enterprise there is an ongoing pilot operation of the specialized system of accounting defects and defective elements of trunk gas pipelines after in-line inspection, which is also an integral part of the concept of technical condition and integrity management (TCIM).

Methodology of time assessment before the destruction of pipeline steel brands with crack-alike defects based on the micromechanical model of acoustic emission of heterogeneous materials

*M.V. Smirnov, V.V. Nosov, M.I. Antonov, M.V. Shabalin
(Polytechtest Test Centre of Saint-Petersburg Polytechnic University)*

The presentation describes the methodology of time assessment before the destruction of statically loaded specimens of pipeline steel brands based on the micromechanical model of acoustic emission.

The method is based on results of acoustic emission examination processed by provisions of micro-mechanical model of micro-damage accumulation and its development into macro-defects of SCC type. The suggested approach does not require introduction of empirical coefficients of stress concentration in the area of defects, and includes just statistic interpretation of acoustic emission results.

The method has passed approbation on welding joints samples and has proved its authenticity.

Document provides new method of safe operation term definition for CS process pipelines based on acoustic emission model.

VI International Conference

**Gas Transportation Systems: Present and Future
(GTS-2015)**

Responsible editor	M. Burova
Cover	I. Belov
Layout	N. Vladimirov

Signed for publishing 26.10.2015 r.
Edition 20 copies. Format 60×84/16
Volume: 10.23 printer`s sheets

Printed in VNIIGAZ