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

PLENARY SESSION

Continental Shelf of the Russian Federation the Arctic and the Far East

V.V. Cherepanov (Gazprom, PJSC)

Development of hydrocarbon reserves of the Russian Federation continental shelf and, particularly, its part in the Arctic and the Far East is the largest infrastructure project justified by the unique discovered oil and gas reserves. Such projects should be developed and implemented with an account of national security strategy and fundamentals of strategic planning in Russia for the period up to 2035 and onwards.

“The development of the Arctic region and the continental shelf natural resources is of special strategic importance. As is well known, all gas prospective resources are in the sea. And here, there is no alternative to the offshore technology,” V.V. Putin.

The structure for implementation of national interests of the Russian Federation in the area of continental shelf includes:

– National interests of the Russian Federation;
– Basic concepts of state policy of the Russian Federation;
– Federal strategies for development;
– Master plans and development programs;
– Gazprom Group single policy for the development of shelf of the Russian Federation;
– Program for development of hydrocarbon resources in the continental shelf of the Russian Federation up to 2035.
– The main tasks of the state policy implemented by Gazprom, PJSC, are as follows:
– Provision of significant increment of hydrocarbon reserves in the offshore fields;
– Elaboration and implementation of the new type of equipment and technologies for the development of the Arctic shelf fields;
– Creation of infrastructure required for the development of continental shelf resources.

Specific features in training personnel for continental shelf development

Ye.B. Kasyan (Head of department Gazprom, PJSC)

Currently a serious challenge for Gazprom is the demand for long-term provision with personnel for shelf projects and improving the quality of training human resources in this field including the quality of training scientific personnel, who ensure shelf resources development.

This work is based on Gazprom human resources management policy, which determines the mechanisms of long-term forecasting the demand for personnel focused on implementation of package of strategic tasks in arctic direction.

System of continuous in-house professional education of Gazprom personnel functions and constantly improves in order to solve problems of personnel training.

Gazprom implements systematic personnel strategy based on the principles of continuous outstripping personnel training and timely arrangement of new work sites and future occupations including:

– mid-term and long-term analysis of demand for graduates, who specialize in marine fields development;

– development and implementation of training and retraining programs for specialists and teachers;

– synchronization of activities of partner higher education institutes of Gazprom;

– development of education programs for specialists training.

The role of Gazprom VNIIGAZ LLC in development of oil and gas fields on the continental shelf of the USSR and Russia

M.Yu. Nedzvetskiy (Gazprom VNIIGAZ LLC)

Gazprom VNIIGAZ LLC is the path-breaking research and development institution in the former USSR and Russia in regards to development of the offschore hydrocarbon resources in the freezing seas.

In 1973, the integrated laboratory for the offshore gas field industry was established which performed the following activity:

– Observations on the hydrometeorological conditions of the Azov and Kara Seas.

– Development of the technology for manufacture, transportation and installation of the stationary platform for the well No. 15 drilling at the Beysugskoye gas field.

In 1974-1979, the winter expeditions were organized to study the ice conditions of the Kara Sea in the area of the Kharasavey gas-condensate field. The field experiments were performed to implement the project of experimental ice islands, methods and technology of their freezing.

In 1977, the Laboratory was reorganized into the Department of Offshore Oil and Gas Industry; in 1995, the Department for Development of Offshore Oil and Gas Resources was established which was expanded to the Center for Offshore Oil and Gas Fields in 2003. In 2014, the Center was assigned by the status of the Corporate Scientific and Technical Center for Development of Offshore Oil and Gas Resources.

For the present, Gazprom VNIIGAZ LLC is taking part in the development of all fields of Gazprom PJSC on the continental shelf of the Arctic Region and the Far East and also it is taking an active part in development of the foreign continental shelf fields (Vietnam, India, Iran).

Russian technologies development in the sphere of the Arctic offshore OIL&GAS wells operation

A. Ponomarev (Gazprom Neft Shelf LLC)

Presentation includes information about achievements in the sphere of Russian technologies development for the oil & gas wells operation at the first offshore Arctic project.

The first national technical solutions were implemented during less than 1 year after the start of oil & gas production at the “Prirazlomnaya” offshore platform in December 2013. And the first ESP system manufactured by Russian service company was successfully installed in 2016.

Further progress of the National oil&gas service sector development program includes strengthening of the competences and infrastructure of the local companies and further cutting-edge technologies formation.

Key milestones of Gazprom PJSC activity when developing oil-and-gas fields on the continental shelf of the Russian Federation

V.S. Vovk (Gazprom Neft Shelf, PJSC),
D.A. Mirzoyev (Gazprom VNIIGAZ LLC)

It is difficult to estimate the importance of the Main Directorate for Exploration and Development of Offshore Oil and Gas Fields of the USSR Gas Industry Ministry for development of hydrocarbon deposits on the Russian continental shelf, as the accumulated experience and the results of production activity over the past forty years are invaluable.

Having economical, financial and political resources, it solved the key tasks of commercial development of the Soviet Union continental shelf and discovered large oil and gas fields in the Barents, Kara, Okhotsk seas, the Ob and Taz bays.

Currently, many projects being an important link in the development of the mineral resource base, are also the key one for Gazprom PJSC which is one of the world's leading energy companies.

The upcoming 21st century had set forward new large-scale tasks which will have to be solved by the current generation of gas industry workers and the entire staff of Gazprom PJSC. Here, the top-ranking specialists are working who hold on worthily the work begun by Sabit Orydzhev, Nikolay Baibakov, Aleksey Kortunov, Vasily Dinkov, Viktor Chernomyrdin, Rem Vyakhirev and other captains of the oil and gas industry.

Rosshelf-Gazprom – “Prirazlomnaya” platform

E.P. Velikhov, V.P. Kuznetsov (Kurchatov Institute, R&D Center),
V.V. Borodin (PO Sevmash, JSC)

Since 1991, GAZPROM and SEVMASH have headed the movement to the development of huge oil and gas resources of the Russian Arctic shelf based on the enterprises, technologies, and production facilities of the nuclear-power submarine building and the oil and gas industry of Russia. Following the partial modernization of the production capacities, in parallel with the nuclear-power submarine building, the development of the new area of production activities – the building of the civil vessels and technical facilities for the development of the oil and gas fields on the Russian Arctic shelf – have been started.

In spring 1995, at the meeting in CDO MT Rubin, the Board of Directors of Rosshelf took a decision on commencing construction of OIFP “Prirazlomnaya” at SEVMASH based on the CDO MT Rubin design project.

Construction of offshore oil and gas facilities (OOGF) at PO Sevmash, JSC, required that quite a number of activities on the technical upgrading of the existing production capacities, acquisition and implementation of a significant volume of a new process equipment, automated lines, and mastering of new technologies were conducted. That was performed jointly with Gazprom. I would like to express gratitude to Gazprom senior officials for prompt support and long-term mutually beneficial cooperation resulting in the first Russian production platform on the Arctic shelf.

Above 20 years history of cooperation with Gazprom allowed Sevmash mastering new and previously not applicable in the company materials, resulted in the development and the industrial introduction of new technologies and training of operating personnel.

Construction of large facilities, such as drilling platforms, is impossible without engaging a wide range of research, scientific (SCC Krylovsky (State Science Center), CRI KM Prometey (Central Research Institute), TsTSS (Center for Shipbuilding and Shipreparing Technologies), etc.), design (CDO MT Rubin, CDO Korall (Central Design Office), etc.), organizations, different production enterprises (NZM (Neftezavodmontazh), VNMZ (Vostokneftezavodmontazh), SPO Arktika, JSC, TsS Zvezdochka, JSC, Energodiagnostika, LLC, and many others) under the guidance of PO Sevmash JSC, taking on the role of General Contractor for construction of OIFP “Prirazlomnaya,” allowed forming and using the new structure for construction control of such large project as OIFP afresh.

It is also worth mentioning that the OOGF construction is impossible without the widespread use of the so-called “dual technology” in the company, including maximal involvement of the enterprise’s all shops and equipment practically. The Company quality management system gained the level of the world standards.

In the course of construction, Sevmash acquired an invaluable experience on production of unique structures, trained hundreds of specialists, developed and mastered dozens of new technologies not applicable in Russia previously:

– New design systems were mastered, including 3D and with the use of remote access; part of design work was carried out in London, Saint-Petersburg, and Severodvinsk;

– The wide-scale restoration of production facilities was performed, including the hull plating shop, the filled basin, the water area, and the outlet channel bottom dredging and the shore protection were carried out;

– The welding production facilities were modernized, the new welding procedures harmonized with ASTM requirements were developed and approved, up to 1,500 welders were trained and certified;

– The new cold-proof steels developed by CRI KM Prometey were implemented into production; the hull plating shop provided treatment of up to 4,500 tonnes of metal per month;

– The new welding materials – the flux-cored wires enhancing the welders' labor productivity – were implemented;

– The mating and welding of large-sized structures afloat were fulfilled (butt-jointing of OIFP "Prirazlomnaya" superblocks 126 meters long and 24.3 meters high was performed; the length of welds on one butt joint between the superblocks – 4.5 kilometers). The underwater welding procedure was applied for the butt joint sealing, the technology allows assembling the structures of unlimited dimensions afloat;

– The unique transshipping operations were carried out: float-over of the topside weighing approx. 15 thous. tonnes, the auxiliary module approx. 2 thous. tonnes, loading of the accommodation module in two parts ~ 1,000 tonnes each;

– The unique marine operations on towing of super-heavy facilities were performed: from Severodvinsk to Murmansk, the platform weight – 110 thous. tonnes, from Murmansk to the field – 230 thous. tonnes; the vessels only under the Russian flag were engaged in the towing operations;

– The new site for the platform construction at 35 CRZ in Murmansk was prepared within a short period; it provided accommodation of personnel throughout the year, including the location of engineering services, warehouses, the performance of outfitting work, and placing of concrete. The online communication with PO Sevmash, JSC, ensuring direct information exchange between the sites in Severodvinsk and Murmansk was organized;

– Management of dozens of subcontractors, including the foreign ones, taking part in the project was organized;

– The platform concrete coating was carried out within the shortest possible time (one and a half month) 122 thous. tonnes of special-purpose concrete were placed;

– The logistic scheme ensuring operations on outfitting and testing of the platform on the Arctic shelf in the Pechora Sea, including delivery of personnel, fuel, and cargoes by the air and marine transport from Murmansk, Arkhangelsk, and Severodvinsk to the settlement of Varandey and on the platform, was organized.

The acquired experience and skills in the platform construction, the performed modernization of existing production facilities, the available skilled staff and production capacities allow ensuring construction of large oil and gas complexes for development of the Russia continental shelf by PO Sevmash, JSC.

Rosshelf – Gazprom – Prirazlomnaya platform: Rosshelf project milestones, 1991–1995

E.P. Velikhov (Russian Academy of Sciences, National Research Center «Kurchatov Institute»), V.V. Borodin (JSC «PO «Sevmash»), V.P. Kuznetsov (National Research Center «Kurchatov Institute»)

Rosshelf establishment and activities are an example of efficient cooperation between science, shipbuilding and oil & gas industry in developing hydrocarbon resources of the Russian Arctic shelf.

Rosshelf milestones:

1991:

– Rosshelf initiated by the defense shipbuilding industry

1992:

– initiative supported by the Russian President
– Gazprom included in the initiative group
– governmental decree on Rosshelf
– constituent meeting of ZAO Rosshelf
– preliminary feasibility assessment assuming reliance on the national industry for Shtokman gas field and Prirazlomnoye oil field
– Rosshelf attempts to contact with the Arctic Star Joint Venture
– Gazprom becomes the majority shareholder
– Russian President's decree on Rosshelf licensing
– Rosshelf licensing decree ratified by the Russian Supreme Soviet
– voluntary dissolution of the Arctic Star

1993:

– Rosshelf licensed to develop Shtokman and Prirazlomnoye fields
– attempt of illegal takeover of Rosshelf
– Rubin starts developing the Prirazlomnaya platform

1993–1994:

– Sevmash reconstructed by Gazprom
– Rubin issues conceptual design of the Prirazlomnaya platform
– non-payments and search for new investors

1994:

– cooperation agreement between Kurchatov Institute and Gazprom
– completion of the Arctic shelf development program

1995:

– Prirazlomnaya platform design selected and construction launched at Sevmash.

Rosshelf establishment involved multiple complex and adverse circumstances that the Kurchatov Institute – Gazprom – Sevmash triumvirate tackled in a friendly, cooperative and mutually supportive manner throughout construction and commissioning of the Prirazlomnaya platform in 1996–2013.

Implementation of the Prirazlomnya Project in conditions of the 1990–2000ies is a great achievement of Gazprom, Sevmash and Kurchatov Institute.

Kirinskoye gas condensate field: shelf energy

V.A. Krokha (Gazprom dobycha shelf Yuzhno-Sahalinsk, LLC)

One of the most important national objectives is development of oil and gas fields on the RF continental shelf. Shelf projects are expensive and technologically difficult. Their implementation requires high-tech manufacturing, modern science and new technologies, well-qualified personnel. The special attention is given to the raw material base development of the Far East regions and, first of all, to the development of the Sakhalin shelf. For the first time in the national gas industry, the subsea production complex was designed for field development of the Russian continental shelf. The Sakhalin shelf is characterized by the difficult hydrometeorological and geotechnical conditions, earthquakes with the intensity 9 on the MSK scale and the deep sea. The subsea development technologies will have no alternative for the majority of fields in this difficult natural environment. The case of the Kirinsky gas condensate field development gave the experience of well construction and subsea completion, subsea production complex operation and detailed the main functional areas covering all development and facilities construction stages of the Sakhalin shelf offshore fields.

The main functional areas are the following: environmental characteristics; ice action on process facilities; well construction; subsea tieback; operation; logistics, infrastructure, supply; environment protection. The up-to-date global technologies of angle building, telemetry tracking equipment (MWD) and modifications of logging measurement instruments (LWD) are used for implementation of Kirinsky block development plan taking into account insufficient knowledge of the geological features.

Taking into account the international practices and the experience in development of hydrocarbon fields by Gazprom PJSC subsidiaries, the innovative technologies are used for construction and operation of Kirinsky field facilities which are able to minimize the negative impact on the environment. Successful project implementation with due consideration of these factors reflects leading positions of Gazprom Group in the global power business.

Gazprom flot LLC: a quarter of a century at the Russian offshore

Yu.V. Shamalov (Gazprom Flot LLC)

In 2019, Gazprom flot LLC is looking forward to celebrate its upcoming Anniversary – 25 years since the Company was established in 1994 to implement the unified gas and oil development policy on the Russian continental shelf. Currently, Gazprom flot LLC is the wholly owned subsidiary of Gazprom PJSC operating its own drilling rigs and the fleet of auxiliary vessels.

The Company's key focus areas are:

– all types of well construction at the Russian offshore;

– shipbuilding and operation of floating units for offshore deposits development;

– development and operation of onshore supply bases and port infrastructure;

– fleet operations and its commercial management.

Since 1994, the Company discovered 9 new offshore deposits and successfully constructed 60 drilling wells with the total of 155,000 meters drilled at the Arctic, the Baltic, the Azov and the Far East Russian offshore. Amid them 7 production wells (P5, P6, P4 bis, P1, P2, P7, P3) at the Kirinskoye GCF (the Sea of Okhotsk).

As the part of the current regular operations and development of new business areas, the Company operates its own floating drilling units – semi-submersible and jack-up drilling rigs as well as various types of vessels inclusive of: platform supply vessels, anchor-handling supply vessels, crane vessel, tanker, research vessel, passenger vessel and multifunctional ice-breaking supply vessels. Besides, the Company currently has two ice-breaking vessels under construction to supply the MODUs.

According to Gazprom PJSC's directives, Gazprom flot LLC was appointed as the Operator of Pipe-Laying Vessel *Akademik Cherskiy* and Floating Storage and Regasification Unit *Marshal Vasilevskiy*.

Until 2000, the Company's main operational area was the Barents Sea (South-Eastern part of the Barents Sea – the Pechora Sea). From 2001 to 2011 the Company mainly operated at the Ob and Taz Bays as well as at the Yamal peninsula offshore (the Kara Sea).

Since 2009, Gazprom flot LLC has been constructing wells at the Sakhalin offshore. The work is being carried out within the East Gas Program of Gazprom PJSC.

In 2012, the Company commenced the construction of production wells at the Kirinskoye GCF (Sakhalin offshore). Between 2012 and 2017, as the part of this project Gazprom flot LLC performed the lowering and assembling operations at the well-heads of horizontal production X-trees. Such works were successfully performed at the Russian continental shelf for the first time.

In 2018, the Company started the construction of production wells at the Yuzhno-Kirinskoye field. The works were performed by means of the modern semisubmersible drilling rigs utilizing state-of-the-art drilling technologies and international practices.

This year the Company provided drilling services to the following companies:

– Gazprom Geologorazvedka LLC — appraisal well No. 1 at the Nyarmeyskiy license block (the Kara Sea offshore) by means of Jack-up *Arkticheskaya;*

– Arctic SPG 3 LLC — appraisal well No. PO1 at the Severo-Obskiy license block (the Gulf of Ob offshore) by means of Jack-up *Amazon*.

Gazprom flot LLC accumulated a quarter of a century experience in the offshore drilling operations utilizing mobile drilling rigs and supply vessels in the harsh weather conditions at the construction of exploration and development wells. This expertise can be successfully applied both to the Gazprom PJSC’s priority offshore projects and to other offshore enterprises.

CDO Korall experience on creating technical facilities for operation on the shelf and prospective proposals

A.A. Aliseichik (CDO Korall, JSC)

CDO Korall has been engaged in works on designing of facilities for development of continental shelf since 1970. During this period, the following facilities have been designed and constructed at the national shipbuilding yards:

– 89 different purpose floating derricks and crane vessels with the deadweights from 25 to 1,600 tonnes, including those for construction and maintenance of the fixed offshore platforms;

– 13 jack-up floating drilling rigs for sea depths up to 100 m and drilling depth up to 6,500 m;

– 7 floating semi-submersible drilling rigs for sea depths up to 300 m and drilling depth up to 6,000 m;

– 1 ice-resistant export terminal for Varandey-More field;

– 20 topsides of fixed offshore platforms for drilling the wells from 4,000 m to 6,500 m deep.

As of today, development of the design documentation on the ice-resistant fixed platform IRFP “A” for the Kamennomysskoe-More field has been completed, and now is under technical design review. Elaboration of the project on the development of the Rakushechnaya field in the Caspian Sea was completed and its detailed designing is underway.

CDO carries out designing of the prospective types of facilities for operation on the shelf, under the Arctic conditions, primarily:

– floating depot for integrated support of drilling operations;

– an ice-resistant drilling rig for operation in shallow waters;

– floating ice-resistant drilling rig for deep waters,

etc.

Concerning readiness of Severodvinsk enterprises for implementation of the arctic oil and gas projects

V.V. Borodin (PO Sevmash, JSC)

PO Sevmash, JSC, has its own design and construction office (DCO Sevmash) with highly-qualified engineering personnel providing development and issue of detailed design documentation. DCO Sevmash cooperates with different design organizations, both with the national: CDO MT Rubin, JSC, R&D Center Kurchatov Institute, FSUE, – CRI KM Prometey, SPMB Malakhit, JSC, CDO Korall, JSC, TsTSS, OJSC, and with the foreign ones.

Beginning from 1995, PO Sevmash, JSC, participates in the building of the offshore oil and gas facilities. The enterprise has mastered the technologies for the production of fixed platforms (OIFP “Prirazlomnaya”), floating semi-submersible drilling rigs (FSSDR “MOSS”), and jack-up drilling rigs (JUDR “Arkticheskaya”).

The Company has carried out re-equipment of shops, restoration of berths, bottom dredging, and preparation of the water area for marine operations when creating the oil and gas platforms.

PO Sevmash, JSC, has mastered welding of cold-proof steels, underwater welding, marine operations on float-over of large-sized structures, etc.

PO Sevmash, JSC, plans construction of the offshore oil and gas facilities using the method of large blocks and further modernization of production facilities (expansion of assembly and welding production, construction of new paint spray booths, new transportation and transfer complex, etc.)

The acquired experience and skills in the platform construction, the performed modernization of existing production facilities, the available skilled staff, and production capacities allow ensuring the construction of large oil and gas complexes for development of the Russia continental shelf by PO Sevmash, JSC.

PO Sevmash, JSC, in cooperation with TsS Zvezdochka, JSC, considers the production of the ice-resistant platform for the Kamennomysskoye field. Engineering study demonstrated the viability of cooperative production of structures enabling to optimize the terms of construction, provide the enterprises with the balanced workload, and reduce the risks associated with transportation of blocks.

The enterprises of Severodvinsk hope for the progress of cooperation with Gazprom, PJSC, in their joint work for the development of fields in the Russian Arctic shelf.

Fiber-optic measuring technologies for prospecting and development of oil and gas deposits on the arctic shelf

V.D. Zherebtsov, N.N. Bolobontsev, N.P. Pastukhov (Experimental Design Bureau of Oceanological Engineering of Russian Academy of Science), V.S. Vovk, A.A. Gafarov (Gazprom PJSC)

The use of fiber-optic measuring systems (FOMS) for prospecting and development of offshore oil and gas fields has significant economic, technical and environmental advantages in comparison to prospecting systems based on the electrical measuring principle (standard systems) used for more than 60 years, what is confirmed both in the Russian Federation and abroad.

Application of FOMS for prospecting increases the formation resolution for marine prospecting to 3-4 m instead of 20-30 m on a standard receiving system, and up to 2-3 m instead of 12-15 m for seafloor systems, which allows high-quality exploration of deposits and reduce the amount of marine drilling operations.

With the activation of the oil and gas reservoir with associated gas and 4D seismic, GIS complex allows to increase the recovery factor of oil and gas condensate (ORF) up to 50-70% instead of 24-32% with the use of standard systems in the Russian Federation and abroad. According to the US Department of Energy, this gives trillion profits at a price of $ 20 per barrel.

FOMSs began to intensively develop abroad at the beginning 21st century for the shelf development using the conversion fiber-optic technology. For implementation of FOMS, the Photonics Group was established by NATO enterprises and foreign oil and gas and other companies in 2014. 70% of its products is designed for the prospecting and development of oil and gas fields. In this regard, the countries of North America became energy self-sufficient, since the ORF was increased to 50-60% instead of 30-32%, which gave a significant economic benefit. In Russia, the ORF is 24-28%.

FOMS is particularly effective in prospecting and development of fields in complex geological structures (under gas clouds, basalt, in permafrost zones, gas hydrates, under pack ice, in a transit zone), which in the Russian Federation make up to 45-48% and have not been explored, and also for additional prospecting of the developed oil fields on the shelf, and for studying the geodynamic characteristics for drilling exploratory wells and developing offshore oil and gas fields. FOMS is extremely necessary for the study of geodynamic processes in the development and exploratory drilling of wells to prevent accidents of the kind that occurred with BP company in the Gulf of Mexico in 2010.

In this area of work, the specialists of the NIIMorgeofizika, Sevmorneftegeofizika, Murmansk, Tsentralnaya geofizicheskaya ekspeditsiya, Russian State Geological Prospecting University, Moscow State University received in 2000 and executed an international grant. The authors of the project received 6 patents for inventions. NIIMorgeofizika (the only research institute in the Russian Federation in the field of prospecting geological exploration) was disbanded in 2005. Work on the development of FOMS and seismic sources was continued by Research and Production Enterprise AQUA LLC.

For geological exploration of oil and gas, active sensing, permitted by ecologists for use on the Arctic shelf, is always used. In the Russian Federation, these are pneumatic sources of seismic vibrations developed by NIIMorgeofizika and improved by AQUA LLC, or foreign sources made by Bolt and Slewgun, which are banned for delivery to the Russian Federation from 2014. At the present time, the pneumatic sources Pulse-6 are being manufactured by Pulse LLC (Gelendzhik) according to the exported documentation of NIIMorgeofizika, but inferior to the new developments of the authors.

In the proposed R&D project “Arkshelf” by Experimental Design Bureau of Oceanological Engineering of Russian Academy of Science together with AQUA LLC, SFUE VNII Okeangeologia named after Gramberg and VNIIGAZ as part of the decision of the Committees of the Federation Council on Agrarian-Food Policy and Environmental Management dated April 11, 2017 and Economic Development dated May 31, 2018, implementation of a multicomponent FOMS with a source of seismic vibrations for the seafloor studies of the shelf, with the possibility of use for VSP and for transit zones. This R&D project uses the developments of the Experimental Design Bureau of Oceanological Engineering of Russian Academy of Science for seafloor control and stacking of the reception of bottom multicomponent streamers.

New seismic source “Pulse-15M” (N.N. Bolobontsev) of Research and Production Enterprise AQUA according to its characteristics is not inferior to the sources by Bolt and Slewgun (from 2014 banned for delivery to the Russian Federation), is made on the basis of domestic components. Considered the use of the control of formation of seismic vibrations at FOMS to synchronize a group of sources, to determine the emission spectra for a more qualitative solution of the direct and inverse problem of geological prospecting.

The R&D project “Arkshelf” is a continuation of research by Research and Production Enterprise AQUA LLC completed in 2012 under an agreement with MPO-Gidropribor Group and agreed with experts of Krylov Central Research Institute. The proposed cost of work is more than 20 times less than a similar foreign development.

Temperature-velocity factors in analysis of strength, useful life and safety of the arctic shelf facilities

N.A. Makhutov (Russian Academy of Science)

In the 1950-60s, began the intensive development of Siberia and the North of our country and creation of equipment of the northern design with the given parameters of strength and cold resistance. The celebrated on the conference 40th anniversary of the development of natural oil and gas resources of the Russian shelf of the Arctic and the Far East region, from the new positions set the task of providing the useful life, man-made, ecological and economic security of the infrastructures created and operated with due consideration of the most important climatic factors (extreme low temperatures, seismicity, ice loads).

The scientific basis for solving these problems is the fundamental academic research of processes and patterns of low-temperature, high-rate, cyclic, dynamic and long-term deformation, damage and destruction. The defining equations and their basic parameters for the description of these processes and patterns included exponential dependencies of the basic characteristics of strength and plasticity from operating temperatures, power dependencies from rates, number of cycles, and loading time. The specialists of the academic science and the oil and gas complex introduced the kinetic characteristics of strength and plasticity into the equations for the computational and experimental determination of the strength, deformation and energy criteria of the useful life, survivability and safety. At the present time, this creates opportunities for scientific and methodological support and scientific substantiation of the ways to implement the state policy in the field of industrial and national security, approved by Decree of the President of the Russian Federation No. 683 dated December 31, 2015, No. 642 dated December 1, 2016, and No. 198 dated May 6, 2018, using materials of the multivolume series “Security of Russia”.

The report presents the results of research and practical development.

Experience of using geophysical technologies to study permafrost on the shelf of the Russian Arctic seas

A.V. Koshurnikov (LLC MSU-Geophysics, Moscow State University)

Since 2006 LLC MSU-Geophysics carries out geological and geophysical researches to study long-term frozen layers on the Arctic shelf of Russia. The study of permafrost was carried out both in summer from the Russian shelf and in winter from the soldered ice. Over 12 years of work on the shelf various geocryological problems have been solved:

1. Study of the boundaries of permafrost on the Arctic shelf of the Russian Federation.
2. Determination of the permafrost roof and sole depth on the Arctic shelf of the Russian Federation.
3. Mapping of non-through, through-through taliks in permafrost strata on the Arctic shelf of the Russian Federation.
4. Study of frozen water on the Arctic shelf of the Russian Federation.
5. Determination of permafrost temperature regime on the Arctic shelf of the Russian Federation.
6. Forecast of the state of permafrost for the entire period of operation of facilities on the Arctic shelf of the Russian Federation.

To solve engineering and geocryological problems it is reasonable to use complex geological and geophysical studies, including:

1. Geophysical sounding by the method of TEM.
2. Test drilling.
3. Selection of soil monoliths of natural composition.
4. Laboratory tests of soils in the field and laboratory conditions.
5. Temperature logging in the wells to final keeping maturing well after unfreezing during drilling.

This complex is necessary and sufficient for solving geocryological problems and has been tested on the shelf of the Pechora, Kara, Laptev East Siberian, Chukchi seas.

Superimposed current protection against corrosion and corrosion monitoring of shelf, berthing and offshore structures

D.B. Zakharov (Truboprovodnyye sistemy i tekhnologii CJSC)

Ensuring the required efficiency of electrochemical protection is not a simple task, especially at offshore facilities, due to the specifics of their location and operation. The wrong approach to choosing a method and type of equipment can lead to large economic losses and catastrophic consequences. In order to really efficiently prevent corrosion processes, it is necessary to use accurate and reliable means of electrochemical protection, supported by reliable information on the corrosion rate and at the same time on the parameters of the corrosion situation.

Currently, two methods of electrochemical protection of the offshore structures against corrosion are widespread - the sacrificial protection and superimposed current protection.

The use of sacrificial protection has been practiced for a long time, but at the same time it has several significant drawbacks:

– the possibility of passivation of galvanic anodes in case of incorrect assessment of the operation of the protected facility and the composition of the marine environment;

– the use of a large amount of galvanic anodes, which must be welded to protected structures, leading to high additional loads on the facility and high installation costs;

– hard-to-reach and costly methods for controlling the residual service life of galvanic anodes.

The method of cathodic protection of offshore structures by superimposed current eliminates these shortcomings of the use of galvanic anodes. However, this technology is still not as widespread in Russia as abroad, where it has been successfully used for more than 30 years. At the same time, today in Russia, technologies for protection of offshore facilities by superimposed current are becoming more and more common. These are the facilities of Gazprom PJSC, Transneft, KTK Projects, Yamal SPG, etc.

For several years Truboprovodnyye sistemy i tekhnologii (Pipeline Systems and Technologies) CJSC has been developing its own line of equipment for protection and corrosion monitoring of offshore structures, also taking into account advanced international experience. For a reasonable selection of systems of cathodic protection by superimposed current, the engineers of Truboprovodnyye sistemy i tekhnologii CJSC use the tools of mathematical modeling and design justification of the parameters of such systems.

Testing of Russian-made geophysical equipment

G.S. Kazanin, G.I. Ivanov, A.G. Kazanin, E.S. Makarov, S.P. Pavlov, S.O. Bazilevich (MAGE), Ya.I. Antonov (Gazpromneft-Sakhalin)

From October to November of 2017 and 2018, MAGE tested home-built seismic equipment in the south-west of the Barents Sea (Pechora Sea) under the Russian Ministry of Industry and Commerce funded program. The testing included pieces of geophysical equipment made in accordance with government contracts with national research and technology leaders, such as Oceanpribor, SI Technology Instruments, Puls, Andreyev Acoustics Institute, Air & Marine Electronics (AME), and P.P. Shirshov Institute of Oceanology (Russian Academy of Sciences). The tested products include:

– gel-filled seismic streamer, acquisition system, and airguns of different volumes;
– towed seismic streamer positioning and control system;
– self-contained 4C OBS nodes;
– acoustic positioning system for OBS nodes.
– self-contained 4C ocean bottom cable.

Marine Arctic Geophysical Expedition was engaged as an expert consulting company with technological capabilities and expertise to draft design and manufacturing guidelines, determine best performance, establish a field trial program, and test a home-built prototype of marine seismic data acquisition system in the Arctic offshore environment.

A major manufacturing base has been set up for the country’s commercial production.

Innovative technology of construction of submarine (subglacial) wells and a set of technical means for its implementation

Ye.Ye. Toropov (Central design bureau of marine equipment Rubin JSC)

Existing technologies and technical means of developing offshore hydrocarbon deposits are successfully used in various areas of the ice-free seas of the world ocean, as well as in areas with seasonal or moderate ice conditions.

For the development of hydrocarbon deposits in areas with a constant heavy ice regime, and especially at sea depths of more than 100-150 meters, it seems reasonable to develop innovative submarine (subglacial) technologies and complexes of technical means. The greatest difficulty is the development of equipment and procedure for underwater well construction.

As part of the joint project of the Advanced Research Fund and Central design bureau of marine equipment Rubin JSC, in 2015–2018, the Iceberg project was implemented, one of the elements of which is the advance design of the underwater drilling complex. The application of the continuous drilling technology developed under the Iceberg project will, in the opinion of its authors, improve the safety of the construction of an underwater (subglacial) well, reduce the likelihood of accidents while drilling and reduce the losses associated with well repair, which together create the necessary prerequisites for developing cost effective underwater robotic drilling rig. This technology involves the joint use of two drilling drives - the upper and lower, as well as the organization of continuous circulation of drilling fluid.

Developed on the basis of continuous drilling technology, a robotic underwater drilling complex is designed to perform year-round work on the construction of production and exploratory wells and ensures their execution without access from the sea surface. The underwater drilling complex consists of separate open modules interconnected by piping systems and flexible drillstrings.

The economic benefit of the developed technical means implementing this technology is associated with the possibility of year-round drilling operations in the conditions of the freezing seas of the Arctic Ocean.

SESSION A:
GEOLOGY & GEOPHYSICS OF OFFSHORE FIELDS

The concept of the Russian arctic shelf development requires revision

Yu.P. Ampilov (M.V. Lomonosov MSU),
M.N. Mansurov (Gazprom VNIIGAZ LLC)

The depths of the shelf contain a myriad of hydrocarbon resources, and this is not questioned by anyone. But the worldwide cost of offshore mining, even in long-established areas, is noticeably higher than traditional onshore mining. Now, when super-profits in the oil industry are in the past forever, these issues have come to the fore. For example, the cost of exploring new fields on the shelf of foreign countries has reduced by more than 4 times over the past 4 years, and is still far from recovery, despite a renewed moderate increase in oil prices [1]. Under these conditions, it is advisable to prioritize the exploration and development of fields in areas adjacent to oil and gas production areas with developed infrastructure for both economic, technological and environmental reasons (transit and coastal zones, non-freezing waters, etc.).

In addition, for the Arctic region, other development directions that are not based on the extraction of hydrocarbons should be seriously considered and studied, and there are such opportunities [2]. In many cases, this will be more profitable than the extremely high-cost oil and gas with unclear sales markets in the face of increasing and increasingly fierce competition for the buyer on world markets.

Remaining in captivity of unchanged traditional ideas, Russia runs the risk of being among the technologically backward countries, while spending large amounts of money and resources on unpromising and expensive projects. Therefore, the general concept of the Russian Arctic development should be radically revised with due consideration of the new realities.

Resources and searches for hydrocarbons in the cretaceous and jurassic rocks of the Yamal-Kara region of the Western Siberia

V.A. Skorobogatov (Gazprom VNIIGAZ LLC)

Study and development of hydrocarbons, including the gas potential of the subsoil (hydrocarbon potential, gas potential) of the West Siberian megabasin (WSMB) and of the same-name megaprovince (WSMP) has been going on for more than 70 years. By 2018, 912 hydrocarbon (HC) deposits were discovered, mainly oil, and also of the oil-and-gas condensate/gas condensate-and-oil type. There are 260 gas-bearing ones, but gas-bearing ones are leading in terms of the size of the initial and especially recoverable reserves (Bolshoi Urengoi, Yamburgsk, Bovanenkovo, etc.).

According to the State Balance, as of January 1, 2017, 26 hydrocarbon fields were discovered in the Yamal Region (land): 19 of the G and GC type, 7 of the gas condensate-and-oil and oil-and-gas condensate type, with initial open reserves of 12.8 trillion m^3 of free gas (FG) and less than 1 billion tons (geol.) of liquid hydrocarbons (oil+condensate). Modern structural and drilling knowledge of Yamal in the Cretaceous horizons exceeds 65%, in the average Jurassic - 60%: all any large positive structures are drilled by 2-5 and a large number of deep wells. This means that the initial FG resources of the Yamal subsoil are unlikely to exceed 17-18 trillion m^3.

On the shelf of the Kara Sea (South-Kara region - Turkistan region), including the Ob and Taz Bay, 17 fields were discovered: 6 gas condensate fields on the shelf, 11 of land/offshore type. The initial FG reserves of the shelf fields are 3.4 trillion m^3 and, in addition, reserves of the cat. C_2 – 2.5 trillion m^3.

In the Yamal area of land and shelf there are 30 deposits with open FG reserves. There are no oil accumulations and reserves on the shelf, except for the Pobeda field with hydrocarbon accumulations not confirmed by testing. Gas is produced at one – unique Bovanenkovo gas condensate field (from the Apt deposits); oil – at Novoportovsk (from the Valanginian deposits).

A.M. Brekhuntsov, V.D. Kopeev, I. Nesterov, V.A. Skorobogatov, L.V. Stroganov, V.A. Fomichev and others were studying the issues of geological structure, gas and oil potential, resources and exploration of hydrocarbon deposits (HCD) in the Yamal-Kara region (YKR), the results of their research published. According to official estimates, the initial potential resources (IPR) of Yamal gas were estimated as 20.8–28.8 trillion m^3 (together with the Ob Bay), Turkistan region - 35.7 (2002) - 34.6 (2009) trillion m^3, oil 2.0-2.1 billion tons (extr.).

According to the latest multivariate calculations, the author of the IPR of gas in the region is estimated in the range of 36 to 40 trillion m^3, liquid hydrocarbons 2.6-4.2/1.2-1.4 billion tons (geol./extr.). The total number of assumed hydrocarbon fields in the depths of the YKR is estimated at 100-110 (45 on land and up to 55 on the shelf), in the size range from 0.3 million tons of standard fuel up to 4.5 billion tons of standard fuel, while on land all deposits larger than 100 million tons of standard fuel are highly likely already discovered. On the shelf, the presence of supergiant gas deposits is possible (from 1.0 to 2.5 trillion m^3 each, hardly more). The report described a rational

scheme for studying and developing the region's gas potential up to 2030 and the next decade, taking into account the optimization of prospecting and exploration works (prospecting only large uplifts on the Priyamalsky shelf by drilling two, maximum three exploratory wells for the Neocomian, etc.). Probable increments of explored hydrocarbon reserves are estimated.

Hydrocarbon resources of the shelf of the Far Eastern seas and the results of their development

A.D. Dzyublo, A.Ye. Storozheva (RSU of Oil and Gas (NRU) named after I.M. Gubkin), I.G. Agadzhanyants (All-Russian Geological Research and Development Oil Institute)

The state of geological and geophysical exploration of the subsoil of the shelf of the Far East seas - the Sea of Okhotsk, the Bering Sea and the Sea of Japan is currently unequal. The main results of offshore oil and gas exploration were achieved in the Sea of Okhotsk, where discoveries of large oil and gas condensate fields took place, both in the Soviet period and in recent years. Recently (2014-2018) complex geophysical works have been carried out at the expense of the state budget in the waters of the Bering Sea (Commander-Aleutian Basin, Khattsko-Anadyr Basin), the Kamchatka shelf (underwater margin of Eastern Kamchatka), the Kuril Islands.

The industrial oil and gas potential of the North Okhotsk basin has been proven, where Odoptinskoye, Chayvo, Arkutun-Dagi, Piltun-Astokhskoye, Lunskoye, Kirinskoye fields have not only been identified, but have also been successfully exploited under Sakhalin-1,2,3 projects. The main Russian subsoil users in the region are Gazprom, PJSC and NK Rosneft, PJSC, while foreign users are ExxonMobil, Shell, Mitsui and Mitsubishi. At the end of 2017, 16.5 million tons of oil and gas condensate and 30 billion m^3 of gas were produced on the Sakhalin shelf.

As a result of the exploration work, Gazprom, PJSC in recent years has opened a unique oil and gas condensate Yuzhno-Kirinskoye and gas condensate Mynginskoye and Yuzhno-Lunskoye fields in the Kirinsky prospect. In 2017, the large Neptun oil field was discovered by Gazprom Neft, PJSC at the Ayashsky subsoil area.

Large-scale prospecting continues on the Primagadan shelf: Magadan - 1,2,3 and Lisyansky license blocks, where in 2016 Rosneft, PJSC together with the Norwegian company Statoil drilled the wells Duktsinskaya-1 (2610 m) and Ulberikanskaya-1 (1947.8 m).

In the Bering Sea, deep drilling on the shelf was carried out in the Anydyr Basin, but oil and gas deposits have not been found.

In the northern part of the continental shelf of the Sea of Japan in the waters of the Tatar Strait in the Central Tatar subsoil Rosneft, PJSC started geophysical work.

The potential of hydrocarbon shelf of marginal seas of Siberian platform

A.N. Dmitriyevskiy, N.A. Yeremin, N.A. Shabalin (OGI RAS)

Oil and gas companies' interest to the arctic region of the Earth is increasing every year despite the inaccessibility of sites of geological exploration works and remoteness from the markets for extracted hydrocarbons. The Siberian platform is characterized by a large concentration of oil and gas resources. Oil source stratum in the Lena-Tunguska oil and gas province are associated with Riphean, Vendian, and mid-low Cambrian deposits, in which major oil and gas deposits were discovered. Large oil and gas potential is the first and main factor in attracting potential investors. An important task in this direction is the geological and geophysical substantiation of presence and location of the hydrocarbon potential in poorly studied regions.

Analysis and systematization of the results of oil-and-gas exploration previously made in a specific region contribute to allotment and updating of areas for further geological study. Works in this direction were carried out from 2012 to 2018 in Analytical Center for Scientific and Technical Forecasting in the Oil and Gas Industry of OGI RAS. Production organizations' reports held in funds from 1927 to 2018 were used as initial data . The results of analysis of geological and physical data show high prospects for oil and gas exploration in the territory of Anabar-Khatanga and Anabar-Lena OGBR in Anabar-Lena regional system. Deep-lying Riphean-Middle Paleozoic sediments not discovered by drilling, are of great exploration interest. According to data of USA Geological Survey the mineral resources of arctic zones of the five coastal states (the United States, Canada, Russia, Denmark and Norway) contain at least 525 billion BOE (barrels of oil equivalent). Mineral resources of the Russian arctic zone contain 315.4 billion BOE including 93.9 billion BOE in arctic zone of Siberian platform.

Construction of the uniform model of daghinsky horizon target section breakdown and the features of its sedimentation within Kirinsky block

V.I. Shegay (PertoTreis LLC), Ya.I. Shtein (Krasnoyarskgazprom Neftegazproject LLC), S.V. Zinovkin (Gazprom VNIIGAZ LLC)

In different years, five oil and gas condensate fields were discovered within the Kirinsky block of the northeast shelf of the Sakhalin island. Each of those was studied as the independent site that affected, among other things, the Daghinsky reservoir indexation. In combination with rather strong lithologic and facies variability of these sediments, this fact resulted in considerable disagreements in the model of the target section breakdown by area and, as a consequence, in errors at studying of the development history of the investigated shelf area.

The set objective is achieved based on generalization and enhanced studying of all updated data provided by the modern 3D seismic survey and their analysis along with the drilling results.

In the course of the works, it was performed the detailed correlation of the Daghinsky sedimentary section in the waters of the Kirinsky area where it presents the powerful rhythmically built complex composed of rhythms of different orders. The cyclic changes of the relative sea level are stipulated by the joint effect of such simultaneous processes as eustatic fluctuations, tectonic movements and dynamics of the sedimentary material entry.

The patterns of the lateral variability of the geological structure and the properties of the productive sedimentary complex were traced including the area of severe reduction in the thickness of sand bodies in the central part of the studied area and the lithological replacement area at the outer boundary of the coastal-maritime shallow water deposits distribution.

When the structure features of the lithological replacement area were determined, it became possible to draw some fundamental conclusions substantiating the morphology and structure of the outer boundaries of the gas saturation zones in the explored fields.

Based on the results of the conducted research, the paleofacial schemes of the main sedimentation cycles of the Daghinsky horizon were made for the first time, to which the productive and prospective horizons of the Daginsky oil and gas field are confined.

Exploration results and prospects of resource base development for oil and gas production in the Russian sea shelf in XXI century

A.V. Tolstikov, D.A. Astafyev, M.Yu. Kabalin, L.A. Naumova
(Gazprom VNIIGAZ LLC)

The work contains the updated results of exploration, the current state of hydrocarbon (HC) resources and reserves on the Russian sea shelf. It shows that there is an increasing demand for raw hydrocarbons (HC) and a continuous requirement for extensive replenishment of their reserves in the world despite accelerating development of alternative energy source technologies. Within this context, it justifies the new promising areas of oil and gas exploration; its new regions will be the water areas of Barents, Kara Sea and the Sea of Okhotsk. It is the conclusion that the extensive replenishment of the gas, condensate and oil reserves is possible in Russia over the next two or four decades (during 2020–2060). It is noted that it is the tendency to develop of the license blocks by Gazprom PJSC at the present time with organization of large oil and gas production multipurpose centers, and organization of the specific clusters within these centers under which the exploration works will be continued as well as the oil and gas processing capacities will be developed which are oriented to reduce terms of bringing the explored gas and liquid hydrocarbon reserves into development. The South Kara and the Barents oil and gas basins with the total current potential gas resources of about 80 bln. m^3 will be the top future oil and gas regions which will be able to maintain the extensive replenishment of reserves and the required level of gas production in Russia in the XXI century. In the Russian Far East, the Sakhalin-Okhotsk Shelf remains the main oil and gas production region providing the ability to maintain the extensive replenishment of hydrocarbon reserves with the following development of the gas resources in the Sea of Japan, the Bering Sea and the East Arctic seas (the Chukchee Sea, the East Siberian Sea). In the South Russian regions, the Caspian, Azov Shelves and some areas of the Black Sea will be able to maintain the high exploration efficiency and extensive replenishment of the resource base for oil and gas production.

Broadband bottom magnetotelluric station for the transition layer

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Geomechanics RDC LLC and VEGA LLC developed in cooperation the shallow bottom station “MT-AMT” for the transition layer (under the government program for development of the equipment for offshore field development, the code is “Селекция-2”). The station development accumulated the long experience of VEGA company in designing of the electrical exploration equipment which uses the natural low-frequency electromagnetic fields.

The distinctive feature of the equipment differentiating it from the analogues is availability of the surface floating buoy equipped with the GPS receiver and Wi-Fi access point connected to the bottom modu;e by the sealed cable, and also implementation of the Russian-manufactured induction pickups of IMS series with the Certificate of Metrology.

The used architecture of the station design makes possible to operate it in shallow water areas almost at the same survey modes as on the Earth's surface including application of the Remote reference technology. The station has the following main parameters:

- the maximum operating depth is 50 meters
- the range of measured frequencies is 0.001 – 2000 Hz.
- the working endurance is 24 hours
- electric lines with nonpolarizable electrodes.

The scope of application is marine electrical exploration using the magnetotelluric-sounding and magnetotelluric profiling method in so called transitional shelf zones of seas, lakes, estuaries. Together with VMTU-10 ground station, it is possible to perform continuous MT profiling “ground - shallow water area”.

This station is the most in-demand in the oil and gas industry for the mineral survey directly as well as for the engineering electrical survey in order to discover features of the bottom sediment structure in offshore strips before construction of harbor and field facilities.

Here are the examples of MT exploration processing.

Assessment of strength and elastic properties of rocks of the Dagi horizon of the Sakhalin shelf

V.S. Zhukov (Gazprom VNIIGAZ LLC)

During the development of the Sakhalin shelf, an urgent task is the need to assess the deformation and strength properties of rocks, the values of which need to be known both in the construction of wells and in the development of hydrocarbon fields.

The subject of research in determining the elastic parameters and compressive and tensile strengths were dry cylindrical sandstone samples with a porosity of 10 to 26.5%, made from the core of the Dagi horizon of Permian age, taken from wells drilled on the eastern shelf of Sakhalin. The determination of tensile strength in compression and tension, Young's modulus (elasticity), Poisson's ratio and strength certificates of rock samples were carried out in accordance with State Standards.

A straightforward dependence of the compressive strength on the porosity of the samples was revealed, which can be recommended for estimating the strength depending on the porosity of the samples. The dependence of the ultimate compressive strength on the velocity of the longitudinal wave also turned out to be informative and made it possible to obtain an estimate of the strength value depending on the velocity of the longitudinal wave. At the same time, a comparison of the tensile strength and porosity of the studied samples did not allow to obtain an acceptable relationship between these parameters.

According to the results of tests of rock samples, several diagrams with Mohr circles were made: minimum and maximum values and average values of compressive and tensile strengths. The bends of Mohr's circles allow to estimate for each point lying on them the values of normal and tangential stresses during the transition from elastic to plastic deformation and to calculate the adhesion and angle of destruction. The estimate, based on average strengths, for a range of compressive stresses of 40 ... 50 MPa, showed that the angle of internal friction is 6.8 degrees, and the adhesion is 17.77 MPa.

Standard studies of the strength and elastic properties of dry samples of the Dagi horizon sandstone in atmospheric conditions gave the following estimates of average values: compressive strength of 27.2 MPa; tensile strength of 5.77 MPa; Young's modulus (static/dynamic) of 6.13/6.37 GPa; Poisson's ratio (static/dynamic) of 0.225/0.237; adhesion (cohesion) of 7.00 MPa; the angle of destruction (internal friction) of 36.3 degrees.

Features of geological support for construction of gas-condensate production wells in Kirinskoye and Yuzhno-Kirinskoye fields

N.A. Ershov (Gazprom dobycha shelf Yuzhno-Sahalinsk, LLC)

According to Gazprom, PJSC strategy to access to the Russian continental shelf the first facilities for hydrocarbon raw materials extraction using subsea production unit are Kirinskoye and Yuzhno-Kirinskoye fields (included in Sakhalin-3 project).

When constructing stack of gas-condensate production deviated wells on continental shelf, best practices are used for geological-geophysical support of technically challenging and unique works taking into account technological characteristics of constructing offshore wells with mobile floating drilling rigs Polyarnaya zvezda and Severnoye siyanie.

One of the main geological tasks when developing marine fields is performing package of works on geo-steering, when slacking off the production string shoe over top of reservoir bed and well drilling in productive reservoir bed.

Use of advanced technologies for measuring and logging during the drilling (MWD/LWD) for each section of well construction (starting from pilot hole) is reasonable due to technological and logistic limitations during well construction on shelf projects; and it allows accomplishing set geological and technological tasks.

The paper describes experience of using modern technologies in the field of geophysical research, when constructing gas-condensate production wells in Kirinskoye and Yuzhno-Kirinskoye fields under conditions of geological uncertainties and low exploration degree provided by prospecting and exploratory drilling.

Microseism infrasonic oil and gas exploration under arctic conditions

A.N. Gulkov (Far Eastern Federal University), A.F. Lukin (Far Eastern Federal University), Yu.V. Sirotinsky (IFHE im. A.N. Frumkin RAS), A.E. Suntsov (Scientific and technological complex “ANCHAR”)

Efficient development of oil and gas resources on the Russian shelf of the Arctic and the Far Eastern seas is becoming increasingly important every year. However, the use of classical methods of geophysical studies of offshore fields and oil and gas exploration is complicated by the presence of ice cover, natural and climatic conditions, and technological and environmental safety requirements. All these factors lead to an increase in cost and time for work.

The authors have developed a new technology for the use of microseismic infrasound oil and gas prospecting ANCHAR using autonomous uninhabited underwater vehicles (AUV). The technology provides for the delivery using the AUV and the installation of microseismic stations at the bottom of a group of water bodies with given coordinates at the bottom of the group. Through the use of synchronous recording of signals, the possibilities are provided not only for temporal, but also for spatial analysis of data from a two-dimensional receiving antenna array. This simplifies the integration of the obtained results with 3D seismic data, increases the sensitivity of the system and its noise immunity. After completing the recording cycle, the AUV detects and moves the microseismic stations to new areas, or delivers them from under the ice to the surface to charge the batteries.

Using the capabilities of the ANPA, along with the well-proven methods and technologies for the direct forecasting of hydrocarbons ANCHAR, reduces not only the cost of oil and gas exploration, but also the time of work in the ice conditions of the Arctic and Far Eastern seas.

Prospects of discovering hydrocarbon accumulations in the upper jurassic-lower cretaceous clinoform strata of the Barents-Kara shelf

A.V. Mordasova, A.A. Suslova, A.V.Stupakova, R.M. Gilayev, D.K. Yershova (Moscow State University named after M.V. Lomonosov)

In the Lower Cretaceous sediments of the western part of the Barents Sea shelf, accumulations of oil and gas are discovered. Unique oil fields have been discovered in the Neocomian clinoform strata of Western Siberia. However, the geological structure and prerequisites for oil and gas bearing potential of the Upper Jurassic–Lower Cretaceous deposits of the Barents–Kara shelf are still unexplored.

Based on the analysis and interpretation of a network of regional seismic profiles, data on wells drilled in the water areas of the Barents and Kara Seas, a seismic stratigraphic and cyclostratigraphic analysis of sediments was carried out. As a result, a regional geological model of the structure of the Upper Jurassic–Lower Cretaceous stratum of the Barents–Kara region was constructed and various types of clinoforms were identified. It has been determined that clinoform bodies of different scale and form were formed in various paleogeographic conditions from shallow to deep shelf and have different prospects for detection of sandy reservoirs and hydrocarbon accumulations. The cyclic structure of the sediments determines a regular change in the conditions of sedimentation along the section and lateral. The transgressive, predominantly clay, part of cyclites can act as a fluid seal or oil-and-gas source stratum, the presence of sand collectors is possible in the regressive part of the cyclite. The greatest prospects for new discoveries are the undaform, shallow, part of the sigmoid clinoforms within the inversion structures, as well as the detrital cone at the foot of the tangential clinoforms.

Assessment of confidence of gas resources of sedimentary basins in the arctic

O.G. Kananykhina, T.O. Khaloshina, Yu.B Silantyev
(Gazprom VNIIGAZ LLC)

Within the Arctic (circumpolar located to the north of the polar circle) the mega-area is separated by more than thirty large sedimentary basins differing by peculiar properties of the geological structure and petroleum potential.

Peculiarities of geological and information space causes the differences in confidence of the available assessments of hydrocarbons resource potential. Within this context, the assessment of confirmation of the existing matrix of total initial gas potential (TIP) is relevant. For analysis, TIP confidence analysis methodology was used. The algorithm of this methodology was proposed in the 80s and 90s by V.I. Starosselskiy (on the basis of analysis of uncertainty interval). In the proposed version, a graphic-analysis method is used, which includes the construction of probability models for estimating TIP and analyzing their structural balance (V. Orlov's triangle). For the purpose of standardization of source and resource information base, USGS estimates from the first decade of the current century were used. Compilation of package of regional probability models with further cluster-analysis enabled isolating oil and gas regions according to confidence degree of estimates .

Estimates of resources of oil and gas basins of the Eastern Hemisphere (Norwegian, East Barents, West Siberian and other basins) and the Western Hemisphere of the Arctic megabasin (North Alaskan, Canada-Greenland and other basins) are characterized by the highest level of confidence. The basins of Eastern Arctic (basins of Arctic hollows, etc.) are characterized by the lowest confidence level.

The results obtained allow evaluating probability of the subsequent adjustment of available estimates of basins under the question and establishing an adapted system of strategic resource of risk management for development of resource potential of the sedimentary basins of the Arctic.

New features of the deep structure and the possibility of clarifying the hydrocarbon resources of oil and gas bearing and potentially oil and gas bearing basins of the shelf and land

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V.A. Ignatova (FSBI All-Russian Research Geological Oil Institute),
A.Ye. Romanko (GIN RAS)

Due to the accumulation of new geological and geophysical data on the structure of oil and gas bearing and potentially oil and gas bearing basins (OGB and POGB), as well as on the deep structure and geodynamics of the Earth as a whole, it became possible to significantly clarify the deep crust and mantle structure and geodynamic mechanism of formation of the OGB and POGB. Due to the hydrogen degassing of deep subsoil, it was also possible to determine the directions for further study of the characteristics of naftidogenesis for the Earth conditions, the formation of hydrocarbon (HC) deposits and, above all, deposits with gigantic reserves of gas and oil. The results of such study allowed to determine the place and purpose of the OGB and POGB in the structure and geodynamic evolution of the Earth - they are a consequence of the convective process in autonomously developing groups of the crust and mantle sectors - (the crust and mantle plates unlike the lithospheric plates as per the concept of tectonics of lithospheric plates). OGB and POGB are the areas of the Earth's deep thermal energy removal, and, at the same time, the "windows" of degassing, manifestations of active magmofluidodynamics, removal of mantle matter to feed continuously active upwelling in the oceans, and partly to the upper crust and volcanism for magmatism. It has been established that the OGB and POGB, despite the destructive processes at the stages of rifting, are the areas of active continent genesis both on especially active continental margins and inside continents in repetitive cycles: rift – sedimentary basin or OGB – orogen – peneplain. In such way, young and then ancient platforms were formed, constantly overgrowing with new platform formations. The lifting mechanism of deep gases (hydrogen, helium, etc.) to the surface layers was concerned. In this regard, the questions have been raised about the possible levels and mechanisms of degassing, the role of the planetary magmofluidodynamic system and deep hydrogen in the genesis of hydrocarbons. For the first time, the questions are raised about the feasibility of additional studies of the OGB and POGB by high resolution deep seismic tomographic profiles along the lines of previously developed DSS profiles, for example, along the line of Berezovo - Ust-Maya and then through the island of Sakhalin and the Kurile Islands, as well as through the Kamchatka Peninsula. Profiles across the Barents-Kara region and further across the Laptev Sea, East Siberian and Chukchi seas would be relevant; through the Caspian depression, then through the South Caspian and the Persian Gulf basin. It is important that such profiles would cross the already discovered giant hydrocarbon fields (Romashkinskoye, Orenburgskoye, Karachaganak, Astrakhanskoye, Tengiz, Kashagan, Shah-Deniz, Pars-Severnoe; in the Arctic: Shtokman, Rusanovsk, Leningrad, Tambeyskoye, etc.). The issues of availability and accounting of possible deep hydrocarbon gases in the total initial resource as-

sessment and forecast of new areas (including those considered unpromising) of large-scale gas and oil accumulation are also raised. Here, areas like the Kovykta gas condensate field, the Baikal environments, the basins of the active margins of Eurasia with the giant Yuzhno-Kirinsky and Bely Tigr fields and similar in structure zones of gas and oil accumulation, some transitional rock complexes in the lower layers of the OGB and POGB, where methane accumulation is possible, can be problematic, partly due to the hydrogen degassing of the Earth.

Subsea gliders – unmanned autonomous underwater vehicles for hydrocarbon fields exploration

B.A. Gaykovich, V.U. Zanin (OSEANOS JSC)

Originally, prospective offshore hydrocarbon field exploration is a high-cost technology demanding large support vessels fleet and wide infrastructure. It is important to develop agile, selective technologies to locate promising emerging basins more efficiently, conquering this new offshore acreage cost-effectively. Given the gradual depletion of easily recoverable reserves, the relevance of this subject will only increase.

The major importance of hydrocarbon production for the Russian Federation forces us to conduct long-term planning and develop prospective technology.

One of the promising areas of research is the design of autonomous underwater vehicles (AUVs) capable to autonomously explore prospective basins in order to identify the presence of hydrocarbon resources there for further oil&gas production.

The report describes Oceanos JSC practical experience in subsea gliders design and construction, trial results, as well as design basis of a prospective AUV for hydrocarbon resources exploration and analysis of the world developments in this field.

Offshore and slope sedimentation basins of the East Arctic: features of the geological structure and perspective zones of hydrocarbon accumulation

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The East Arctic (Amerasian) megabasin is located in the junction zone of the largest lithosphere blocks, the North American and Eurasian plates; which affected its tectonic evolution in the form of the geological structure features.

The shelf-slope basins of the East-Siberian and Chukchi seas: Novosibirsk-North-Chukotomorsky (East-Siberian and North-Chukotka sub-basins), Predvostochnosibirsky and South-Mendeleevsky are related to significant hydrocarbon prospects. This assumption is based on an analogy with basins with proven hydrocarbons occupying the same tectonic position on the passive continental margins of the South Atlantic [Khain and Polyakova, 2004; Zabanbark and Konyukhov, 2005]. The study of the features of the "geological architecture" of deep-sea fans off the coast of West Africa, conducted in detail in the paleo-deltas of the Niger and Congo rivers, showed that both transit and terminal complexes are characteristic for the continental slope [Adeogba et al., 2005; Wynn et al., 2005; Corredor et al., 2005]. The above-mentioned under-water fans are based on world-class oil source strata (comparable to the Bazhenov Formation) - Akata, Landana, Malembo, etc. Large oil fields are discovered off the coast of West Africa: Bonga, Erha, Agbami, Dahlia, Girassol, etc.

Within the Chukchi Sea, it is also possible to note the South Chukotka (including the Hope Trough on the shelf and the coast of Alaska) basin, shared with the above-mentioned Herald-Wrangel uplift zone, extending from Cape Lisburn in Alaska to Wrangel Island. Such a structure causes a sharp difference in the oil and gas potential of the individual parts of the Chukchi Sea. The thick (more than 8 km) passive-marginal cover of the North-Chukotka sub-basin, extending into the waters of the Beaufort Sea, is characterized by much higher hydrocarbon prospects [Obukhov, Agapitov, 1999], which is indirectly confirmed by the presence of a giant field deposit Pradho Bay on the north coast of Alaska. Relatively thin (2, rarely 3-4 km) terrigenous cover of the South Chukotka basin with little probability is able to ensure the formation of large concentrations of hydrocarbons. The prospecting surveys carried out on its Alaskan continuation (Hope Trough) showed the possibility of discovering only small gas fields.

Black Sea: features of the structure of the north-western part of the western Black Sea depression

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The reviewed part of the Black Sea has now been rather well studied by geological and geophysical exploration methods, and the results of deep drilling have been obtained for individual areas of the shelf. On the whole, on the basis of the obtained results, ideas about the geological structure of the region under consideration were formed. However, unresolved issues in the region structure still remain. In particular, this concerns the inconsistency of existing ideas about the structure with the actual data in the areas of the junction of the Mizi plate and the western plunge of the Mountain Crimea with the West Black Sea deep-sea depression.

The basis for such a conclusion is the data of gravimetric studies, according to which, it is possible to distinguish in the region under consideration a sublatitudinal band of positive gravitational field values from Southern Dobruja to the North-West Caucasus. Within this band, zones of the elevated gravitational field values are noted (South Dobruja, Gubkinsky, Crimea, Anapa regional gravity maxima). By analogy with the maxima within the land, the Gubkinsky maximum within the water area also can be associated with a raised block of the Mizi plate foundation.

Such a view suggests the need to clarify the structure in the areas of the junction of the Mizi plate and the western plunge of the Mountain Crimea with the West Black Sea deep-sea depression.

Clarification of the geological structure of the region under consideration can be carried out on the basis of materials of regional seismic studies of 2011, carried out under the Geology Without Borders program within the water area of Russia, Ukraine, Romania and Bulgaria.

The estimated clarification of the geological structure of the region under consideration will make it possible to more reasonably evaluate the oil and gas bearing potential of the western and northwestern parts of the Black Sea.

Influence of the lithologic and mineralogical characteristics on the gas permeability of reservoir rocks of the Dagi formation of Okhotsk oil and gas province (shelf of the Sakhalin island)

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In accordance with the energy strategy of Russia, the main volumes of hydrocarbon reserve growth are planned to be carried out by involving the resources of the Russian continental shelf. The Okhotsk oil and gas province (shelf of the Sakhalin Island) has significant energy resources and plays a major role in organization of gas supplies to consumers in the Russian Far East and the Asia-Pacific region. At the same time, the shelf areas are characterized by insufficient exploration of deposits, a high degree of uncertainty in the geological structure and the nature of the distribution of productivity parameters in the reservoir volume, which is associated with small volumes of prospecting and exploration drilling, high financial costs for the construction of wells, etc.

The main hydrocarbon reserves are concentrated in the deposits of the Miocene period Dagi formation, which are represented by sandy-aleuritic pore-type reservoir rocks separated by clay rocks. The paper presents the data of complex lithological-mineralogical and petrophysical studies of core material from reservoir rocks of the Dagi formation of the Sakhalin Island shelf. Based on the identified lithologic and mineralogical characteristics of the reservoir rocks, it has been determined that the main factor affecting the poroperm properties of the rocks is the content and composition of clay minerals. The obtained dependences of the gas permeability of rocks on the content and composition of clay minerals allow us to estimate the potential yield of production wells and use them in hydrodynamic modeling.

Recommendations are proposed for increasing the reliability of assessment of reservoir properties on the basis of a complex of geophysical data studies.

Effect of water saturation on the change of physical properties

V.S. Zhukov, I.V. Pleshkov (Gazprom VNIIGAZ LLC)

Experimental determination of the physical properties of rocks under conditions that simulate reservoir, is of great importance both for calculating reserves and interpreting data from geophysical surveys of wells, and for preparation of projects for the development of hydrocarbon deposits. The study of the processes of change of physical properties, under controlled conditions, allows not only to reliably determine them, but also to estimate the dynamics of their changes depending on the temperature and pressure conditions in the reservoir and the water saturation of rocks.

This paper is devoted to assessment of the effect of water saturation on the physical properties of reservoirs by creating residual water saturation in rocks and comparing them with values at full saturation. Changes in the petrophysical parameters of partially water-saturated rocks during the growth of effective pressure are studied and estimates of these changes are obtained.

Samples of sandstones and siltstones of the Dagi formation occurring at depths from 2742 to 2900 m were studied. The range of changes in atmospheric conditions is for 2.9% to 33.4% porosity and 2.91 to 1557 mD gas permeability. The number of studied samples: 240 pcs. - with saturation with the formation water model, 70 pcs. - measurement of gas permeability.

On the basis of the conducted research, it can be concluded that in the reservoir modeling conditions, with an increase in the average values of residual water saturation from 0.25 to 1.00, the average electrical resistivity decreases from 19.6 to 2.24 Ohmm (88.6%) and the velocities of longitudinal waves increase from 3.21 to 3.42 km/s (6.54%) and transverse waves from 1.68 to 2.08 km/s (23.8%). With the growth of residual water saturation, the effective permeability decreases, both in atmospheric and reservoir conditions. It is necessary to conduct additional experimental tests of samples under temperature and pressure conditions simulating reservoirs to clarify changes that are described by power or exponential equations. These data can be used both to assess changes in reservoir conditions during the development of a field using GIS-control data, and to assess the degree of change in productive horizons.

Technologies and features for development of hydrocarbon fields in the shallow water transit zones of the Yamal region Kara sea shelf

K.V. Alekseeva (Gubkin Russian State University of Oil and Gas (NRU))

Kharasaveiskoe and Kruzenshternskoe fields are located on the Arctic shelf of the Kara Sea. Basic complexities occurring during their development: severe Arctic climate; navigation season of 2-3 months; available permafrost rocks; shallow sea waters with a thick mass of ooze up to 20 m. Based on climatic and geological conditions, different variants for development of hydrocarbon fields in the shallow waters of the Yamal region Kara Sea shelf are proposed in the Report. It is proposed to use current technologies and methods for development of fields: the construction of production islands and offshore directional drilling of wells.

SESSION B:
DEVELOPMENT OF OFFSHORE FIELDS

Localization of the equipment used for drilling and construction of the offshore wells on the shelf – “mudline suspension system” of the production of the “Gusar” plant in pair with column head

B.V. Lonkin (Gusar LLC)

Gusar LLC has been working on localization of equipment used for drilling and construction of offshore wells on the shelf since 2015. Its main partner is the Plexus Ocean Systems company, which specializes in equipment for drilling exploratory wells using SEFDR (self-elevating floating drilling rig) in difficult geological and climatic conditions, namely, a mudline suspension system for the casing strings and a monoblock column head. Gusar LLC and Plexus offer for Russian Customers a complex product consisting of:

– pre-engineering works;
– equipment for exploration drilling;
– additional equipment for the full execution of the Customer’s drilling program;
– services for the descent, installation, dismantling of equipment.

Gusar-Plexus equipment:

– allows drilling in difficult ice conditions and taking the platform away when the ice floes are passing;
– increases the safety of work on the platform due to the constant work under the well-control equipment protection;
– reduces the drilling time to 5 days due to the absence of intermediate operations for installation/dismantling of the well-control equipment;
– reduces the cost of equipment due to localization of production.

As a result of the localization of production carried out by Gusar LLC, the Russian Customers obtained not only high-tech equipment for exploration drilling with SEFDR, but also engineering and service personnel competent in the field of offshore hydrocarbon production.

Nuclear energy supply of subsea and sub-ice development of the shelf of the Arctic seas

V.S. Ustinov, N.Sh. Isakov, V.P.Kuznecov, V.V. Kushtan, V.I. Makarov (NRC «Kurchatov Institute»)

When creating subsea and sub-ice development technique of the shelf of the Arctic seas, the following special aspects of its usage should be noted:

1. Difficult ambient climatic conditions
2. High safety and reliability requirements with regard to emergency prevention and response
3. The need to provide electricity for underwater equipment
4. Lack of infrastructure and difficult conditions of transportation and its installation at the place of operation
5. Applicability of routine activities and servicing in subsea and sub-ice conditions

The task of electricity and heat supply for the development of offshore fields in the difficult ambient climatic conditions is relevant and possible to resolve with the use of atomic energy sources. The experience of using nuclear energy in the Arctic is about 60 years, it is confirmed by reliable and safe operation of nuclear icebreakers, the implementation of the entire life cycle of shipboard nuclear power plants. At the stage of concepts and technical proposals, there are various developments in oil and gas shelf field development projects. There are projects with surface trim atomic energy sources based on producing the platform and with a submerged condition of energy module near technique oil or gas ocean mining. Besides there are a lot of projects with land bases atomic energy sources with electro-transmission via cable to technique oil or gas mining.

The existing successful experience in the development and operation of nuclear power plants will allow us to use some technological improvements in the field of creating new energy sources that are intended for the reliable and safe energy supply of field facilities. Such technological changes will allow us to increase the automation of the energy source, minimize the cost of maintenance personnel and maintenance work and solve issues of regulatory support, environmental monitoring and ensuring, high reliability through the use of passive safety and energy storage systems.

Analysis of hydraulic operation modes in subsea pipelines for different types of hydrate inhibitors

N.A. Buznikov, V.A. Suleymanov (Gazprom VNIIGAZ LLC)

Under the development of offshore gas condensate fields by means of subsea production systems, a reservoir fluid without preparation is transported to onshore processing facilities by a system of subsea pipelines. The presence of the condensed and produced water in a multiphase fluid leads to the risk of hydrate formation at high pressures in pipelines and low ambient temperatures. Thermodynamic inhibitors such as methanol and monoethylene glycol (MEG) are commonly used to prevent the hydrate formation.

In this work, a comparative analysis of the efficiency of MEG and methanol in lengthy subsea pipelines is carried out in terms of flow assurance. Hydraulic operation modes were simulated by means of OLGA software for subsea pipelines with the various length and sea depth.

The analysis shows that for a steady-state operation mode, the usage of methanol has the advantage over the usage of MEG allowing one to reduce the pressure drop and volume of the accumulated liquid in the pipeline. This is due to the fact that to provide the same level of protection of a pipeline against the hydrate formation the required mass of methanol turns out to be significantly less than the mass of MEG.

The initial filling of a subsea pipeline has also been studied. To estimate the duration of the pipeline filling we used a balance model, which is in a good agreement with the results of the dynamic simulation by means of OLGA. It is demonstrated that the time of the initial filling of a subsea pipeline with a required concentration of MEG is less than that for the pipeline with methanol. The decrease in the filling time is especially important for a lengthy subsea pipelines, since it provides more reliable protection of the pipeline against the hydrate formation when MEG is used as an inhibitor.

Theory, digitization and experiment while designing offshore oil and gas field development

M.N. Mansurov (Gazprom VNIIGAZ LLC)

The key aspect of risk mitigation at implementation of offshore oil and gas field development projects is the need of better understanding of the fundamental physical and chemical properties of rocks and fluids which have a decisive influence on maintenance of the total output and achievement of the project economic efficiency.

The field which uses the IT technologies is called “a digital field”; it is the complex of technologies of petroleum operations in geological prospecting works, drilling, production and digital control together with the standard communication technologies.

Unlike onshore deposits, the offshore fields are characterized by small scope of prospecting-exploration drilling and lack of the pilot production stage. The final result of the forecasting component shall be supplemented by processing of data obtained during exploration and drilling of offshore fields, interpretation methods in 2D and 3D geological models of deposits used as the base for execution of hydrodynamic models. So, even in the models based on the equations of mathematical physics, the circumstantial uncertainties stipulate the uncertainties in final results.

Field digitization in the context of initial data insufficiency and uncertainty typical for an offshore field state of exploration together with lack of exact mathematical formulation of the field problems set (spatial variation of reservoir characteristics: thicknesses, porousness, permeability, oil and gas saturation, etc.) may result in calculation errors. That’s why the empiric studies are required for proper forecasting of these parameters within digital models. Such studies are generally performed on the test sites used for testing of offshore technologies. The well-known test sites are the following: Rocky Mountain Oilfield Testing Center (USA), ProlabNL B.V. (Nitherlands), Ullrigg Drilling and Well Centre (Norway), etc.

Gazprom VNIIGAZ LLC has the practical conditions for organization of such test site in Russia, as it operates already the modelling benches for study of vertical, inclined and subhorizontal flows and also for diagnostics of gas-liquid flows in the wellbottom zones and pipelines with complex configuration, etc. The comprehensive researches of technologies on a test site allow to minimize risks associated with reliability of design output forecasting and maintenance, and to use the obtained results at all stages of development and facilities construction designing, selection of the well design and field facilities construction elements, determination of operating modes and control algorithms of production systems in certain geological and field conditions of the practical field.

The persons taking strategic decisions with time horizon of effect on production which reaches decades must take into consideration the risks associated with the specified uncertainties. Development and implementation of forecasting system based on the data analysis make possible to reduce uncertainties and corresponding financial risks efficiently.

Computation of the gas transportation parameters and offshore pipelines glaciation in the Arctic seas

N.N. Ermolaeva, G.I. Kurbatova, A.Yu. Shemakhin, S.A. Mikheev
(Saint Petersburg State University)

The specificity of offshore gas pipelines on the Arctic shelf is related to the low ambient temperature close to the freezing temperature, and the difficulties of intermediate compressor substations construction. Low water temperatures lead to the possibility of the subsea structures glaciation. Gas pumping through long pipelines without intermediate substations requires high inlet pressures. The authors have developed a mathematical model of gas mixture transportation by sea pipelines on the Arctic shelf, taking into account these features. The model takes into account the difference between the dynamics of glaciation in salt seas and the dynamics of ice grow in fresh water. The model covers different variants of pipeline location into the bottom soil. The effective numerical algorithm of calculation on the developed mathematical model realized in the form of a program complex is offered. The numerical simulations made it possible to determine the flow characteristics in the unsteady flow regime and to find the thermophysical characteristics of growing sea ice on the outer surface of the pipeline. As a result of numerical experiments based on the developed model, recommendations on the selection of the gas pipeline route relief are obtained. The computational model provides a way to compute an admitted gas pressure and temperature region at inlet, which makes it possible to avoid pipeline vibration. The paper presents examples of calculating the temperature, pressure and flow rate, as well as the thickness of the sea ice layer on the outer surface of the pipeline for the parameters of the problem of interest in the design of offshore pipelines on the Arctic shelf.

The role of primary studies of wells for determination of pressure-and-temperature reservoir parameters

G.M. Geresh, O.Yu. Yashchenko (Gazprom VNIIGAZ LLC),
M.B. Shevelev (Gazprom PJSC)

The development of gas-condensate fields on the RF shelf is the most important strategic mission. Scientific support begins at the earliest stages of offshore field development. The degree of freedom for decision making for development is low due to the following restrictions: the remoteness of the field from the coast, sea depth at location, ice conditions.

To solve this problem, in some cases it is reasonable to use underwater technologies for the development of offshore wells. As a rule the offshore fields are characterized by complicated geologic structure and after completion of prospecting surveys not all fields areas are covered with sufficient information regarding physicochemical properties of the fluid, pressure-and-temperature conditions. In this connection determination of pattern pressure-and-temperature conditions at the stage of initial studies in the course of development and testing of production wells is the main source of information for further forecasting of development parameters.

The existing methods to determine some parameters of physical and chemical properties of fluids are not adapted to new geological conditions of offshore gas and condensate fields. Pattern temperatures here are characterized by high values (above 100°C),the accuracy of their measurement affects the accuracy of definition of properties of reservoir fluids, and as a result, the technological indicators of development, on which basis decisions on production technology are made. One of the parameters depending on pattern pressure and temperature is the equilibrium moisture content of the pattern gas. The authors evaluated the change in the design moisture content, the report reviewed the range of moisture content values with possible deviations in the measurement of pattern initial pressure-and-temperature parameters and composition of formation fluids.

The system approach to location of production wells on an offshore gas condensate field

P.E. Yushin, G.M. Geresh (Gazprom VNIIGAZ LLC),
A.A. Timofeev (Gazprom PJSC)

Rational placement of high-output offshore gas condensate wells can be referred to the most important tasks of field development designing.

Many selection criterion should taken into account for arrangement of the well location system. The layout of drilling out centers and well grouping into clusters should:

– meet the purpose of the maximum field coverage by drainage for even recovery of reserves,

– ensure maximum possible approach of bottom holes to productive interval areas with the best permeability and porosity,

– if possible, avoid the negative effect caused by interference of gas wells with high output.

High cost of offshore well construction, requirements to their output, restrictions in methods and means of development control complicate the issue of location. For offshore fields, the influence of risks at well construction increases greatly, such as the risks associated with shallow gas distribution and seabed topography.

Use of subsea tieback technologies applies additional restrictions on well arrangement on the field area.

Complexation of arrangement principles taking into account the existing conditions and restrictions by applying the system concept methodology makes possible to reach the most rational arrangement of high-output gas condensate subsea wells.

Features for design of the Arctic shelf fields development

A.I. Zakharov, M.V. Kodash (Gazprom VNIIGAZ, LLC)

The Report is dedicated to the issues of the hydrocarbon feed design of development in the Arctic shelf conditions. The authors present the data on the state of knowledge structure of the resource base on the shelf of the Russian Federation. It is demonstrated that the major share of the original total resources falls on the water areas of the Kara Sea, the Barents Sea, and the Pechora Sea. The features for justification of the system main elements for the development of hydrocarbon deposits and the flowchart for development of the offshore oil and gas field complex are considered. In addition, the issues of the standard support for the design of development of the offshore fields are highlighted.

Approaches to modeling of fluid flow technological process in the system: “bench-well-gas collecting systems” of the offshore gas production field

K.N. Iksanov, G.M. Geresh, F.R. Bilalov (Gazprom VNIIGAZ LLC)

The digital computer modelling is a tool for natural gas field development analysis.

The natural gas field development technology is a broad concept covering various areas of science and technics while solving the labor-intensive task of hydrocarbon reserve extraction.

The report includes characteristics of the fluid flow processes in the “bench-well-gas collecting systems” system of the offshore gas production complex which are an integral part of the field development. Compliance with technological constrains imposed by technical and processing characteristics of an offshore technological complex and with well productive characteristics plays a key role at justification of a production forecast and a final recovery rate.

In the course of development, the parameters and characteristics of the extracted product flow are in dynamics, and the current values may pass from the intervals of allowed values in the range of critical unfavorable values. The proposed principles of the process simulation in the “bench-well-gas collecting systems of an offshore gas processing field” system consists in development of the mathematical apparatus controlling allowed values of development parameters. They include values of flow velocity in a gas collecting system units, well operating process parameters, gas compression ration in BCS. Additionally, the report notes the specific features of the dedicated software at designing of digital models and gives recommendations for their further improvement for offshore gas condensate fields.

Gas compressing technology when designing offshore field development and facilities construction. methodical approaches to optimization of design and engineering solutions

M.A. Vorontsov, G.M. Geresh , A.V. Kozlov, A.S. Grachev
(Gazprom VNIIGAZ LLC)

High capital costs for development of offshore gas condensate fields and their remote location from the coastal structure require development and implementation of effective methodical approaches for optimization of design and engineering solutions when designing their development and facilities construction, intended to minimize capital and operational costs, weight and dimensions of subsea equipment and to increase the operational reliability. This applies especially to the frozen water areas when access to the offshore field is restricted.

The report shows that optimization of compressing technology as an element of the integrated gas production, collection, preparation and transportation technological system makes it possible to optimize the technical and engineering parameters of the field development plan in whole, provides conditions for reliable and efficient field operation during the whole period of field exploitation.

It presents the list of optimization problems which should be solved at the stage of development and facilities construction designing to justify the variant recommended for implementation:

– synchronization of the gas production profile and the dynamics of the well head pressure values with the gross installed capacity (allows to smooth the “peak loads” in the compressing system);

– justification of effective gas collecting system (GCS) configuration based on the energy and metal consumption of “BCS-GCS” system;

– the assessment of sensitivity of design and engineering solutions to deviation of actual development values from design values.

Also, it presents the main results of application of the specified methodical approaches in practical designing of offshore field development and facilities construction.

Improving the methods of subsea well tests

G.M. Geresh, D.S. Yefimchenko (Gazprom VNIIGAZ LLC)

At the stage of offshore gas-condensate field design and development one of the most important tasks is the justification of the operating practices for high-flow-rate wells based on permanent monitoring of filtration parameters of strata. An applicability of existing methods for the study of high-flow-rate gas-condensate offshore wells is on the agenda. The report pays special attention to a need of improving the methodology for conduction and interpretation of primary and current gas-dynamic studies (GDS)of offshore subsea wells.

At the initial stage of field drilling development the wells were studied at maximum production rates, which amounted to only 30-40% of the required design value. The authors provided rationalization for maximum possible expansion of rates range on stationary modes when conducting gas-dynamic studies of well (GDSW) based on the capacity of the equipment at the MFDR. Improvement of the technique at subsequent wells showed better repeatability of interpretation results with the actual parameters of the technological mode of operating wells.

The next step of improvement was made by changing the procedures for research practice mode change, i.e. after the well cleaning modes at the maximum rate of 1.8 mln m^3 GDSs were conducted firstly in mode of reversing stroke to minimum rate, and then they returned to the forward stroke modes.

For the first time according to a specially developed program with preliminary modeling on the offshore field with a subsea tieback the current GDSs were comprehensively conducted under steady-state conditions of two wells without stopping the field, without releasing gas into the atmosphere. A special feature of studies is the observance of minimum total production to ensure gas treatment technology at the field when changing the operating modes of the wells.

Synergy of GDSW, PBU, WL results coupled with hydrodynamic simulation provide for a significant increase in confidence for predicting the development indexes.

SESSION C:
FACILITY CONSTRUCTION & OPERATION OF OFFSHORE FIELDS

Complex approach for facilities installation and production of Gazprom, PJSC marine fields

A.I. Novikov (Gazprom, PJSC)

Implementation of marine fields development projects, as well as activities on shelf in general is a multidisciplinary task, which involves various segments and directions such as engineering and technology, logistics, law of the sea, environment protection and etc.

Although the Russian Federation has huge experience in performing works in polar latitudes on onshore fields on both development and transportation of hydrocarbons, its experience in active works on the shelf is not that huge.

Along with this, Gazprom group of companies successfully implements oil and gas projects in a wide geographic range from polar latitudes, where oil is extracted in Prirazlomny field, to Far East seas, where Sakhalin shelf fields are developed.

Broad geography of works, remoteness from industrial centers, adverse climatic conditions, which determine seasonality of works, are the problems, which may only be solved based on complex approach. Such methodology allows avoid the risks, decrease capital and operating expenses and increase projects economic efficiency.

The report covers current situation and advances in facilities installation and production of Gazprom, PJSC shelf projects and shows main directions of development in these areas.

FEB RAS IMPT innovations in the area of subsea robotics for development of the national all year SPC equipment monitoring and maintenance system

A.F. Shcherbatyuk (FEB RAS IPMT)

The report reviews new developments of FEB RAS IMPT innovations in the area of subsea robotics which can improve the separate elements of the previously offered all year UUV-based SPC equipment monitoring system operated from a bottom mooring facility.

For the autonomous undersea robot control system, the algorithms were developed and passed the model based testing which ensure automatic search of specified bottom items by the side-scanning sonar and their following study using the photosystem.

The configurable UUV navigation command and control system (NCCS) was developed on the basis of the distributed event-oriented software platform. The system is configured flexibly for working with equipment of a certain UUV and it can be used in devices of various classes and purposes. The NCCS implements the functionalities to solve search and survey tasks.

The float-type navigation and communication module (FCNM) was developed to increase efficiency of shallow-water works performed using the UUV (for example, for monitoring of hydrobiont state) which can be towed by the submerged vehicle. The FCNM is equipped by the high speed communication channel connected to the support vessel (control station) which makes possible to transfer large volumes of on-line data and to control promptly the information collected by the UUV. The data from the navigation satellite system receiver are used for periodic correction of the cumulative vehicle position error.

The small-size efficient floating control system is developed which is operated by working fluid pumping between the UUV pressure hull and the outer membranes of variable volume. The system design with two spaced membranes ensures control of the vehicle depth of submersion and its trim angle.

Experience of science and technical support of subsea production unit operation

S.I. Golubin, D.A. Onishchenko (Gazprom VNIIGAZ, LLC)

Science and technical support is a complex of technical and technological, research and methodological, expert and analytical and experimental researches conducted by the Leading scientific organization (Gazprom VNIIGAZ, LLC) intended to increase quality and efficiency of taken engineering design decisions at design stage and also to implement corrective actions at production stage.

Currently Kirinskoye gas-condensate field is the only field in continental shelf of the Russian Federation, where extraction is performed using subsea production unit without using platforms and other above water structures. Thus, science and technical support of Kirinskoye gas-condensate field not only ensures operation reliability within the framework of taken engineering design decisions, but also provides new unique information. Gained experience will allow optimize designing and developing of further similar fields.

Within the framework of science and technical support of Kirinskoye gas-condensate field the results of long-term periodic surveys of offshore facilities were analyzed. Based on analysis results conclusions were made about current condition of operated facilities and also measures were proposed on improvement of diagnostic studies methodology in order to increase the quality and accuracy of obtained initial data.

Assessment of the state of anti-corrosion protection of underwater sea steel structures of extraction complexes

N.N. Glazov, D.N. Zapevalov, D.S. Sirota (Gazprom VNIIGAZ LLC)

The reliability and safety of the operation of subsea mining complexes and pipeline systems for transportation of products from offshore oil and gas fields largely depends on the corrosion state of the facilities and the effectiveness of the anti-corrosion protection (ACP) systems.

The task of the ACP is to limit corrosion processes, ensuring free of corrosion-caused troubles operation of the facilities during the design period of the subsea production complex (SPC) operation. The effectiveness of ACP is affected by the state of protective equipment, which has a tendency to change (degrade) under the influence of operating environments or external factors.

The report based on the experience of the participation of Gazprom VNIIGAZ specialists in diagnostic examinations of ACP systems of SPC facilities and underwater pipelines reviews the main stages and results of corrosion examination, demonstrates the used tools and diagnostic methods for means of protection against corrosion of underwater structures.

The analysis of “bottlenecks” that require the development for large-scale implementation of methods and technologies for corrosion examinations at offshore oil and gas production facilities.

Definition technique of residual term operation for subsea production system

E. Saleev (LLC "Gazprom dobycha shelf Yuzhno-Sahalinsk")

At the Kirinsky gas condensate field located on the shelf of Sakhalin in the Sea of Okhotsk, for the first time in Russia technologies with a fully subsea arrangement were used. Subsea equipment provides all year round production, collection and transport of well products from the offshore field without direct human participation. Diagnostics, scheduled maintenance at the facilities of the subsea production system are carried out using ROV during the navigation season, which lasts from June to October in the Sea of Okhotsk. The rest of the year carrying out any work with the equipment located at the bottom of the Sea of Okhotsk is practically impossible. Therefore, compared to other areas of offshore hydrocarbon production where it is possible to conduct all year round work in the field the requirements for equipment and technologies that are implemented in the subsea production system of the Kirinsky gas and condensate field should be more stringent in terms of reliability, technical and environmental safety.

Therefore, one of the main tasks facing the operating organization is to maintain operability and determine the actual technical condition of the subsea production system in extreme meteorological conditions (ice fields, minus water temperatures at the seabed, bottom flowings). The implementation of this task dictates the need for additional requirements and the development of a method for monitoring the state of the equipment that would allow all year round exploitation of the fields with the subsea arrangement which could be located not only on the shelf of the Far East, but also in the Arctic.

To determine the residual term of subsea production system it is proposes to consider a methodology based on following methods: the first one is a classical method based on the manufacturer's requirements, operational documentation and regulatory documents; second method is one based on a risk inspection methodology that allows for more flexibility in planning, financial distribution and technical resources.

High intensity of biofouling on the deep-water constructions and related riscs on the shelf of the sea of Okhotsk

V. Mokievsky, A. Chava
(P.P. Shirshov institute of oceanology, RAS)

Our knowledge of marine fouling processes is based mostly on experimental and observational data in shallow depth. For decades fouling in this area has been crucial for various commercial activities. In the shallow regions a great deal of accumulated data allows us to predict developmental patterns of the fouling as well as develop successful protective measures. However, marine fouling is not limited by depth. As we go deeper, the amount of solid substrate decreases rapidly. Though, if found at the bottom, the substrate is occupied by sessile organisms immediately. Deep-water research is technically complicated, that's why fouling communities there are still underexplored. Over the last years this knowledge gap became particularly noticeable as more and more industrial structures are installed at great depth. High intensity of biofouling occurs unexpectedly on the constructions of gas production on the deep shelf zone of the Sea of Okhotsk. It could cause unpredictable problems and risks in usage of the constructions.

Localization of concrete offshore structure technologies for shelf filed development according to schedule

D.V. Kazakovtsev, L.V. Papadmitrieva (Kverner LLC)

KVERNER, the Norwegian company, designs and constructs ready-to-operate (EPCI) offshore structures for development of offshore hydrocarbon resources. For 50 years, it constructed 26 large reinforced concrete stationary and floating facilities, 45 steel substructures and 24 superstructures for the projects on the continental shelf of Russia, Norway, Great Britain and Canada. KVERNER is on the Russian market for more than 20 years. The period of the peak economic activity in 2005-2015 was marked by the construction of three platform gravity base structures for Sakhalin-1 and Sakhalin-2 projects.

According to KVERNER, promotion of large-scale projects implementation on the Russian shelf can be ensured by transfer of innovative project scheduling and controlling methods with the focus on risk mitigation and the maximum economic benefit. The corporate procedures integrated under the name of “Project Implementation Model” (PIM) is the methodological basis ensuring success of the projects implemented by KVERNER. The PIM embodies the long-term KVERNER experience in implementation of EPCI projects. The PIM determines the sequence of phases, stages and works for each project; the scope and composition of design, manufacturing and administrative works, and also criterion for completion of preceding and starting of following works.

While designing concepts, KVERNER is focused on their feasibility with emphasis on the cost control and integration into design decisions of the facility design, construction and operation strategy. Investments in high-quality engineering at a beginning of a project is a guarantee of a project implementation on time and within a budget by means of risk mitigation and cost reduction at further phases.

KVERNER expresses readiness to cooperate with the Russian operators, design and manufacturing companies through joint implementation of offshore facility projects with optimal cost effectiveness and minimum risks on the shelf in the MIP environment.

In 2016, KVERNER LLC was established in Russia which should ensure the most effective execution of the outlined strategy.

The analysis of technological hazards when operating subsea compressor plants

A.I. Novikov (Gazprom PJSC),
M.A. Vorontsov, A.S. Grachev, D.N. Snezhko, I.E. Ibragimov,
A.V. Drozdov (Gazprom VNIIGAZ LLC)

The subsea compressor plants (SCP) is the innovative technology ensuring development of continental shelf fields. This technology is believed to be promising, especially for the Arctic offshore fields, but, at this date, there is no enough experience in the SCP operation, that's why consideration of their use is associated with the certain technological risks.

As the SCP operation is provided in the projects of development of the Russian Federation continental shelf fields, so it remains pertinent to perform researches for the qualitative and quantitative assessment of technological risks resulting in the following:

– providing proper technological solutions compensating potential adverse effects;

– forming proper requirements for designing of subsea compressor modules taking into account specific parameters of pumped medium and natural climatic conditions;

– determining the most important areas of scientific and practical works in order to increase reliability and efficiency of subsea compressing technology.

The report will include the following:

– brief overview of the current status of the subsea compressing technology;

– the methodical approach to the assessment of technological risks in SCP operation based on the sensitivity analysis of the development target values to deviation of the actual SCP operational data from the design values;

– recommendations on the measures at different lifecycle phases of offshore field development which will allow to minimize adverse effects if UCP operation is complicated;

– the main areas of scientific and practical works in increasing reliability and efficiency of offshore field development using UCPs in the Arctic conditions.

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International practice in the application of clad pipes for protection of submarine pipelines against carbon dioxide corrosion perspectives of application on Gazprom PJSC's facilities

A.B. Arabey (Gazprom PJSC), V.A. Yegorov, M.V. Simakov, T.S. Yessiyev (Gazprom VNIIGAZ LLC)

The development of offshore fields in the Arctic and the Far East is a promising direction for the development of the oil and gas complex of the Russian Federation. Operations of Gazprom PJSC on the Arctic shelf are carried out in accordance with the Program for Hydrocarbon Resources Development on the Shelf of the Russian Federation until 2030.

Considering the inaccessibility and complexity of offshore fields Gasprom PJSC pays a special attention both to industrial and ecological safety at the facilities.

Deposits of the Far North (Bovanenkovskoye OGCF, Chayandinskoye GCF, Kharasaveyskoye GCF) and the shelf (Kirinskoye and South-Kirinskoye GCF) are classified as corrosive due to the presence of CO_2 in the produced fluid. When interacting with formation waters carbon dioxide (CO_2) forms carbonic acid (H_2CO_3), which causes intensive corrosion of internal surface of pipelines and equipment manufactured from carbon steels.

Carbon dioxide corrosion is manifested not only by the uniform dissolution of surfaces, but also by uncontrolled local damage, and therefore is one of the most dangerous types of corrosion. Local corrosion rate can achieve 2 mm/year, while the risk of sudden destruction of pipelines is maintained even with increased pipeline walls thickness calculated for corrosion.

According to the World Corrosion Organization's estimates the cost of protection against corrosion and eliminating its consequences in the oil and gas and petrochemical industries is about one trillion dollars a year.

Kazakhstan's experience of 2013-2014 is indicative. There was a break of offshore pipeline designed and built from low-alloy steel pipes from the Kashagan field on the Caspian Sea shelf to the coastline in six months after the start of commercial production. For environmental damage from hydrogen sulphide leakage a fine of 432 million dollars was paid, after which the entire pipeline was redesigned and built using clad steel pipes.

To protect pipelines and equipment from corrosion two main technologies are basically used in world practice:

– corrosion inhibitors to protect pipelines made of low-alloyed carbon steels;

– tubular products made of corrosion-resistant materials: pipes made of high-strength alloyed steel with an internal cladding layer of austenitic steel, pipes made of 13Cr martensitic steel and pipes made of austenitic-ferritic steel (22Cr, 25Cr duplex steels).

Cladding pipes meet the highest demands for strength, corrosion resistance, and become widely used in construction of marine pipelines conveying corrosive agents.

Practical absence of operating costs, high corrosion resistance and long service life of cladding pipes (up to 40 years) make their usage Practical absence of operating costs, high corrosion resistance and long service life of cladding pipes (up to 40 years) make their usage in many cases more preferable and optimal in offshore fields of Arctic and the Far East.

36 anchors and one “Kola”. Installation of transshipment complex on the port murmansk anchorage

O.V. Tervinsky (JSC Beluga Projects Logistic)

As of today, “Kola” is the largest storage-tanker in the Kola Bay. Its deadweight makes 340 thousand tonnes, length – almost 335 metres and width – 58 metres. The harbor transshipment complex with capacity of 12 million tonnes of oil per year was brought to anchors in December 2017. It is expected that at least seven million tonnes of oil will be transshipped via this vessel by the end of 2018.

The Company Beluga Projects Logistic has acted as one of the main contractors on bringing the storage tanker “Kola” to anchors in the Kola Bay in the area of Filinsky Cape.

For safe installation and reliable fixation of the storage-tanker in the selected point, the Company specialists have preliminarily installed twelve anchor and mooring members. Each of them included three anchors with 50, 200 and 220 tonnes of weight, as well as the anchor interchains and the hawse chains linked with the tanker anchor and mooring system. Thus, 36 anchors of 5640 tonnes total deadweight were fastened on the bed of the Kola Bay, and the total length of all chains made approx. five kilometers. The anchors were delivered to the site of operations from the port Murmansk using the pontoon barge Damen Riverstar 2.

In this project, the company Beluga Projects Logistic applied a new technology: the heavy reinforced concrete anchors were installed in the Kola Bay bed using the rigging method by means of Strand Jack of Enerpac brand name hydraulic system. The submersion depth made above 155 metres. Nobody has applied this system for submerging the cargo on the sea bed; hence, such engineering solution can be regarded as the unique one. The Company other know-how is the semi-automatic system for cargo delivery under water, which was developed especially for this project.

The selected technology features for comparatively low price and high accuracy for positioning of the installed facilities – up to two meters, and it sets apart favorably from the more habitual method requiring involvement of expensive high load carrying capacity floating derricks. For fulfilling this order, the Company refitted the barge. As a result, the used solutions enabled to ensure safety and efficiency of works, meet the established budget and time framework.

Estimation of corrosion conditions and ensuring protection against carbon corrosion of the offshore hydrocarbon production facilities

D.N. Zapevalov, R.K. Vagapov (Gazprom VNIIGAZ LLC)

A number of active and promising offshore hydrocarbon production facilities, both in Russia and abroad, are characterized by the presence of elevated levels of corrosive CO_2 in their products. Its presence in the products in combination with other factors stimulates the risk of intensive development of corrosion processes (up to 2-3 mm/year), and requires careful and reasonable attitude to the choice of technical solutions for the material design of the pipelines and equipment and the corrosion protection to ensure reliable and safe operation of the mining facilities.

The authors analyzed the existing approaches to the assessment of the corrosion hazard of the produced media, the selection and implementation of solutions for the protection of the offshore facilities producing hydrocarbons from internal carbon dioxide corrosion. The factors that determine the selection of solutions for corrosion protection and corrosion monitoring are reviewed. It has been shown that in case of using carbon steel at hydrocarbon production facilities in the presence of corrosive factors, including CO_2,one of the best means of protection is to use corrosion inhibitors.

On example of the analysis of bibliographic data and the work carried out by Gazprom VNIIGAZ LLC on the selection of corrosion inhibitors for offshore shelf facilities, the features of accounting and modeling of operating conditions affecting the assessment of corrosion inhibitor properties and the effectiveness of inhibitor protection are shown.

Bimetallic pipes: protection against corrosion and economy

K.S. Cheskidov (Tekhnomash LLC)

Application:

– Marine projects, S-lines, J-lines

– Technological pipelines for the transportation of highly aggressive reservoir gas-liquid fluids from production wells to preliminary water discharge unit (PWDU), booster pump station (BPS), sewage pumping station (SPS).

– High and low pressure water conduits for the transportation of highly corrosive formation waters to injection and absorption wells.

– On-site technological pipelines at the BPS, PWDU, oil treatment unit (OTU), oil pump station (OPS), etc.

– Bimetallic tubing

Bimetallic pipe consists of two layers of metal. The outer layer is a pipe made of carbon steel, mainly used to achieve the required strength. The inner layer is a pipe made of corrosion-resistant alloy or stainless steel, mainly used for corrosion resistance.

Due to the use of combined pipe, high corrosion resistance and strength are achieved. At the same time, the price is significantly lower than the price of corrosion-resistant pipe capable of withstanding the same pressure.

Economic and environmental performance:

– Reducing the costs on the use of corrosion inhibitors.

– Reducing the costs on purchasing pipes made of corrosion-resistant steel with a high Cr content (more than 5%).

– Increase the period of trouble-free operation.

– Reduction of operating costs for the repair of pipelines.

– Reducing the risks of environmental pollution.

Efficiency of application of electric heating systems in extreme conditions

A.A. Dochkin (Teplovyye Sistemy LLC)

1. Experience in the use of electrical heating systems during operation in extreme conditions.

Electrical heating systems (EHS) at the facilities of GAZPROM, ALROSA, ROSNEFT, LUKOIL, INK. Features of the EHS construction for operation in extreme conditions. Our differences from others. The answer to your doubts is in our solutions.

The scope of electrical heating systems at sea. Heated decks, gangways, platforms, covers and blinds, handrails, pipelines and tanks, fittings.

Pilot developments in the field of EHS. Heating of the helicopter pads on ice-resistant platforms in the northern seas. Features of electrical heating systems.

2. The optimal composition of the electrical heating system as a decisive factor in the performance of the EHS.

Smart cable. Self-regulation is the basis for energy saving and efficiency of the electrical heating system.

The program for calculation of heat loss. The scope of the linear part of the EHS: cable (self-regulating, resistive), connecting boxes, accessories. Electrical heating control by main set parameters. The selection of thermal insulation.

Total control in the heating cable production. Features of the production of control cabinets and junction boxes. 25 years of EHS service is not the limit.

3. From design to installation and commissioning - a united area of responsibility.

Positioning of our company as six in one. Design in a short time. Production of heating cables in optimal time. Stocks. Commissioning and training of the customer personnel during installation. Opportunities for strategic partnership. Album of typical units. Certificates for products and works.

Innovative heavy-duty cable solutions

R.Yu. Voroshilov (Bi Pitron LLC)

The Russian manufacturing enterprise Bi Pitron LLC, under the conditions of the current import substitution, offers innovative technical solutions in the field of transmitting control signals, monitoring, and also heating of external devices.

Due to the unique combination of knowledge and experience that has arisen as a result of the mutual enrichment of the company's border areas, a synergistic effect arises - the effect of dynamic expansion of competencies. The result of this process is formed advanced ideas in solutions for design and manufacture of cable systems, where the company has its own know-how technologies and patents.

The proposed solutions are built on the platform of information support for the life cycle, the calculation of reliability and the whole complex of tests of developed cable systems. Products of Bi Pitron LLC provide reliable data transmission via protocols at the rate of 10 Gbit/s and higher over copper and fiber-optic communication lines. They have excellent electromagnetic compatibility, provide a low degree of the signal attenuation, increased wave impedance, temperature range from minus 70 to plus 1200 ^{O}C, fire and explosion safety, tightness, flexibility, low weight, small size, the minimum amount of harmful impurities released in case of a fire. Sealed connectors of the systems allow signal transmission between equipment that is submerged at depths of up to 1000 m.

The company's products are able to perform online monitoring of the stress-strain behavior of mining complex structures, performing processing and long-term storage of the read data arrays.

Designed heating systems are able to provide effective automated autonomous heating of equipment for a long period of time.

The proposed solutions are suitable for use in both oil and gas processing equipment, and for a wide range of tasks of monitoring and controlling of the complex technological processes of automated subsea production.

Computer modeling of the interaction of sea pipeline and soil with weak strength properties

P.V. Burkov (TPU, TSUAB),
V.P. Burkov, Le Thi Thu Thuy (TPU)

The giant oil and gas condensate fields discovered in recent years on the Arctic shelf are promising for production, in light of depletion of many fields on land and increasing demand for oil. Hydrocarbon deposits in the Arctic region are estimated by some experts as one third of the world's reserves. A large number of open deposits are located on the sea shelf. Offshore production is 2–3 times more expensive than onshore production, because more complex technologies and other, more high-performance equipment are needed to develop underwater deposits of oil and gas. It is much more convenient and economically expedient to extract oil in the shallow part of the sea belonging to Russia than at depth. But there are many reasons that complicate the exploitation of deposits in this region. For these reasons, it is impossible to lay the pipelines along the bottom in sea conditions, it is necessary to bury oil and gas pipelines into the ground. Currently, there is no clear procedure for designing offshore pipelines in soils with weak strength properties, and there is also no method for testing water-saturated soils for strength and bearing capacity in relation to the offshore pipelines. In the course of work: the idea was proposed and approved - to consider joint calculation as a two-stage method for analyzing the stress-strain behavior of a pipeline using FEM; the elements of a mathematical model of the pipeline interaction with the geo environment have been developed. The regulatory documents, defining the procedure for calculating the pressure pipelines, specify the requirement for joint calculation of the pipeline and the soil in-situ. Evaluation of stresses arising in the pipeline during buckling, due to weak strength properties of the soil, showed the need for mandatory modeling, formulation and mathematical formalization of the problem of interaction of the offshore pipeline with the surrounding soil with weak strength properties and allowed to calculate the optimal parameters that ensure the stability of the system.

Assessment of risks of the interaction of sea pipeline and soil

P.V. Burkov (TPU, TSUAB),
V.P. Burkov, Le Thi Thu Thuy (TPU)

In the process of extracting offshore oil and gas, the underwater pipeline is an important part of a project for offshore oil and gas production. If such event as the leakage of oil from the pipeline occurs, it will cause huge economic losses and serious pollution of the marine environment [1]. Pipeline bending strain is a common form of pipeline damage. The pipeline bending strain is a local, perpendicular and horizontal bending, in which the pipeline is under external pressure and without free deformation. Voltage occurs inside the pipeline. At the moment, the location of the pipelines in the ground will provide some resistance to loading in order to prevent the occurrence of stress in the pipeline of arbitrary shape. Thus, the resistance of the soil is an important part of the study of the pipeline bending [2]. In the course of work: the idea was proposed and approved - to consider joint calculation as a two-stage method for analyzing the stress-strain behavior of a pipeline using FEM; the elements of a mathematical model of the pipeline interaction with the geo environment have been developed. The regulatory documents, defining the procedure for calculating the pressure pipelines, specify the requirement for joint calculation of the pipeline and the soil in-situ. Modeling of the process of horizontal resistance to the action of the seabed soil and the pipeline under the ANSYS program is possible. The displacement-stress curve from the finite-element model approaches the ideal elastoplasticity curve and is close to the results obtained from the calculated theoretical formula. In addition, the use of ANSYS for the analysis of soil resistance generates the need for other studies.

Unique electrically driven pumping units for offshore hydrocarbon deposits

O.V. Kryukov (Gazprom VNIIGAZ LLC),
V.N. Meshcheryakov (Lipetsk State Technical University)

At the present time, electrically driven oil and gas pumping units are the only and non-alternative option for the implementation of power systems for structures and facilities of the underwater mining complexes. The new hardware base of electrical engineering, power electronics and microprocessor equipment ensures the creation of high-tech, energy efficient, reliable and quickly recouped units and automated systems based on unmanned technologies. It is especially relevant in conjunction with the complex of power supply systems of field facilities, where the requirements for guaranteed survivability of the underwater deposit structures and facilities in category 1 of power supply reliability are high.

The features of implementation of the new original technical and technological solutions for the functionality of electrically driven gas pumping units with intelligent control and diagnostics systems are reviewed: gearless and oil-free performance in a single monocase with superchargers; reliable electromagnetic suspension of a rotor; smooth safe start under load; frequency and frequency-current relay control of parameters and automatic adaptive adjustment of control laws; built-in system for monitoring and forecasting of technical condition.

The typical examples of many years of successful industrial exploitation of innovative electric gas and oil pumping units that provide the implementation of partially unmanned and unmanned technologies, including autonomous power supply systems of the Arctic hydrocarbon deposits, are given. Modular invariant structures and laws of optimal control of power supply systems for consumers of offshore oil and gas fields have been proposed, which allow to guarantee energy-efficient power supply to the main process units and other consumers of the underwater mining complex.

Gas chromatographs Khromos as a solution for marine fields facilities installation and production. Experience of use in oil and gas industry

A.L. Pakhomov (Khromos Engineering, LLC)

Khromos Engineering is a reliable partner.

Business strategy consists in implementation of digital bus.

Company achievements is a formula of successful business growth.

Remote diagnostics ensures work without borders.

On-stream chromatographs Khromos is a high-tech engineering solution for gas monitoring.

Results of the deadweight ratios FPSO/FLNG platforms study

K. Berezhnoi (Krylov State Research Centre)

The displacement of vessels is one of its most important characteristics, which gives an idea of its overall dimensions. In the theory of ship design the definition of displacement at the initial design stages is inextricably linked with the value of its deadweight rates: ratio between major parameters and total displacement.

Deadweight (net payload) for bulk carriers and oil tankers is taken as the main parameter, for container vessels - the number of containers (twenty-foot equivalent unit - TEU). These coefficients are determined by prototype vessels and may have different values: oil tankers - 0.65-0.9, bulk carriers - 0.70-0.85, container ships - 0.04-0.07. Level of deadweight/net load capacity/TEU (usually given in the Terms of Reference) with a known deadweight rates allow us to determine mass and dimensional characteristics of the designed object, by which we can judge value of CAPEX.

The database of deadweight ratios of marine transport vessels is constantly updated, however, the determination of the deadweight ratios of FPSO/FLNG has not previously been performed.

Applying this approach to FPSO / FLNG has some peculiarities. Various hydrocarbon production per day, period between offloading and volume of storage; significant top side weight (more expensive then hull) depending from hydrocarbon production per day; the composition and mass ratio of consumables that make up the total deadweight.

The result of the research performed are deadweight ratios of the FPSO/FLNG platforms which will be used for determination of mass and dimensional characteristics of designed platforms which ultimately makes it possible to determine the capital costs of the object with known distribution coefficient of construction costs.

SESSION D:
EMERGENCY RESPONSE & RESCUE SUPPORT & NORMATIVE LEGAL REGULATION WHILE DEVELOPING OIL-AND-GAS RESOURCES

Topical aspects of the development of the rescue support system of marine activities in the Arctic

V. Ilyukhin (non-profit organization "Association for the development of search and rescue equipment and technologies»)

The report discusses the main regulatory, organizational and technical aspects of the development of the Federal system of search and rescue, as well as of the relevant aspects of departmental systems of marine activities rescue support, taking into account the real natural and climatic conditions and long-term plans for the development of oil and gas fields in the Arctic. The expediency of updating the federal and departmental normative documents that regulate the requirements to the organization of functioning of rescue systems is shown, as well as the updating of national standards to means of evacuation and rescue from sea vessels and constructions. Proposals for improving the organization of the creation of advanced search and rescue equipment and technologies are formulated. Examples of innovative technical solutions for the creation of rescue and evacuation facilities with the required technical characteristics for ships and structures in the Arctic are given.

About liquid hydrocarbon spills response capability in freezing seas without vessels

A.V. Marichev (Gazprom VNIIGAZ LLC),
V.R. Marichev (Research Guidance Center "Risk Informatics" LLC)

After accident in the Gulf of Mexico in 2010 a huge quantity of scientific researches was carried out abroad in the field of planning and eliminating marine spills of oil and oil products including those in ice conditions, but no breakthrough technologies were created in this area at all. Existing methods for cleaning the liquid hydrocarbon spills under ice conditions still fail to achieve optimum effect, while almost all works indicate the need to start work on the elimination of oil pollution during the first days after the accident.

In Russian Arctic this problem is significantly complicated due to the small number of ice-class vessels and huge distances. In the most cases ships are not able to promptly perform the works for elimination of hydrocarbon spills, which necessitates developing methods and technologies of spill elimination without usage of ships.

The report covers an analysis of the results of scientific and technical researches in the region of interest carried out in Russia and abroad among which the most interesting are the studies carried out in the framework of international joint projects (Joint Industry Program on Oil Spill Contingency for Arctic and Ice-Covered Waters, Arctic Monitoring and Assessment Program). International and Russian experience of liquid hydrocarbon spill cleaning under the ice conditions.

The analysis of the conditions required for responce of spills of liquid hydrocarbons in seas without vessels was carried out, and the possible steps of using aircrafts for dispersants and oil and oil products combustion were considered, and the technology of underwater dispersants spraying was analyzed.

Concerning the issue of estimation of liquefied hydrocarbon flux parameters at pipeline depressurization

Yu.Yu. Petrova, Yu.V. Gamera (Gazprom VNIIGAZ LLC)

Recently observed fast development of the Arctic territories imposes high requirements to the industrial safety of the hazardous production facilities (HPF) of the oil and gas complex in whole, and, in particular, to the safety of the liquified hydrocarbon transportation facilities. Thereby, the need arises to perform the detailed risk analysis on these facilities. This, in turn, induces improvement of the methodological approaches to the mathematic simulation and calculation of the basic parameters responsible for formation and propagation of the affecting factors at accidents in condensate lines and product lines transferring stable and unstable hydrocarbon liquids.

At risk assessment of condensate and product pipe lines, the flux parameters are the basic: first of all, the flux volume and intensity at pipeline depressurization.

The present work presents the review of some engineering methodological approaches for calculation of hydrocarbon liquid flux parameters at pipeline depressurization. It gives comparison of the estimated data on the dynamics of liquid propane mass changes during depressurization of a pipeline section with the experimental data.

Special aspects of accident risk assessment for hazardous facilities of the oil and gas industry operating in the Arctic conditions

Yu.V. Gamera, Yu.Yu. Petrova (Gazprom VNIIGAZ LLC)

The critical component of the hazardous production facility (HPF) operating process is protection of people, infrastructure and environment from potential accidents. Considering that the risk-based approach is adopted in the industrial and fire safety area, this objective can be achieved only through identification, evaluation and minimization of risks associated with accidents at HPF using risk analysis methods. At that, as regards to representativeness, the risk analysis procedure should be based on the regulatory and procedural documents covering all calculation stages (from determination of an accident frequency and affecting factor (AF) distribution patterns taking into account different HPF operating conditions to calculations of risk values).

The report discusses specific aspects of the technology-related risk analysis for Arctic HOFs of the oil and gas complex (OGC) based on the climatic and natural features of the region and facility scales in the following areas:

- expected accident frequency;
- formation, distribution and affect of AFs;
- regulatory and methodical support of calculations.

The review showed that the procedural framework for accident risk analysis at OGC HOFs located in the Arctic regions is rather limited at present and does not cover the most part of events and AFs typical for the specified facilities. Above all, this refers to the AFs forming and propagating in the presence of the temperature inversion layers in the atmosphere or in the large-size HPFs.

Challenges of standard and engineering regulation of off-shore oil and gas facilities on the continental shelf

A.A. Lyapin, Ya.S. Gusarova (FSAEI HE Gubkin Russian State University of Oil and Gas (NRU)) (Federal State Autonomous Educational Institution for Higher Education)

The off-shore oil and gas activity implies the activities on the continental shelf aimed at geological survey, marine research and resource study, prospecting, production, storage, transportation, transshipment, processing of the continental shelf hydrocarbon natural resources, which is carried out in the form of designing, construction, commissioning, operation, restoration, retrofitting, upgrading, overhaul, preservation and decommissioning of the off-shore oil and gas facilities.

The regulatory legal acts available at the moment and the existing federal executive authorities supervising the off-shore oil and gas facilities (OOGF) do give an opportunity to consider OOGF as an integral structure, but divide it into component elements within the limits of their own regulation area.

OOGF, in its turn, is an integral processing complex with its main functional purposes consisting in prospecting and production of hydrocarbon feed, its rough processing and storage, acquisition and storage of wastes, provision of space for personnel work and rest.

The aspect listed above generate the problem of insufficiency in the available regulatory enactments, expertise, activities of supervising bodies for possibility to make integral assessment of all issues related to OOGF safety, as well as for consideration of the questions based on interaction of various hazards existing at OOGF.

As a result of emerging contradictions and imperfection of the system existing in the country for regulation, expertise and supervision of OOGF industrial safety, the prospecting and development of the off-shore oil and gas fields are encumbered.

Eventually, the need arises for review of the available laws, their harmonization, as well as elaboration of a single integrated system for regulation, expertise and supervision of the off-shore oil and gas facilities safety based on improvement of the applicable laws and the foreign practice synthesis.

The regulatory framework in the area of arctic operations

A.V. Melnik (Gazprom VNIIGAZ LLC)

The standards regulating operation of buildings and vessels are the main sources determining working efficiency, safety and probability of accident occurrence. The work originality is that the requirements to development of offshore oil and gas fields in the Arctic conditions were formulated for the first time in the Russian Federation taking into account the characteristics and specific features of the Arctic operation environment.

The report will present the results of works on implementation of the Program on Preparation of GOST R National Standards of Offshore Field Development in the Arctic Conditions. Also the issues will be discussed which arose before the developers while working with standards from the “Arctic operations” series and the demands for the regulatory support of offshore field safe development on the Russian continental shelf in the Arctic conditions will be determined.

Conflict resolution approaches between regulatory bodies and Russian maritime register of shipping in respect of MODU legal regulation

V.F. Aminev (Murmansk Branch of Gazprom flot LLC)

In the Soviet period, both the USSR Gosgortekhnadzor and Register of Shipping of the USSR were responsible for operational safety of Mobile Offshore Drilling Units (thereinafter – MODUs) at the continental shelf of the USSR.

The foreign Classification Societies had an obvious advantage over the Register of the USSR in terms of MODU's operational safety. The principal difference was that the foreign Classification Societies had the generally unified Rules for the Classification and Construction of MODUs. These Rules mutually complemented the Rules of Engineering Supervision for MODUs excluding any contradictions.

The Register of Shipping of the USSR had no MODU classification, which caused excessive inconveniences while drafting of Standards and Technical Documentation for MODUs operating control as well as professional engagement and interaction with USSR Gosgortekhnadzor.

After the disintegration of the USSR, the MODU oversight functions moved to Russian Maritime Registry of Shipping (thereinafter – the RS). Rostekhnadzor had the function of well construction supervision only.

Since the enactment of the Federal Law on July 21, 1997 No. 116-FZ "On Industrial Safety of Hazardous Production Facilities", Rostekhnadzor recommenced to provide MODU safety oversight. From that point forward, the Russian and foreign MODU operators began to face challenges due to contradictions in Rostekhnadzor and RS requirements in the matters of MODUs operation security.

Comparative analysis of the Rostekhnadzor's and RS's Standards and Technical Documentation has exposed some differences in approaches, the requirements duplication as well as in the related areas, where the mutual control should be strengthened.

In our opinion, the main objective is to adopt the universal solutions enabling Rostechnadzor and RMRS to develop the elements of legal regulation, which will give them the opportunity to maintain comprehensive safety oversight in respect of MODUs as well as their Shipowners.

Study of the transformation of light hydrocarbon spills in the Arctic shelf and technical and technological solutions to eliminate them

G.D. Vorsina, V.Ye. Zolotarev
(RSU of Oil and Gas named after I.M. Gubkin)

Today, the degree of study of the Arctic shelf is no more than 4%, which determines the high prospects for geological prospecting work (GPW), the likelihood of discovery of new deposits and, as a consequence, the risks of emergency situations caused by oil and oil products. Particular attention is paid to gas and gas condensate fields, where the main source of spills are light hydrocarbons, such as gas condensate (GC) and diesel fuel (DF).

The nature of the impact, the area of distribution of the spill, as well as the physicochemical interaction of GC and DF with the environment, due to their high flammability and fractional composition, predetermines a special approach to the actions to eliminate the spill, in order to reduce the negative man-made impact.

As part of this work, a mathematical model has been built for calculating the possible scenarios of the spilled oil product behavior in accordance with modern concepts of the main processes of propagation and physical and chemical transformation of light fuel, also taking into account the specifics of operation in the Arctic regions. Based on this analysis, there is a need to modernize the methods of localization of accidental spills. It is important to note that we are not talking about creating from scratch the entire infrastructure of forces and means to respond to the GC and DF spills, it requires optimization and taking into account international experience that will allow to eliminate the accident in the shortest possible time.

SESSION E:
ENSURING INDUSTRIAL & ENVIRONMENTAL SAFETY ON THE SHELF

Features for safe exploitation of Kirinskoe gas condensate field by means of subsea production complex

A.V. Suetinov (Gazprom Dobycha Shelf Yuzhno-Sakhalinsk, LLC)

The project for the Kirinskoe gas condensate field (GCF) development is the first project implemented by Gazprom, PJSC, on the shelf of the Russian Federation and the first project in the country, within which framework the hydrocarbon feed production is performed using the subsea production complex (SPC).

The Sakhalin shelf features for complicated hydrometeorological and engineering-geological conditions. The technologies used during the field development allow for carrying out industrial and business activity with a minimal negative impact on the region ecological system.

The Kirinskoe GCF implies application only subsea facilities in the field water area using the central gathering manifold and the wells connected with the manifold via the intra-field pipelines and flexible drill strings.

During construction of wells, two Gazprom floating semi-submersible drilling rigs (FSSDR) “Polyarnaya Zvezda” and “Severnoe Siyanie” were used. In accordance with the terms of reference, all used SPC equipment was presumed on the failure-free operation during 30 years with no replacement and has permission for its application issued by the Federal Service for Ecological, Technological, and Atomic Supervision.

Technical condition monitoring is performed using the dedicated equipment (the bottom profiler, the multiple-beam echo sounder, the side-scan sonar, pipeline finder and the like) and the remotely operated vehicle by means of the specialized vessel.

For prevention of potentially hazardous incidents, the Company has developed the action plans for localization and elimination of the accident the consequences on the Kirinskoe GCF facilities (onshore facilities and SPC) and for prevention and response to oil and oil products spills (onshore and offshore areas).

In accordance with regulatory legal documents requirements, the integrated and the tabletop exercises, training and drills on the issues of a potential accident and emergency response at the Kirinskoe GCF onshore and offshore development facilities are conducted. Successful implementation of activities ensured that there were no accidents, emergencies, and incidents during 10 years of operation of the Company.

Issues of ensuring the safety of tanker LNG transportation

V.S. Safonov (Gazprom VNIIGAZ LLC)

The report systematizes and analyzes current ideas of domestic and foreign experts on provision of the safety of LNG tanker transportation.

A comparative analysis of the constructive stability of LNG tankers with various systems of cargo tanks (spherical, self-supporting trapezoidal, corrugated trapezoidal) to external dynamic effects was performed in scenarios of grounding and ramming of various cargo capacity vessels to the side of the tanker hull.

It has been shown that tankers with spherical cargo tanks have the greatest “survivability” (the least probability of damage to cargo tank).

The analysis of the typical consequences of depressurization of one of the LNG cargo tanks for possible outflow scenarios at the waterline level, above the water surface and below the waterline was performed, including:

– the dynamics of LNG entry into the environment and into the inter-hull space;

– spreading and evaporation of LNG on the water surface and in the water column with due consideration of the formation of ice and the effect of the rapid phase transition;

– burning of the LNG “puddle” on the water surface and the thermal effect of the flame on the environment, including the structural elements of the tanker and cargo tanks with LNG;

– cryogenic effects of LNG on the structural elements of the outer hull and the internal bulkheads of the tanker.

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Protection of submarine facilities against the impact of ice formations in the Arctic shelf conditions

A.A. Garkavko, V.B. Glagovsky, S.A. Sosnina, O.M. Finagenov
(Vedeneev VNIIG JSC)

In Arctic shelf areas with a relatively small sea depth, submarine oil-and-gas-field facilities can be exposed to the impact of keels of ice formations that are freely drifting or "plowing" the seabed. Similar issue occurs with a two-year cycle of exploratory drilling at a shelf of freezing seas with a short navigation season and forced preservation of the well in winter period.

To ensure the integrity of submarine facilities for the operation period, it is required to provide for structural activities aimed at protecting them against the impact of ice formations.

In connection with conditions of the Russian Arctic shelf (Kara Sea), the following possible types of equipment protection were studied: "pit"; "large-diameter shaft" of pre-assembled reinforced-concrete rings with lining; "shelter" of a dome made of steel or reinforced-concrete; "shelter" of a "barrel" type supposing its burial in soil and arrangement of a "sacrificial" part.

For all considered protection types, an analysis was performed as to efficiency of a method under the impact of various types of ice formations (keels of ice ridges, glacier bergs, tabular bergs) and possibility of its implementation with involvement of predominantly Russian contractors; besides, there was a feasibility study of the options for various scenario conditions (hydrometeorologic, engineering-geologic conditions, sea depth, parameters of ice formations, height of the facility).

Based on generalization of study results, preliminary recommendations were developed for selection of the best possible option for protective structures depending on engineering-geologic conditions at the considered area of exploratory drilling. While a dredging (of the pit) can be considered the best possible protection option for dense soils the site is composed of, a steel "shelter" structure of "barrel" or "dome" type can be considered the most efficient protection arrangement for weak soils.

MMBI experience in application of remote sensing and geolocation methods to evaluate migrations of animals in the Arctic

P.R. Makarevich, D.G. Ishkulov (MMBI KSC RAS)

When working out geoecological basis for the development of oil and gas fields on the Arctic continental shelf, one needs a comprehensive analysis not only of the background status of the biota, but also of those possible changes in the structure of biological communities, which can be natural or man-caused. Existing evaluation methods are based mainly on discrete monitoring surveys and on the analysis of previously obtained and archived data. It should also be borne in mind that one of the factors that can affect the structure of communities is the change in animal migration routes. Such migrations can significantly alter the composition of biota in ecosystems including those in areas of development of oil and gas fields. Without having comprehensive information on migration processes, it is impossible to clearly determine whether changes in ecosystems are natural or man-caused.

During long practice of field studies on the Arctic continental shelf MMBI has gained good experience in application of up-to-date technologies to study migrations of marine animals using seals, toothed whales, fish, and zoobenthic animals as subjects of research.

During these studies new knowledge has been obtained, which allows revising ideas on the timing, directions, and quantitative parameters of migrations of animals during the year.

The data obtained can be used to develop technologies for the decision-making process in sustainable ocean management practices, predict possible consequences of man-caused impacts and ensure the environmental safety in the Arctic.

Analysis of storm situations in the Okhotsk sea detailed in the coastal zone of the Sakhalin island

N.A. Diansky, V.V. Fomin (SOI),
M.M. Chumakov (Gazprom VNIIGAZ),
D.V. Stepanov (TOI RAS)

One of the features of the atmospheric circulation over the Okhotsk sea is the frequent occurrence of extreme situations in the autumn-winter period, when a large number of cyclones are recorded. The cyclones transit, in turn, leads to a significant intensification of surface water velocities and storm surges. This paper outlines the storm activity over the Okhotsk sea with a more detailed analysis of the coastal zone of Sakhalin island. The atmospheric and ocean reanalysis of the Okhotsk sea, based on numerical models COSMO-ru (The Consortium for Small-scale Modeling) and INMOM (Institute of Numerical Mathematics Ocean Model) with a spatial resolution of 6 and 3.5 km, are used as initial data. It is shown that atmospheric conditions during periods of extreme wind speeds in the region of Sakhalin island can be divided into three types: cyclones from the southwest, cyclones from the west, and frontal zones. The strongest response in surface currents is observed with cyclones coming from the southwest, when there is an intensification of the cyclonic gyre of the Okhotsk sea and, accordingly, an increase of the East Sakhalin current. Atmospheric fronts have the least response to the variability of the circulation of the Sea of Okhotsk. The spatial variability of the currents, as well as their vertical structure, are investigated. The necessity of using a physically complete hydrodynamic model for a more accurate simulation of the response in the sea circulation is shown.

Using the results of maritime field investigations during preparation of initial data for designing the offshore fields facilities in the shelf area of the sea of Okhotsk

M.M. Chumakov, D.A. Onishchenko (Gazprom VNIIGAZ LLC)

The initial data for designing offshore field facilities include information of performance (operational and extreme) characteristics of hydrometeorological components and parameters of ice cover (HMC), on the basis of which the estimate impact on structures is determined and ancillary marine operations are planned. The absence of long series of hydrometeorological observations in the Okhotsk Sea necessitates the use of a special methodology for determining the performance characteristics of HMC, which includes two main components: hydrodynamic simulation method (HS) and probabilistic modeling method (PM). The HS method developed is a synthesis of up-to-date mesoscale modelling of atmospheric processes, marine dynamics, wind-driven waves and ice cover evolution. The accuracy of reproduction by models of interannual, seasonal short-period variabilities being HMC inherent directly in the water area of the field of interest depends largely on the tuning parameters of the models used. The optimum value choice of tuning parameters and verification of models is possible only based on analysis of observational and measurement data obtained in the framework of summer and winter expeditionary research using research ships including icebreakers. The paper also shows the role of in-situ measurements of morphometric characteristics of ice formations in the development of methods for interpreting the results of modeling the evolution of ice cover.

Morphometric features of the ice gauge furrows at oil and gas prospective areas of Barents-Kara shelf

S.G. Mironyuk (Center for Seismic Data Analysis, Moscow State University named after M.V. Lomonosov), A.A. Ivanova, D.I. Damyanovich (Morskaya proyektno-izyskatelnaya kompaniya LLC)

The study of the features of spatial distribution and parameters of the ice gauge furrows (plow marks), the depth of the introduction of ice formations into the soil, as well as the assessment of the age of the plow marks is one of the priority tasks of engineering surveys for designing the offshore structures on the Barents and Kara Sea shelf. This issue is of particular relevance in relation to the plans for the further development of the hydrocarbon resources of the Arctic seas. The development of pipeline and cable networks, other underwater technical means for development of the Arctic shelf may increase the likelihood of their damage by icebergs and hummocky formations. From the point of view of the general problem of the impact of ice formations on underwater facilities, it is of interest to study not only modern, but also ancient (relic) earthing furrows. The latter are particularly well preserved within the deep-water (prevailing depths of 300-350 m) of the Central lowland region of the Barents Sea. The analysis of data of the sonar survey and multibeam echo sounding (MES) performed in this part of the Barents Sea indicates the extensive development of relic plow marks here. They have the following morphometric characteristics: length 3.5-6 km, width 30-300 m, depth 1-16 m. MES in the Novaya Zemlya region of the Barents Sea showed that along with the numerous relic plow marks, in some places, at the sea depths of 110-180 m presumably modern furrows are present as well.

The exaration activity of ice formations in the Kara Sea is reflected in the seafloor relief (at a sea depth of more than 50 m) in the form of mainly modern iceberg furrows. In shallow waters (sea depths of 30 m and less) in the overwhelming majority of cases the furrows are created by the keels of ridges and single drifting hummocks. Most of the furrows on the edges have swells (side berms). Some furrows end with a front berm.

SCANEX maritime: complex of geo-services for monitoring of freezing water areas

A.V. Kobyzev, T.S. Khaybrakhmanov (SCANEX Group)

In the freezing water areas of the world, including in our region of the Russian Arctic, due to unfavorable and often extreme natural conditions, there is a high need for complex spatial knowledge, ensuring rational management of marine economic activities. One of the effective ways of transferring such knowledge is modern geo-information services (geo-services) developing at the intersection of GIS technologies and the Internet.

In the existing market of IT-solutions for shipping, you can find suppliers of various disparate geo-services for monitoring freezing water areas, but, in most cases, it is necessary to use these services together to form more complete information to make the most effective decisions.

From 2016, the ScanEx group has been implementing a project to create a portal for geo-information and satellite data and services of the maritime industry “Scanex Maritime” (Maritime portal). The project is being implemented as part of the National Technology Initiative Marinet. The main objective of the project was to create a single web platform to provide industry participants with access to modern geo-services operating on the basis of prompt satellite information. The pilot areas for the implementation of work results are the freezing areas of the Russian Arctic.

Currently the project is close to completion: all the necessary tools for the Maritime Portal were successfully implemented, more than 11 new software products were developed, communications were established with more than 10 partner service providers, territorial coverage includes all areas of the world. The Scanex Maritime platform is already successfully used by 50 new business customers, working closely with them allows us to actively develop the existing Portal solutions and promptly introduce new products into production.

Monitoring of the ice and metocean conditions as the necessary stipulation for the ice management

I.V. Buzin (FSBI «Arctic and Antarctic Research Institute»)

The long-term cooperation of the AARI with the largest gas and oil companies operating in the Arctic, providing hydrometeorological and ice information for the implementation of the plans for the development of the Arctic and the NSR, and the need for prompt decision-making under extreme conditions led to the development of the ice management (IM) concept.

Practice of companies operating now in the Kara Sea and the Ob Bay proves once again the need for the introduction of IM. An integral part of the IM is a subsystem for monitoring and forecasting the state of the ice cover, which includes hydrometeorological monitoring.

Lack of the observational network of the ROSHYDROMET in the remote regions lead the solving of this problem by the means of the oil and gas companies. The main problems these companies face on the Arctic Offshore are dealing with the lack of real-time and forecast information on the sea level, currents, and wind waves. This situation causes economic losses that could be minimized by implementing of the following actions:

1. Use of the modern methods of the data analysis, able to record the climate change,
2. Installation of the measurement equipment with the function of the real-time data measurement (for the purposes of the maintenance and forecast),
3. Development of the new methods of automatic processing of the real-time information,
4. Implementation of the regression models for the short-time forecasting,
5. Implementation of the hydrodynamic models for the long-term forecasting.

Solving of these tasks as well as tasks connected to the ice cover monitoring will let us create the system of the local monitoring and forecast of the metocean and ice conditions.

Morpholitodynamic laws and protection of facilities and communications on accumulative shore in the cold sea conditions

V.V. Afanasyev (IMGG FEB RAS)

As the review of the issue shows, shore protection is necessary primarily for facilities and communications located on Holocene sand-and-shingle accumulative formations (barrier islands and spits). Undoubtedly, due to the presence of permafrost and seasonally frozen soils in the beach area, contact of fast ice with ice and the specificity of the hydrodynamic mode, the erosion of the coastlines of the subarctic and arctic regions has significant differences from erosion in middle latitudes. However, in recent years, the main attention has been paid to the study of the erosion activity of the permafrost sediments of the coastal plains. And the basis for determining the long-term trends in erosion of the problem areas of the coast lies only in interpolation of the average long-term data obtained from the analysis of remote sensing materials.

The report compares the approaches to the protection of the coasts of Alaska, Chukotka, Kamchatka and Priokhotye. The evolution of coastal protection solutions on the arctic and subarctic shores is shown. It is concluded that the justification of design solutions does not always correspond to the level of modern knowledge of coastal dynamics. In relation to the problem of coastal protection, trends in erosion of coastal plains and dynamics of Holocene accumulative forms are considered, the scheduled reorganization of which, as well as the decrease or increase in area, are largely related to the development mechanisms of these forms due to the parameters of the alongshore sediment displacements, the tendencies of displacement of the lagoon straits, seasonal features of the coastal profile structure. Particular attention is paid to the analysis of the features of geomorphological processes on the arctic and subarctic shores. Deformations of the underwater relief under fast ice, an increase in the steepness of the upper part of the coastal profile during ice formation, and deterioration of the wave suppression properties of beach deposits during their freezing were noted. It was concluded that on the basis of complete set of data on the development and dynamics of the reviewed sea coastal area, biopositive and safe coast protection solutions are possible.

Quantitative analysis of destruction of the shores composed of bedrocks in conditions of the cold seas (application and results)

V.V. Afanasyev (IMGG FEB RAS)

The destruction of rocky shores is a function of the characteristics of the bedrock, wave climate, tidal regime and weathering features. At the present time, it is believed that wave effect is decisive in the development of such shores in areas with high wave energy, whereas the role of weathering prevails in warm temperate and tropical areas.

High-precision digital multi-temporal models of the relief of abrasion-denudation shores with up to 200 meters wide benches allowed to determine the rate and nature of destruction of bedrocks of weak and medium stability, as well as to estimate the ratio of subaerial and subaqueous components of destruction of the shores in cold seas. The role of wave erosion turned out to be significantly lower than expected, and was reduced mainly to the mobilization and removal of debris resulting from frost weathering at negative air temperatures during the open sea period. At the same time, the number of freezing and thawing cycles reaches several dozen. The formation of resistant spread ice mounds stops the active process of frost weathering in the area of wave and tide effect. A map of the intensity of frost weathering effect on the coast of Sakhalin Island has been compiled.

High-precision orthophotomaps and 3D models of high coastal ledge composed of volcanogenic sedimentary rocks allowed to determine the mechanisms of destruction of cliffs with heterogeneous strength and their quantitative parameters. It was found that the destruction proceeds along structurally weakened areas, as well as during the collapse of large blocks of rocks due to the formation of wave-tide niches in rapidly degrading tuffs. Boulder and shingle beach sediments also form the niches in the andesite-basalt varieties of the section, but at significantly lower rate. Internal erosion of tuffs and their contacts significantly weakens the strength characteristics of volcanogenic-sedimentary mountain massif. The recession of the edge of the beach scarp composed of volcanogenic-sedimentary rocks under these conditions can reach several meters per year.

3d modeling of the process of gouging of a sandy soil by the ice features keels using finite element method

P.S. Shushpannikov, D.A. Onishchenko
(Gazprom VNIIGAZ LLC)

A 3D finite element model and results of modeling of the process of gouging of a sandy soil by ice features keels are presented.

Within the framework of the study the soil is supposed to be elasto-plastic and is modelled on an eulerian finite element mesh. The keel is supposed rigid, modelled on a lagrangian finite element mesh and has the shape of either truncated pyramid or truncated cone. It is supposed that there is the Coulomb friction on the contact between the keel and soil. The modeling is performed using the LS-DYNA software.

The mechanism of gouging process is studied in details. In particular, trajectories of the soil particles forming a soil mound in front of the moving keel and berms along a gouge are analyzed. Characteristic features of soil deformations in the gouging process are also analyzed. An influence of the keel shape and keel front side slope angle on the soil resistance force is studied. Special attention is paid to an achievement by the gouging process of the steady state conditions at which the size of the mound in front of keel, the size of the berms along a gouge and also the value of the force acting on the keel from the soil attain their critical values. The achieved success in the numerical realization of this aspect confirms the efficiency of the developed ice gouging model and allows to pass to the next stage of a problem solution in which it is planned to obtain reliable estimates of the stress-strain state in the pipe buried in a soil and affected by the ice gouging process.

Evaluation of physical protection system effectiveness in hazardous production facilities of the oil and gas sector located in the extreme north conditions using spatial databases and routing algorithms

V.S. Petrov (NIIgaseconomiks LLC)

The work provides the method of numeric evaluation of physical protection systems in hazardous production facilities of the oil and gas sector (HPF PPS) based on the numerical models. On the basis of spatial databases, a HPF PPS model is built, whereon critically vulnerable areas are highlighted. The penetration/detection isochrones are determined using the optimization algorithms for different intruder models. The integral criterion of the critical penetration/detection isochrone deformation for the model object is used as the assessment criterion.

This numerical evaluation will make it possible to grade PPSs, including those located in the Extreme North conditions, according to the protection level using different intruder models such as taking into account the detectability for the upper hemisphere and the aqueous medium.

Application of the safety barriers concept at risk analysis on LNG HPFs

I.S. Zhykov (AIPR ANCO)

The “safety barrier” concept is used most commonly in a number of semiquantitative methods of the accident risk analysis. The declared objective of these methods is to assess adequacy of technical and organizational methods and means of protection presented at a facility for potential dangers. The term “safety barriers” representing the organizational and technical methods and means of protection provided for prevention, control and mitigation of undesirable events and accidents is reflected in some translated standards for the risk analysis as well as in the regulatory and methodical documents of the Federal Service for Ecological, Technological and Atomic Supervision, for example: The Federal Rules and Regulations in the area of industrial safety “General requirements to justification of a hazardous production facility safety”, the Safety Guideline “Methodical framework for hazard analysis and accident risk assessment on hazardous production facilities”. Besides, the Federal Rules and Regulations in the area of industrial safety “Safety rules for liquefied natural gas facilities” being under development currently include the requirement whereunder organizational and technical safety measures (safety barriers) existing at a facility shall be considered during risk analysis.

One of these methods is safety barrier diagrams (barrier diagrams). The safety barrier diagram is the graphic representation of undesirable event development through different system states depending on operation of the safety barriers intended to prevent such development. This is an oriented acyclic graph similar to the event tree, the fault tree where each safety barrier is presented as AND circuit. Application of the barrier diagrams for LNG HPFs enables receiving the data on probability of accident occurrence taking into account functioning of emergency protection measures and devices at the facility and also to assess efficiency of each separate safety barrier.

Preventive forecasting of the state of EDGPU by the means of artificial neural networks

O.V. Kryukov (Gazprom VNIIGAZ LLC),
V.N. Meshcheryakov (Lipetsk State Technical University)

In order to increase the reliability and safety of the process units of the offshore oil and gas field structures and facilities with the possibility of preventive forecasting of the technical condition and transition to maintenance by the actual condition, it is necessary to develop scientifically based methods and systems of prompt monitoring.

It is advisable to provide direct control of the technical condition of electrically driven gas pumping units (EDGPU) by integrated system of prompt monitoring and forecasting (ISPMF) of basic parameters. Its basis are: database of experimental data on failure statistics; multivariate analysis of the causes and dynamics of the influence of external disturbances; mathematical formalization of the procedure for monitoring and synthesis of regression algorithms; neuro-computer implementation of the EFGPU ISPMF architecture.

ISPMF on the basis of artificial neural networks (ANN) provides information with the forecast and greatly weakens the effect of all perturbing factors. On the basis of the analysis of the types and intensity of failures in the main units of the EFGPU, the depth of monitoring of the power drive structures is determined by means of the ANN.

A new mathematical approach is proposed, it is based on the identification of an EFGPU or a separate engine by an abstract dynamic system, the functioning process of which consists of changing the state under the influence of disturbing factors. As a result, the ISPMF models allow not only to synthesize an algorithm that is invariant to the depth of monitoring and the hardware structure of the ANN, but also to apply unified smart sensors of primary data.

ISPMF with ANN in the “on-line” mode uses the principle of the expert system. The prediction algorithm uses the preliminary fuzzification of the current input variables and their rates of change. The predicted values of the monitored data are determined from obtained linguistic values.

The original architecture of the EFGPU resource forecasting system and the neuro-fuzzy algorithm for which patents of the Russian Federation were obtained and which are implemented at seven pump stations of Gazprom PJSC are presented.

SESSION F
TWO OCEANS: PRESENT AND FUTURE OF THE RUSSIAN OFFSHORE OIL & GAS PRODUCTION

Analysis of development concepts of the North Wrangel license area within the data insufficiency conditions

I.M. Kurchatov (LLC "Gazprom Neft Shelf")

The Russian Arctic continental shelf has significant hydrocarbon reserves (15.5 billion tons of oil and 84.5 TCM of gas, according to the Ministry of Environment).

Due to insufficient knowledge about the Arctic offshore and its severe environmental conditions, oil and gas field development is technically and commercially complicated in the region. The localized infrastructure development, especially in areas such as the East Siberian Sea, makes it hard to collect the data necessary for detailed technical analysis within conceptual studies.

The objective of this project is to develop the comprehensive analytical basis for possible development concepts of the hypothetical field in the North Wrangel license area (NWLA) of PJSC "Gazprom Neft", within the data insufficiency conditions, by:

– determining the status of technology for field development in extreme Arctic and ranking various best practices applicable for the East Siberian Sea;

– analyzing comparatively environmental conditions of similar regions;

– calculating possible environmental impacts on the facilities that can be used for drilling and production;

– identifying limiting factors and challenges.

The survey techniques and monitoring of technical state of Kirinskoye subsea production facilities

E.S. Desyatnichenko
(LLC Gazprom dobycha shelf Yuzhno-Sakhalinsk)

The development of oil and gas fields of continental shelf of the far East and Arctic seas using subsea production systems is one of the promising and strategically important activities of Gazprom. Today the Kirinskoye field is first field on the Russian shelf developed using the subsea production system in difficult climatic conditions.

The operation of subsea production system and transportation of the flowstream is complicated by a number of conditions: limited access to subsea facilities in severe ice conditions in winter, the location of the field in the seismically active region, aggressive marine environment, subsea equipment is subject to intensive biological fouling and corrosion, multiphase transportation of flowstream to the shore technological facilities, periodic development of the field, the possibility of hydrate formation.

In order to ensure reliable and safe development of the Kirinskoye field, prevention of emergency situations, as well as forecasting the technical state of subsea production systems, it is necessary to survey techniques and monitoring of technical condition of subsea production systems.

The paper presents the experience of LLC Gazprom dobycha shelf Yuzhno-Sakhalinsk in organization and conduction of survey techniques and monitoring of technical state of subsea production system, describes the main types of work, as well as recommendations for their further improvement.

Prospects for development of low tonnage liquefied and compressed natural gas transport by sea

K.Yu. Balykova (Krylov State Research Centre FSUE)

At the present time, the main method of natural gas delivery to a consumer is transport by ground and subsea gas pipelines. This delivery method has the advantages if gas pipe lines are laid in safe areas and in water areas with well-developed local infrastructure and maintenance service.

If it is necessary to transport natural gas in remote areas, especially in foreign countries, some technical, organizational and legal problems may arise due to a large length of a gas pipeline, many natural and anthropogenic restrictions and also due to local regulatory barriers and political factors. Besides, a gas pipeline damage may result in continuous partial or complete shutdown of the delivery process especially if a major accident occur.

In that context, the technology of liquified and compressed natural gas (LNG/CNG) delivery becomes more and more actual, in a volume not exceeding a consumer's needs considering a delivery schedule optimal for a consumer. Also the technology provides gas supply for consumers in areas without well-developed gas transport infrastructure.

The most promising method of product delivery is low tonnage LNG/CNG transportation by sea and river vessels (gas carrier vessels, container carriers). This mode of transportation has a number of important advantages which may include: no technical connection of a supplier to a receiver, less dependence on geographical obstructions on a supply route, high technical and economical efficiency when transporting for long distances, less sensitivity to geopolitic factors and regional instability, scalability of delivery.

For Russia, there are some difficulties together with the above mentioned advantages in usage of this low tonnage LNG/CNG delivery. In particular, time and cash expenditures are required for designing and construction of low tonnage LNG carriers and container carriers and also of additional infrastructure for their receipt and shipping, or, alternatively, for modernization of the existing terminal capacities with regard to maintenance of low-tonnage vessels and product traffic. Also, inadequacy of the existing regulatory support for the use of low-tonnage LNG / CNG, both internationally and in Russia, has an effect.

In recent years, Krylov State Research Centre FSUE performs scientific and technological researches in this area and offers to implement some organizational and technical solutions for the above mentioned problems.

Development of method of calculation of the integral index of personnel individual risk at the main gas pipeline compressor station personnel in cases of emergency situations in Arctic conditions

I.N. Alexeev, A.L. Terekhov (Gazprom VNIIGAZ LLC)

Due to necessity to improve the occupational safety of the main gas pipeline compressor station employees under the conditions of limited financial backing it is actual and practically relevant to work out a calculation method of integral index of personnel individual risk. For the first time it is proposed to make assess using an integral index that includes the risk of occupational diseases, the risk of exposure to chemicals that occur during the reproduction of offspring, the risk of disability days loss due to mild to moderate injuries, the risk of fatal injury (as a result of such damaging factors as air blast, fragments hit, exposure to thermal radiation subject to specificity of northern conditions) and the risk of exposure to hygienic factors of conditions labor (microclimate caused by extreme environmental conditions; intense noise; vibration of a hand tool at low air temperatures; gas pollution of premises; chemical factors;strongly fibrogenic aerosols; biological factors; lighting and visual impairment; air aeronization; non-ionizing radiation; ionizing radiation). The report presents the results of a weighted estimate of all components of the individual risk of the compressor station personnel and gives recommendations for their decrease. The recommendations given enable effectively distributing limited material resources and providing economically sound and sufficient safety level.

Research features of off-shore boreholes with subsea completion

R.A. Shologin (LLC Gazprom dobycha shelf Yuzhno-Sakhalinsk)

Gradual depletion of the oil and gas reserves on the mainland determined the need for a wider development of oil&gas resources of the global ocean, in which interior the concentration of oil and gas is three times larger than on the mainland. Thus, for the first time in the Russian practice of gas production, the development of the fields with underwater wellhead location was implemented in the Kirinskoye field.

The approaches to surveying the boreholes with underwater wellhead location and the examples with the solutions applied in the Kirinskoye gas condensate field are described in this publication.

In particular, the following issues were considered:

– Differences in approaches to surveying the boreholes with underwater and platform wellhead location;

– Set of studies at the well development stage and telemetry fitting of the well with subsea completion for obtaining maximum possible data volume;

– Gained experience and results of the boreholes with underwater wellhead location studying based on Kirinskoye GCF.

Further on, the obtained experience will allow for required system of research and fitting of the boreholes with telemetry when developing the future off-shore fields in the complicated conditions at the stage of designing exploitation and development of the field.

Spray icing hazard analysis on offshore oil and gas field facilities and development of method for its prevention

E.V. Bogatyreva, V.A. Mishin (Russian State University of Oil and Gas (National Research University) n.a. Gubkin I.M.)

Today, the great attention is paid to development of the Arctic offshore shelf. Here, the large oil and gas reserves are concentrated, a number of large deposits have been already discovered and they are under development now, and the majority of deposits have to be discovered yet.

The Arctic Region is the special area with its own natural and climatic, environmental and political special features posing the problems, solution of which predetermines possibility of deposit development. Currently, each project under implementation is innovative with its own technological solutions which can take into account all features of this region.

Spray icing of offshore oil and gas field facilities is typical for each point of the Arctic shelf. At each field, it is necessary to develop an effective method of its prevention, as spray icing causes significant damage to the structure of utility facilities, may damage the field equipment or make it inoperative and also causes injuries to the operating personnel.

This work reviews the natural and climatic features of the arctic seas of the Russian Federation, identifies the areas subject to spray icing. It gives consequences of spray icing on the offshore platforms. The global experience of protection from spray icing is analyzed, the detailed report is made for each method. The work offers the method of spray icing prevention using gas furnaces and a pipe network. Using the equation of Nov'ye-Stokes, the ice formation model was developed and the mathematical analysis of the proposed method efficiency was performed.

Designing of the universal ice-resistant platform for field development in the Arctic shelf

D.A. Mirzoyev, A.A. Kalmykov (Russian State University of Oil and Gas (National Research University) n.a. Gubkin I.M.)

The Russian Federation has the largest territory and the longest coastline in the world. The hydrocarbon potential promotes development of severe and inhabited territories in the Extreme North.

The aim of this work is to design the universal ice-resistant platform (UIRP) for the freezing seas of the Russian shelf. The most important and main aspects of the study were reviewed:

1. Determination of potential surface field locations for production of crude hydrocarbons.
2. Analysis of hydrometeorological conditions in the region.
3. Analysis of the shipping period in the freezing seas.
4. Analysis of the technical availability of the Arctic fields.
5. Research of the sea bottom configuration.
6. Determination of selection criterion for the substructure design.
7. Design features of the ice-resistant fixed platform unification.
8. Estimation of wind and seaway loads on the UIRP.
9. Analysis of manufacturing plant locations.

For the last fifty years, many oil and gas fields with unique reserves were discovered on the Russian shelf. Their development and commissioning require significant intellectual, material and financial investments.

The IRP unification is the key condition for reduction of costs for designing and construction of hydraulic structures; it will trigger development of offshore projects in the Arctic Region.

Power supply of subsea production complexes

Ya.A. Kharchenko, S.S. Sunugushev (Russian State University of Oil and Gas (National Research University) n.a. Gubkin I.M.)

Currently, the world consumption of crude hydrocarbons is increasing year on year, onshore fields are being depleted and new fields are generally discovered on the continental shelf or in the deep ocean. Facilities construction for these fields requires another approach. The Russian Federation has the longest coastline in the world, the discovered offshore deposits are generally located in the Arctic and Far East freezing seas.

One of the problems at facilities construction for offshore remote oil and gas fields is difficult maintenance of reliable power supply. The great distance to the shore causes losses in the power cable stipulated by usage of the alternate current. This work reviews the existing power supply systems of the oil and gas field SPCs in the Norwegian shelf. It studied the principles of subsea power transfer for long distances using high voltage DC cables. It reviewed the invertor as the motor in the compressing system of the subsea production complex.

The theme of this work is actual due to the large number of gas fields with uncompleted infrastructure construction in the Russian Arctic Region and short shipping season, as offshore field development in the freezing seas is possible only by the subsea method. Development of the subsea production complexes system will make possible to put into operation the remote offshore fields in the Arctic Ocean within a short time.

Overview of the geological hazards at the southwestern part of the Kara sea according to high-resolution seismic data

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In recent years there was conducted a huge volume of the seismic investigations at the Kara Sea (either 2D, or 3D). During the interpretation of this data it is important to consider that the studied region was affected by various freezing including Quarternary. A set of vertical sections and horizontal slices of dynamic attributes was examined in the analysis of the seismic data. For each type of hazard there was determined a set of signs uniquely characterizing it among the other types of risks. As a result of the interpretation of the obtained data the following potentially hazardous and unfavorable elements of the geological section for drilling were identified: paleovalleys, estimated distribution areas of permafrost accumulations, tectonic disjunctive faults, subvertical linear elongated tectonically weakened zones, gas-bearing sediments, weakened zones in bed-rocks, post-cryogenic deformations. In addition, during the study of objects directly or indirectly related to the formation of frozen rocks, an explanation of the mechanism of their formation in the sediments of the Kara Sea shelf was proposed.

Development of the scheme of in-field collection of well products as part of subsea production facilities to perform operations on in-line inspection of underwater pipelines without the use of marine vessels

A.D. Panychev (LLC «Gazprom dobycha shelf Yuzhno-Sakhalinsk»)

The purpose of this study is to develop a technique of the piping of wells with underwater completion as a part of subsea production facilities, it's implementation will contribute to reducing financial expenses of the company-operator for operation on diagnostics and cleansing of the cavity of the pipeline. Moreover, within the framework of the proposed methodology, in order to perform the above works without stopping the process of oil and gas production from the wells, a special device has been developed that has no analogues in the world, which allows redirecting the means of purification and diagnostics to the required in-field pipeline.

Risk analysis and engineering and technological solutions aimed at safety of works on design and construction of wells under available geological hazards in the upper borehole on the continental shelf of the Russian Federation

A.Yu. Zavatsky (Gazprom VNIIGAZ, LLC)

The task for development of the offshore oil and gas fields becomes more and more crucial due to the industry's growing demands in raw materials and energy and significant depletion of the mainland resources.

The issue of ensuring the industrial and environmental safety of drilling works is relevant in a number of problems for the development of the oil and gas shelf fields. During drilling engineering and geological, exploratory, and production boreholes, the occurrence of emergencies is frequent, which are determined by the available shallow gas lenses (gas pockets) with increased formation pressure and the layer of permafrost rocks (PFR).

During hydrocarbons production, all the above-described hazards create the potential risks for artificial structures, to which the platforms and the jack-up drilling rigs belong. PFR upper layer thawing, intensive caving formation related to rock falls and slides causes reduction of the well and soil foundation load carrying capacity, which may result in a gas breakthrough to the bottom surface during drilling and lead to instability of platforms and loss of drilling vessel buoyancy.

Two conclusions derive from that: first, during drilling the borehole upper interval, the special attention shall be paid to its hydrostatic and temperature control; and second, the drilling platform personnel safety, alongside with environmental protection, are the most important factors taken into account during development of the drilling technique and selection of the drilling method on the continental shelf of the Russian Federation.

Designing of «ESP unit» pump for lateral hole operation

A.V. Varentsov (Russian State University of Oil and Gas (National Research University) n.a. Gubkin I.M.)

This work contains the design of the electric centrifugal pump for wells with the outer diameter of production string equal to 114 mm. Thus, this pump can be operated in wells with lateral holes of small diameter.

Operation of lateral holes decreases the costs for construction of horizontal wells; in fact, the well flow rate increases as operation of lateral holes makes it possible to extract hydrocarbons from the collectors which have been not previously covered by development. It means that cutoff and operation of lateral holes with small diameter is the promising technique to increase well productivity.

Currently, there are several types of installations for operation of wells with lateral holes, such as: SShNU with cable drill rod, jet pumps, small-size ESP.

Since the pump impeller diameter is a very important characteristic of centrifugal type pumps affecting the stage discharge head and the pump efficiency, and it can not be large when using in lateral holes, so it is necessary to compensate this negative effect. In this regard, different solutions are used, such as: use of submersible AC electric motors with the rotation speed of 4500 rpm. Also, the stage radial distributor is used in this project to increase ESP plant energy efficiency, which has the following advantages: less liquid impact loads on the ESP working elements and, accordingly, higher hydraulic efficiency of the stage. But, this distributor is more difficult in manufacture.

The use of drill ships during the exploratory drilling on the Arctic shelf

Yu.A. Kharchenko, R.B. Sangadzhi-Goriaev
(Gubkin Russian State University of Oil and Gas)

When conducting exploration work on the shelf, it is necessary to ensure maximum mobility of the drilling rig and its safety under the conditions of possible impact of extreme hydrometeorology, including ice threats. One of the possible technical means that meet these conditions are self-propelled drill ships. The report analyzes the fleet of modern drill ships and formulates requirements for drill ships that can be used on the Arctic shelf.

Integrated safety of ship-based oil and gas platforms

Ya.A. Kharchenko, M.R. Dzhantemirov (Russian State University of Oil and Gas (National Research University) n.a. Gubkin I.M.)

Survivability being the characteristic of floating structures may be regarded as the criterion of their integrated safety. The factors affecting survivability may be both natural and anthropogenic.

The present article considers abilities to provide the integrated safety of ship-based oil and gas platforms (complexes) (SBOGC). It gives comparison of SBOGC with the semisubmersible, TLP and SPAR platforms showing that the first ones have much greater stability and floatage, and this is beneficial for their integrated safety.

Simulation of gas explosions impact on the offshore platform construction to calculate their endurance criterion

Yu.A. Kharchenko, N.A. Artemev (Gubkin Russian State University of Oil and Gas (National Research University))

A significant difficulty in analyzing the consequences of emergency gas explosions is the determination of the possible parameters of damaging factors affecting the structures and equipment of the platforms.

The report discusses the peculiarities of accounting for damaging factors in domestic and international regulatory and methodological documentation. The possibilities of increasing the reliability and objectivity of parameters for offshore platforms using computer simulation are analyzed.

Advantages of complex schemes of Arctic offshore oil and gas field facilities

D.O. Glumova, D.E. Golubtsov (Gubkin Russian State University of Oil and Gas (National Research University))

The economic performance of the offshore oil and gas field development project depends on capital and operating costs. There are many ways to optimize this index, one of which is a complex field facilities method.

The features of the complex method for the development of Arctic offshore fields are reviewed in the report in order to reduce capital and operating costs. The possibilities and conditions for use of the transport capacity of the exploited fields for the development of nearby prospecting areas are analyzed.

Research of liberated gas in upper part of the profile with the purpose of minimizing risks during sea wells construction

A.D. Dzyublo, V.E. Perekrestov
(Gubkin Russian State University of Oil and Gas)

During the construction of exploration and production wells on the shelf, there is a risk of serious complications associated with the shallow gas. In case of accidental opening of gas accumulations in the process of drilling, an uncontrolled gas eruption occurs, leading in some cases to catastrophic consequences. The report identifies the reasons for the formation of shallow deposits of liberated gas and discusses methods for their identification.

Drilling rig for subsea production well pads drilling

D.A. Mirzoev, F.F. Shirinov
(Gubkin Russian State University of Oil and Gas (NRU))

The growing demand for hydrocarbon feed and – as a consequence – reserves depletion have already enhanced research activities of the Arctic region states in the difficult-to-reach areas of the Arctic. The Russian shelf preserves from 25% of oil reserves and up to 50% of all country reserves. However, the extent of exploration of the Arctic continental shelf is extremely low. Development of the Arctic HC (hydrocarbons) restrains plenty of factors, one of which is the unfavorable natural and geological conditions (low temperatures, drifting bergs, all-year-round water area icing-up).

Due to severe climatic conditions and the production energy consumption, the use of the subsea drilling complex (SDC) was proposed.

As of today, there are some proposals for the use of SDC: based on a submarine with its energy generated at the nuclear power plants and the drilling with self-contained modules.

Having examined the current proposals, I would like to set forward an opinion on the use of SDC based on a submarine.

Implementation of the subsea drilling complexes will result in the development of the Arctic shelf without limitations throughout the year, an increase in raw materials extraction, reduction of dependency on the foreign equipment as well as practical implementation of the import substitution program. Traditionally, Russia is a power of resources, but HC fields onshore are gradually depleting. The justification for the Arctic region development becomes evident.

SESSION S
POSTER SESSION

Offshore oil and gas pipelines in the Arctic shelf conditions. Ensuring of their serviceability

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

It is known that the Arctic shelf of the Russian Federation is a very promising region for the extraction of hydrocarbons, where, according to geologists, up to 87% of the initial total hydrocarbon resources are concentrated. The Arctic seas are characterized by harsh climatic conditions, as well as relatively weak geological and geophysical exploration of the subsoil, which is hundreds of times lower than the similar values for the North Sea shelf, Gulf of Mexico and a number of other water areas. When developing the Arctic deposits, one of the most pressing problems is the choice of the method of transportation of the extracted products: comparing tanker and pipeline transport, for a number of reasons, preference is given to the latter. The main requirements for the Arctic offshore oil and gas pipelines, which are hazardous production facilities, are to preserve the integrity and performance over the entire period of long-term operation in difficult climatic, hydrological and geocryological operating conditions (currents, seafloor excretion with ice formations, the presence of perennial frozen rocks at the seafloor, etc.), which should be ensured both at the design stage and at the operation stage.

The issues of ensuring the serviceability of the offshore oil and gas pipelines laid on the Arctic shelf by creating new calculation methods developed by the authors of software systems for assessing the reliability and safety of offshore oil and gas pipelines are described.

Usage of artificial intellect for oil and gas production in the Arctic region

A.V. Fedotovskikh (the RUIE Coordination Council for development of the Northern Territories and the Arctic Region)

In May of 2018, the interdisciplinary research and practical project “Usage of artificial intellect (AI) systems in the context of the new stage of the Arctic Region development” started. The authors and performers of the project: The Subarctic Union of Industrialists and Entrepreneurs with the support of the RUIE Coordination Council for Development of the Northern Territories and the Arctic region and PORA Expert Center ANCO.

The preliminary project outcome is foundation of the Expert Council for AI usage in the Arctic Region consisting of 23 experts including Gazprom PJSC experts as well as the analytical review with the information about the ready-to-use AI systems and the AI systems being under design in our country and dedicated for the Arctic Region. The new scientific discipline “artificial intellect use in the extreme conditions of the Arctic Region and extreme North” was registered. One of the areas of AI use in the Arctic Region is the oil and gas production.

Now, it is necessary to create automated industrial complexes which will eliminate substantially the demand for human labour. Instead of working in the severe arctic conditions, people will monitor operation of machines. It is planned to implement intelligent automatic process control systems by 2030 already. Implementation of remote technologies for field development, automation of oil and gas production and adoption of unmanned transport systems in the Arctic region will enable to reduce costs and to make oil and gas production almost “unmanned”. In the context of certain professions, so the driller profession will disappear soon. Development of robotics technology and control satellite systems will make possible to remove a man from the extraction cycle while increasing the scope and intensity of works. The operators of drilling robots working “on the Continent” remotely will be able to replace the romantic driller profession and the drilling process will be fully robotized.

Full information about the project implementation as well as the final review are available at the site of the Russian Arctic Region Employers’ Associations http://www.rspp-arctic.ru/vyisokie-texnologii.

We invite companies to cooperate and develop the project.

Site system of offshore field protection

L.A. Kopaeva, M.N. Mansurov, T.I. Lapteva, V.I. Efremov
(Gazprom VNIIGAZ LLC)

The modern trends of the industry development are characterized by increased scale of offshore oil and gas fields development. At the present time, the threats from terrorist, extremist and criminal elements to industrial, transport facilities of various purposes including offshore oil and gas fields are quite real and their delivery causes great damage to the state, both in terms of casualties and material damage. Therefore, the current problem is the necessity to protect offshore fields from external unlawful actions of subsea intruders (antiterrorist protection).

The main task of the offshore field site protection system is their coverage from all directions, i.e. continuous observation of air, surface and subsea situation. To solve this problem, the protection system should include: the system of fighting subsea swimmer/terrorist detection; the communications system; the technical controls of the security equipment; the system for neutralization of detected subsea intruders; maneuver forces. One of the promising methods of active influence on an subsea intruder is usage of water electrolyzable barriers; means of water area protection on the basis of the electrohydraulic effect; the system of non-fatal effect on intruders including sound effects, SHF effects, hydroacoustic effects.

This report is focused on the issues of improvement of the methods of offshore oil and gas field site protection ensuring their safe operation.

INTERGAZSERT voluntary certification system in the field of “pipe products” for perspective projects of shelf deposit development

I.P. Shabalov, A.V. Ivashchenko, O.P. Talanov, A.N. Alistaev
(Autonomous non-profit organization “Center for research, certification and technical tests “transport pipeline systems”)

In order to develop the resources of the Russian shelf, it is necessary to create technical equipment and infrastructure that meet the requirements for safety, quality and operational reliability.

Gazprom PJSC has implemented unique projects for the construction of the underwater pipelines Nord Stream 1 and 2, Turk Stream, a section of the underwater crossing in the Gulf of the Kara Sea of the Bovanenkovo - Ukhta trunk gas pipeline, etc. Domestic manufacturers of pipes (ChTPZ PJSC, OMK JSC, ITZ JSC, TMK PJSC) together with metallurgic companies (Severstal PJSC, MMK PJSC, NLMK PJSC) confirmed their qualification in production and supply of exclusive products for these projects.

When designing the Nord Stream underwater pipeline, the main regulatory document was DNV-OS-F101-2000, developed in 1996 for the “special conditions” of the shelf of Norway, Denmark, Canada and the USA. On the basis of this standard, STO Gazprom 2-3.7-050-2006 was put into operation and it is a relevant document today, however the shelf deposits of the Russian Federation differ from European ones, and the design and construction of infrastructure requires the development of new engineering solutions and requirements, for pipe products as well.

The implementation of the INTERGAZSERT VCS is the result of combining competences and experience of: Gazprom, PJSC, pipe industry, fundamental science for providing the gas industry with high-quality pipe products. One of the tasks of the INTERGAZSERT VCS is to harmonize scientific and technical documentation, including the standards for which the products are certified.

Complying with the requirements of INTERGAZSERT VCS, manufacturers confirm the possibility of producing high-quality products with high operational reliability, which fully complies with the requirements of infrastructure projects of Gazprom, PJSC.

Paleoseismofacial peculiarities of the neocom sediment formation and forecasting of hydrocarbon traps according to seismic exploration in Ob-Taz shoal

M.A. Kalita (Gazprom VNIIGAZ LLC)

In the Berrias-Barrem, the deep-water marine paleobasin of Western Siberia was filled with sediments in the mode of overcompensated tectonic subsidence. This period is associated with the development of the clinoform sediment complex of the Akhsk suite, the formation of which is determined by the ratio of three factors — the speed of tectonic subsidence, eustasy, and the volume of incoming sedimentary material. The main method for studying the neocom clinoform deposits using seismic data can be a sequence-stratigraphic analysis.

The formation of the main hydrocarbon reservoir in Southern Yamal - the Novoportovskaya stratum (Berrias - the beginning of the Goteriv), which has a limited distribution in the southern part of the Ob bay area, is associated with the predominant flow of sedimentary material from the Urals (Skorobogatov V.A., 2003). According to seismic data, in the northern part of the Ob bay in the Berrias-Goteriv, there was an accumulation of clay deposits from the underwater slope. The peculiarities of the Novoportovskoy stratum formation are due to the syn-depositional development of uplifts; the main prospective objects may be associated with offshore sandstones of high-standing tracts (HST) in areas of the water area continuation of structures where hydrocarbon deposits are found in Southern Yamal.

The vector of predominant precipitation inflows changed in the Berrias-Barrem period. The formation of the clinoforms of the upper part of the Akhsk suite - the BYA (Ob Bay) and BU (Taz Bay) groups - is associated with the Eastern and South-Eastern sources of ablation (Siberian platform, Altai-Sayan folded region). In 2D seismic deep sections, a decrease in the angle of the clinoform incidence in the Ob Bay is observed in comparison with the Eastern regions. The gravitational component of sedimentary material income to the foot of the accumulative slope is probably weakened. The main perspective objects are supposedly connected with sandstones of well-developed shelf parts of the clinoforms of the BU and BYA groups (HST tracts).

Studying of natural conditions and modeling of external effects on the facilities for development of the off-shore fields

D.A. Onischenko, M.M. Chumakov, S.D. Kim, S.V. Lutkov, P.S. Shushpannikov (LLC Gazprom VNIIGAZ)

Development of hydrocarbon resources in the shelf of the Arctic and Far East seas shall be based on the reliable information about natural conditions of the corresponding water areas. For well-established planning of works on drilling the production boreholes, performance of the off-shore construction works, servicing and maintenance of the subsea systems, the accurate information on the ice regime and performance hydrometeorological characteristics is required. For assessment of technical feasibility, when using the fixed, and, possibly, the floating platforms (with the ice situation management system support), the reliable prediction of the extreme ice situations and correct evaluation of the extreme ice loads is required. Determination of the required performance and extreme characteristics is based on these field measurements carried out within the framework of field research, the results of numerical simulation and the analysis of the Earth remote sensing (ERS) data.

The Report presented the information on the performed and expected field research in the Baydaratskaya Bay and in the shelf of Sakhalin Island during non-ice and ice seasons.

The proprietary know-how technique for obtaining the data on the ice situation based on ERS data was presented. The examples on using the technique to determine ice conditions in the Kara Sea western part water areas and demonstrating its efficiency are given.

According to the field research data, the results of the numerical finite element simulation for the pipeline section stressed-deformed state (SDS) were presented. The minimal set of initial data on the pipe and soil properties and of the field measurements necessary for correct estimation of SDS in the pipe is analyzed. Results sensitivity to the errors in the initial data and the field measurements is shown.

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