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TRANSLATIONS ON USSR RESOURCES
(FOUO 10/79)

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ELECTRIC POWER AND POWER EQUIPMENT

UDC 658.26.004.18

ECONOMIC TRAINING--AN IMPORTANT FACTOR IN ENERGY RESOURCES

Moscow PROMYSHLENNAYA ENERGETIKA in Russian No 3, Mar 79 p 2

[Article by Engineer G. K. Pisarev, Ukrainian SSR Ministry of the Coal Industry]

[Text] In the letter to the Central Committee of the CPSU, the USSR Council of Ministers, the All-Union Central Trade Union Council and the Central Committee of the All-Union Lenin Young Communists League "On the Development of Socialist Competition for the Fulfillment and Overfulfillment of the 1978 Plan and Intensification of the Efforts to Improve Production Efficiency and Operating Quality" it is pointed out: that to achieve greater efficiency it is necessary to save the national wealth, to reinforce the economy regime in every possible way and especially with regard to fuel and electric power.

In solving the problems of the utilization of economy reserves, an important role has been assigned to the economic education of workers. At the enterprises of the Ukrainian SSR Ministry of the Coal Industry, economic training is being offered; the primary organizational forms are seminars, economics schools and schools of communist labor. Offices and study areas for economic education have been set up to help the trainees.

The activity of the schools of advanced experience for widespread propagation of such principles as the struggle to achieve a 100 ton/day or more load on the working face, effective use of mining equipment, the study of the experience in high-efficiency operation of individual collectives, is worthy of praise.

The entire country knows about the work experience of the brigade of V. G. Murzenko at the Krasnyy Partizan Mine of the Sverdlovantratsit Association. It has fulfilled its obligations in honor of the 61st Anniversary of the Great October Revolution six days ahead of schedule, delivering up 3 million tons of anthracite since the beginning of the five-year plan. On the average the brigade has extracted 3,241 tons of coal daily. At the present time this amount of fuel is being extracted by an average mine with 2,500 people.

The utilization of the economy reserves depends to a great extent on the management personnel, the level of their professional knowledge, skill in combining economic and educational work; therefore the leading specialists of the Ukrainian SSR Ministry of the Coal Industry and the production associations are being sent to the institute for advanced training of management workers and specialists of the USSR Ministry of the Coal Industry. The workers of the power machine services of the mines and the enrichment plants are undergoing training at the Donetsk and the Voroshilovgrad branches of the second institute. For two days the auditors study the urgent problems of Marxist-Leninst theory and economic strategy of our party on the modern level.

A great deal of attention has been attached to the economic education of the workers operating and maintaining the electrical equipment. In the first half of 1978, 46 chief mechanical and power engineers of the mines and 230 mechanical engineers from the sections underwent training at the Institute for Advanced Training and its branches. The auditors note that the training permits deeper analysis of the production process and more complete utilization of the possibilities of modern mining equipment.

The economic training is improving the activity of the workers in the annual all-union competition for best proposal with respect to economy of electric and thermal power. The results of the economic training are especially perceptible during the socialist competition of the enterprises with respect to electric power economy.

In the mines of the Donets basin a great deal of attention has been given to the use of gas (previously discharged into the atmosphere) from the degasing of the coal beds. At the present time more than 25 boiler rooms are operating on this gas, which provides a saving of more than 120,000 tons of coal. The conversion of the mine boiler rooms to gas from degasing has been basically completed. In the mines where the methane concentration in the mixture is less than 30 percent, the developers of electromechanical services are performing experimental work with respect to the use of methane-air mixtures with methane concentration to 2.5 percent for blowing during operation of the boilers on solid fuel, which permits up to 25 percent of the coal to be saved.

During two years of the Tenth-Five Year Plan the enterprises of the coal industry of the Ukraine saved 261 million kilowatt-hours of electric power and 48,500 tons of provisional fuel as a result of reducing the specific consumption and 753 million kilowatt-hours of electric power and 102,200 tons of provisonal fuel as a result of implementation of organizational-technical measures.

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ELECTRIC POWER AND POWER EQUIPMENT

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NATURAL GAS AND THERMAL POWER ECONOMY--A PROBLEM OF PRIMARY SIGNIFICANCE

Moscow PROMYSHLENNAYA ENERGETIKA in Russian No 3, Mar 79 pp 9-11

[Article by Engineer G. I. Ibragimov, Moscow Territorial Inspectorate of Gosgaznadzor]

[Text] Natural gas is acquiring more and more significance in the fuel balance of the country. Its use in the national economy is promoting the acceleration of technical progress, an increase in productivity of labor and improved standard of living for the people. The reliable provision of the enterprises with natural gas must be realized not only by increasing the extraction but also by more efficient use of it. The solution of this problem is unthinkable without improving the technical-economic indexes of the operation of the gas-using equipment. It is here that the greatest reserves for saving thermal power are hidden.

In the resolution of the Central Committee of the CPSU on the organizational and political work of the Kemerovo Oblast Committee of the CPSU for economy of fuel and energy resources at the enterprises and construction sites of the oblast, "it has been proposed that the ministries and departments persistently expand the application of technically substantiated norms for the consumption of fuel and energy resources at the enterprises and in the organizations, that they develop measures to strengthen the state control of the use of fuel and energy in the national economy and also improve the consumption accounting system and the material incentives for economy."[1]

The enterprise and organization leaders are being faced with great problems in the Tenth Five-Year Plan with respect to mobilization of all of the reserves for saving energy resources and accounting for their consumption. In industry more than one third of the total boiler and furnace fuel economy is to be obtained as a result of introducing new equipment and improving the economy of the operating equipment, the improvement and intensification of the technological processes, the introduction of the energy technology processes with a simultaneous increase in unit power of

1. PRAVDA, 14 March 1978.

the units, improvements of the gas burning units, automation of the production processes and use of secondary energy resources.

The investigations performed by the Moscow Territorial Inspectorate of Gosgaznadzor [The State Gas Inspectorate] at the industrial enterprises indicates that many of the plants and factories are working hard in this direction. It must be noted that the problem of gas economy is being solved successfully wherever there is high production, most improved production output processes, a high level of technical equipment of the enterprises and innovations are being introduced. As an example we have the work being done at the following production associations: Voskresensktsement, Karbolit (Orekhovo-Zuyevo), Minudobreniya imeni V. V. Kuybyshev (Voskresensk). At these associations measures are being developed systematically for efficient utilization of energy resources. The implementation of these measures is being monitored. A great deal of attention is being given to the introduction of advanced processes, mechanization and automation of the production processes. As a result of the performance of organizational-technical measures and qualified servicing of equipment, a high level of use of natural gas has been achieved.

The Moscow Oblast is one of the greatest gas users in the country; therefore gas economy has been given constant attention here on the part of the party, Soviet and economic agencies. At a number of the industrial enterprises, the reserves for saving fuel and energy resources have not been completely used. The overconsumption of natural gas is permitted, and secondary energy resources have not been fully utilized.

By the results of the inspections of 178 industrial enterprises of Moscow Oblast in 1977, including 71 enterprises inspected more than once, deficiences were discovered in the natural gas utilization. Secondary energy resources are not being used at 12 of the enterprises, and exhaust-heat units to use the products of combustion have not been installed at 10 of them (the Lyuberetskiy Commercial Machine Building Plant, the Lyuberetskiy Construction Materials and Structural Element Combine, the Podol'sk Machine Building Plant imeni S. Ordzhonikidze, and so on), at the Proletariy Tin Cloth Plant (Serpukhov) the exhaust-heat units are not in operation. At these enterprises the temperature of the exhaust gases after the boilers reaches 300° C which leads to overconsumption of gas and a 4-6 percent reduction in boiler efficiency.

At 10 of the enterprises there is no automatic adjustment of the combustion in the boilers (the Balashikha Cotton Spinning Plant, the Lyuberetskiy Building Materials and Structural Elements Combine, and so on); at 89 of the enterprises the automatic equipment is not operating (the Shchelkovskiy Sheet Rolling Plant, the Elektrostal' Heavy Machine Building Plant, the Likinskiy Bus Plant, and so on).

At 146 enterprises there is not quality control for burning of gas in the boilers. Gas analyzers have not been installed at 111 of them (the

Shchelkovskiy Sheet Rolling Plant, the Lyuberetskiy Farm Machine Building Plant imeni Ukhtomskiy, and so on), and they are not in operation at 35 of them (the Podol'sk Machine Building Plant imeni S. Ordzhonikdze, the Narofomn Silk Combine, and so on).

At 76 of the enterprises, the gas using equipment is operating without regime-adjustment tests and regime charts (the Serpukhov Structural Elements Combine, the Glukhovskiy Cotton Combine, the Silikatnenskiy Reinforced Concrete Plant, and so on). At 74 enterprises it is the fault of the service personnel that the boilers are operating with deviations from the existing regime charts (the Shchelkovskiy Sheet Rolling Plant, the Elektrostal' Heavy Machine Building Plant, and so on), which leads to significant gas losses. The adjustment and operation of the boilers with respect to the monitoring and measuring instruments provides about 5 percent fuel economy.

The aging, uneconomical boilers (60 to 80 percent efficiency) are in operation at the Lyuberetskiy Building Materials and Structural Elements Combine, the Katuarskiy Ceramic and Tile Plant, and so on; as a result, up to 20 percent of the burned fuel is lost.

Measures have not been developed for gas economy at 29 of the enterprises (the Podol'sk Municipal Dairy Plant, the sovkhoz imeni Lenin, the production enterprise combine of the Mosoblstroy Trust No 26 of the Ramenskiy Rayon, and so on).

The absence on the part of the superior organizations of proper control of the observation of the economy regime, the planning of specific fuel consumption standards and implementation of them will lead to unsubstantiated increases in them by comparison with the standards. Thus, the specific provisional fuel consumption standards have been raised at a number of the Glavmosoblstroy enterprises (the production enterprise combine of the Mosoblstroy Trust No 26, by 25-30 kg/gigacalorie, the Shchelkovskiy Health Building Combine, by 30-35 kg/gigacalorie, and so on) and the Glavmosoblstroymaterialov (the Butovskiy Building Materials Combine, by 30-40 kg/gigacalorie; the Bronnitskiy Brick Plant, by 30-40 kg/gigacalorie, and so on).

It has been established that at 66 enterprises the specific fuel consumption standards have not been technically substantiated or have not been developed in general. The basic fuel consumption measure--the standard for its consumption established in accordance with the production output volume--must be technically and economically substantiated. Otherwise it is impossible to determine the effectiveness of the utilization of the energy resources. However, at the Lyuberetskiy Experimental Plant for compact purification units of Glavmosoblstroymaterialov, at the enterprises of the RSFSR Ministry of Agriculture (the sovkhoz imeni Mossovet, poultry farm, Mirnaya, Tomilinskiy Poultry-Raising Association, and so on) the specific norms were not presented during the inspection.

Gas is used uneconomically at the Domodedovskiy Reinforced Concrete Products Plant. Modern boilers of the DKVR type have been installed at this

enterprise, but they are not equipped with automation for regulating combustion or exhaust-heat units for utilizing the heat of the combustion products. Regime-adjustment tests have not been run on the boilers, there is no quality control of the fuel consumption, there is no accounting for the released and consumed thermal energy. The overconsumption of gas amounts to 710 thousand m^3 annually.

Similar deficiencies are characteristic of the Pushkinskaya Light Furniture Plant and the Serpukhov Reinforced Concrete Products Plant. The gas losses at these enterprises amount to 6 to 8 percent of the annual gas consumption.

In 1977, at the Moscow territorial inspectorate of Gosgaznadzor a test was run on the implementation of the previously issued prescriptions with respect to increasing the efficiency of gas utilization at 71 industrial enterprises of Moscow Oblast. It was discovered at 19 of the enterprises the necessary measures were adopted to improve the use of gas, and the inspection suggestions are being implemented in a timely manner. Nevertheless, at a number of the industrial enterprises not only is there no initiative being exhibited in the problems of improving the efficiency of the use of fuel and energy resources, but the inspection recommendations are not being implemented.

The unsatisfactory situation with regard to the utilization of fuel and energy resources is also explained by untimely provision of the enterprises with modern gas using equipment, exhaust heat recovery units, instruments for automatic regulation of combustion and accounting for the consumption of gas and thermal power. Moreover, a significant part of the installed exhaust-heat recovery units the automation and gas analyzers for the combustion products frequently are not operating as a result of insufficient qualification of the service personnel. Thus, at the Domodedovskiy Building Materials and Structural Elements Plant in 1974 the inspectorate proposed the installation of instruments to monitor the temperature of the exhaust gases and account for the generated thermal energy, to set up accounting for the returnable condensate and monitor the composition of the exhaust gases. However, in the inspection made in 1977 it was established that the indicated deficiencies had not been eliminated. As a result, the gas losses at the enterprise amount to more than 200 thousand m^3 per year.

In order to improve the reliability of equipment of the users located far from the gas sources, reserve fuel management enterprises are being organized inasmuch as it is impossible to create gas reserves separately at each user. When inspecting the industrial enterprises, special attention has been given to the work with respect to the construction and preparation of such enterprises for operation. The inspection demonstrated that at the Shchelkovskiy House Construction Combine and the Tomilinskiy Poultry-Raising Production Association the planned deadlines for the introduction of reserve fuel enterprises into operation have not been met. Serious disturbances of the fuel situation at the Kudinovskiy Elektrougli Plant and the Mozhayskiy Municipal Pasteurized Milk Plant are creating difficulties for normal gas supply of the communal-domestic users, and they are also

lowering the operating reliability of the enterprises themselves in the case of emergencies on the gas lines and freezing weather.

A rhythmic, stable gas supply is impossible without observing strict gas consumption discipline, especially under the conditions of constant growth of the use of gas and removal of the users from the supply sources. A daily gas consumption standard has been established for each enterprise. However, at a number of the enterprises overconsumption of gas is permitted (the Glukhovskiy Cotton Combine, the Krasnogorsk Cement Machine Building Plant, the Krasnogorsk Mechanical Plant, the Kucha Ceramic Block Plant, and the Akrikhin Chemical-Pharmaceutical Plant, and so on).

The basic areas for improving the efficiency of the use of natural gas at the industrial enterprises are as follows:

Performance of planned preventive repairs on the gas and heat using equipment and also regime-adjustment operations, combustion of the gas in accordance with the regime charts (fuel economy 3 to 5 percent of the annual gas consumption by the enterprises);

Introduction of systems for automatic regulation of combustion with correction for the composition of the combustion products (economy 1-4 percent);

Effective recovery of the exhaust gas and low parameter steam heat (economy 4-8 percent);

Reduction of heat losses by improving the insulation of the lines and the heat-consuming equipment (economy 10-15 percent);

Conversion of the enterprise heating from steam to hot water (economy 3-4 percent);

Reconstruction and improvement of the heat supply systems, automation and adjustment of the heating and ventilation systems (economy 10-15 percent);

Improvement of the gathering and use of condensate (economy 5-10 percent);

Replacement or modification of the obsolete, low-efficiency and uneconomical gas using equipment (economy 5-10 percent).

The economy of raw materials, materials, electric power and fuel must be provided for in the socialist obligations, the performance of which must be taken under strict control.

In order to mobilize the efforts of the enterprise and organization collective in the efforts at further improvement of the economy conditions, the All-Union Central Trade Union Council, the Central Committee of the All-Union Lenin Young Communist League and the USSR Gossnab have adopted a joint resolution for performance of the All-Union Social Inspection of the Efficiency of Utilization of Raw Material, Materials, and Fuel and Energy

Resources in 1978-1980. The industrial enterprises and design organizations must develop and implement the organizational-technical measures promoting the fulfillment of the assignments with respect to economy, establishment of contacts with the VNIIpromgaz Institute, which is the head organization in the problems of gas utilization and the test center for gas burning devices with the corresponding departments of the Moscow Institute of the Petrochemical and Gas Industry imeni I. M. Gubkin and also with the adjustment organizations.

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ELECTRIC POWER AND POWER EQUIPMENT

STANDARDIZATION OF ELECTRIC POWER CONSUMPTION BY THE INDUSTRIAL ENTERPRISES

Moscow PROMYSHLENNAYA ENERGETIKA in Russian No 3, Mar 79 pp 45-46

[Article by I. S. Kopytova]

[Text] On 18 May 1978, a meeting was held of the "electric power supply of industrial enterprises" subsection of the section on industrial power engineering of the Scientific Council of "Higher Engineering and Electrification" of the State Committee of the USSR Council of Ministers on Science and Engineering devoted to the problems of standardizing the electric power consumption by the industrial enterprises.

At the meeting reports were head by Yu. V. Kopytov (Gosenergonadzor) on "Improving the Standardization of Energy Consumption in Industry," by Yu. I. Korbman (VNIIPIenergoprom) on "Comparison of the Specific Electric Power Consumption for Production Output in the USSR and Abroad," by L. A. Shevchenko (Scientific Research Institute of Planning and Standards of the USSR Gosplan) "Methodology and Procedural Support of the Standardization of Electric and Thermal Power," by V. K. Zhubit (Chermetenergo of the Ministry of Ferrous Metallurgy) on "Standardization and Efficient Utilization of Electric Power at the Enterprises of Ferrous Metallurgy," by V. I. Kalinin (the Main Administration of Power Engineering of the USSR Ministry of Nonferrous Metallurgy) on "Standardization of the Consumption of Electric Power at the Enterprises of Nonferrous Metallurgy," by N. G. Derevyanov (Administration of Repair of the Enterprises of the Chemical Industry and Equipment of the USSR Ministry of the Chemical Industry) "On the Work of the Ministry of the Chemical Industry in the area of efficient and economical consumption of energy resources," and also by P. P. Yastrebov (the Voronezh Institute of Technology), V. L. Gromova (the USSR Ministry of Light Industry), Ye. N. Priklonskiy (State Scientific Research and Planning Institute of the Nitrogen Industry and Products of Organic Synthesis). V. V. Mikaylov (VNIPIenergoprom Institute), A. A. Tayets (Management Institute imeni S. Ordzhonikidze), P. I. Golovkin (Energosbyt of Mosenergo), and V. I. Krupovich (VNIPI Tyazhpromelektroproyekt Institute).

At the subsection meeting the following were noted:

1. The goal of the standardization of electric power consumption by the industrial enterprises is to ensure efficient consumption of its electric power during production output.

2. The development of advanced, scientifically substantiated standards for power consumption is an important work providing for the theoretical and procedural studies, the application of the required accounting systems requiring special technical training of the workers, giving rise to the necessity for the creation of the corresponding structural subdivisions in the ministries, the branch scientific-research organizations and at the enterprises.

3. The problems of improvement and bringing order into the standardization of electric power consumption at the industrial enterprises under the conditions of intense fuel and energy balance are acquiring especially important significance: as means of advanced planning and the design of power equipment and as an index of the efficiency of energy use.

4. The ministries, the departments, the industrial enterprises and the scientific research organizations are working to improve the standardization of electric power consumption at the industrial enterprises. This has made it possible to save about 60 billion kilowatt-hours of electric power in the Ninth Five-Year Plan and to provide in the Tenth Five-Year Plan for the reduction of electric power consumption by 5 percent as opposed to the electric power consumption standards in 1975.

5. Nevertheless, in the field of standardization of electric power consumption there are a number of significant deficiences:

a) The majority of the electric power consumption norms have been developed by the statistical reporting method; the standards determined in this way even with realistic corrections in practice do not discover the non-productive losses of electric power at the enterprises, and they cannot serve as an index of efficient electric power consumption;

b) At many of the enterprises, the structure of the norms has not been determined, in connection with which undulation is permitted when compiling the reporting documents with respect to the fulfillment of the established consumption norms. This distorts the statistical data and introduces errors into the energy consumption plans;

c) In spite of the requirements of the "basic principles with respect to sanitation of fuel, electric and thermal power in production" approved by USSR Gosplan on 1 April 1966, the majority of ministries and departments have developed branch instructions with respect to standardization of the electric power consumption for the production of a significant part of the products;

d) When designing new enterprises and rebuilding the existing ones the master planners have not developed optimal complex energy balances or efficient standards for the use of the energy resources on the basis of introducing advanced technology; they have not provided for accounting systems required for operative monitoring of the electric power consumption and compiling the actual energy balances which under the operating conditions will lead to the necessity for using the statistical accounting method and the randomly developed energy consumption structure to work up the standards; insufficient attention has been given during overall planning in the selection of energy-saving equipment and advanced processes;

e) The operating system of providing economic incentives to the workers in the power services of the enterprises and departments is providing insufficient utilization of the energy resources available to the enterprises.

In order to improve the standardization of the electric power consumption at the industrial enterprises, the subsection decided the following:

1. To ask the USSR Gosplan to exonerate the regeneration of the "basic principles with respect to standardization of fuel consumption, the consumption of electric and thermal power and production," approved on 1 April 1966.

2. To consider that the electric power consumption norms must have scientific-economic substantiation, they must be compiled considering the current and the prospective energy balances of the enterprise, the energy characteristics of the process equipment and provide incentive for taking measures aimed at lowering the consumption of the shorter and more expensive types of energy. The development of the standards only on the basis of the statistical accounting indexes with deep, comprehensive analysis of their structure is inadmissible.

3. To recommend the following to the ministries and departments:

a) To investigate the normative materials effective in the branch, and in the absence of them to develop and introduce branch instructions and procedures into effect for 1979 to 1980 for the development of the standards for the consumption of power reserves for production output, providing for a scientifically substantiated approach to the standardization of the power consumption and promoting the introduction of advanced technology and equipment with more economical indexes for the energy resources consumption;

b) To determine the lead organization of the branch responsible for the coordination of all of the operations at the enterprises of the ministry to improve the standardization of the electric power consumption, compile branch instructions and procedures with respect to standardization and application of systems for energy consumption accounting;

c) To introduce the compilation of the optimal prospective energy balances of the enterprises into practice, and on the basis of these energy balances,

for the development of the plans for five-year and annual plans of economic and social development to provide measures aimed at improving the efficiency of the use of the fuel and energy reserves.

d) To develop basic areas of reducing the electric power consumption in the branch, providing above all for the elimination of nonproductive energy losses and the implementation of the generally accepted measures decreasing its consumption;

e) To obligate the subdepartmental enterprises and organizations to develop current (for 1979) and prospective plans for the organizational-technical measures with respect to saving fuel and energy resources and considering their effectiveness, to approve norms for specific energy consumption;

f) To improve the quality of accounting and to intensify the control of the consumption of the power resources, in 1979-1980 to develop an accounting system at each enterprise for the consumed electric and thermal power, using the summation circuits or the automated information and measuring monitoring and accounting system for the energy consumption (including with the application of computers).

4. To recommend that the scientific research organizations expand the development of the theoretical problems of determining the energy characteristics of the process equipment, compiling and calculating the energy balances (planning, prospective, normalized) of the enterprises of the different branches of industry, calculation of the energy consumption norms.

5. To recommend to the design organizations that they do the following:

a) When planning and designing the process systems to be oriented toward advanced technology, ensuring the highest level of efficient use of energy resources;

b) When developing the designs of the newly built and reconstructed enterprises, to develop the normalized energy balances of the enterprises, and on the basis of them to calculate the substantiated advance energy consumption norms, the fulfillment of which in operation can be ensured for optimal process conditions and exclusion of the nonproductive energy losses; planning norms for energy consumption must be compared with the ones approved for the analogous advanced enterprises of the given branch, and the advanced achievements of science and engineering must be taken into account;

c) On the basis of the normalized energy balances of the enterprise and the technical-economy calculations:

To realize efficient selection of the energy carriers for the technological processes and the devices, to substantiate the optimum procedures and volumes of use of secondary energy resources;

To plan efficient energy supply systems, to substantiate the selection of the parameters of the power installations and equipment on the network;

d) When designing and planning the power supply for an enterprise, it is necessary to develop a system for accounting for the used energy, providing for monitoring of the satisfaction of the energy consumption standards, and to make a comparison between the actual and calculated energy balances of the enterprise;

e) To use the advanced, scientifically substantiated energy consumption norms to check out the correctness of the calculation of the proposed loads, the selection of the parameters of the elements of the electrical and thermal networks of the designed enterprise.

6. Considering the great economic significance of the problems of standardizing energy consumption in industry, the expediency of solving the problems of efficient consumption of electric power by the enterprises (beginning with their design stage), to request the USSR Gosstroy to introduce the corresponding corrections into "The Instructions for the Development of Plans and Estimates for Industrial Construction" (SN 202-76), "The Instructions for Planning and Designing the Electric Supply for Industrial Enterprises" (SN 174-75), and the instructions with respect to designing enterprises of different branches of industry, providing for the required development of optimal energy consumption balances and standards for energy consumption for unit production output, accounting systems providing for operative monitoring of the observation of the approved general plan and technological norms for electric power consumption in the plans for the newly built enterprises.

7. To request that the USSR Ministry of Instrument Making:

a) Increase the output of automated electric power accounting and monitoring systems and continue the work on improvement of them;

b) Organize the manufacture of the instruments considering the electric power of high precision class. Ensure a metrologic base for the production, operation and maintenance of such instruments.

8. Request that the scientific research institute for planning and standards of the USSR Gosplan and the VNIPIenergoprom Institute intensify the work with respect to the development of the basic areas of improving the standardization of the energy consumption by the industrial enterprises, the procedural recommendations with respect to calculating the standards and organizing the work with respect to standardization in the various branches of industry, the generalization and spread of the advanced experience in the field of normalization of the energy reserves.

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FUELS AND RELATED EQUIPMENT

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PLANNING GAS EXPLORATION OPERATIONS

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 2, Feb 79, pp 2-7

[Article by I. P. Zhabrev, Ministry of the Gas Industry, V. I. Yermakov, M. Ya. Zykin, V. P. Stupakov, M. O. Khvilevitskiy, All-Union Scientific Research Institute for Gas]

[Text] As is known, the basic indexes of the current system for planning gas and oil exploration operations are the nature of the reserves in categories $A+B+C_1$ and the volumes of capital investments. The analysis of the modern state of the art with respect to gas exploration operations indicates that the developed planning system does not in the majority of areas, especially in the old gas extraction areas, ensure the required rates of development of the raw material base of the gas industry. This is caused primarily by the following:

a) The lag in regional research within the prospective territories and the absence of data for selecting the most effective areas for exploration work connected with this lag;

b) Insufficient preparation of the areas for deep exploration drilling;

c) Excess volume of exploratory drilling, delaying the development of the deposits;

d) Failure to take into account the specific nature of the preparation of the reserves in the old gas extraction areas;

e) Low requirements in the effective classification of reserves to substantiate category C_2, which causes a reduction in quality of preparation of the areas and effectiveness of the oil and gas exploration work.

The experience in performing regional and exploratory operations and also the data with respect to a large number of gas deposits where experimental industrial operation has been started will permit formulation of a number of proposals for improving the planning system to increase the gas reserves and the conditions for conversion of the deposits to experimental industrial operation.

1. Regional studies in full volume and on a modern procedural level must precede the development of exploration operations in each new area or new gas bearing stage in the partially assimilated areas. The effectiveness and the improvement of the regional study stage must be evaluated by the conversion of reserves from subgroup D_2 to D_1.

The lag in regional operations will lead to a sharp reduction in the effectiveness of the exploration work in many areas which is expressed above all in the slow conversion (or depletion) rate of the predicted reserves from D_2. Under these conditions these reserves in D_2 can significantly predominate with respect to volume over the reserves in subgroup D_1 and higher categories. Now in the Predkavkaz'ye Region, for example, in spite of the prolonged period of geological exploration work, only 23 percent of the predicted gas reserves belong to subgroup D_1. This unfavorable ratio of reserve subgroups in this region has continued for the last 10 years and is connected with a sharp lag in regional studies. As a result, the effectiveness of preparing the reserves of the industrial categories is very low here, and the nature of the reserves does not make up for the decreasing gas extraction.

The regional studies are lagging in such gas extracting areas as the Komi ASSR, the Kalmytskaya ASSR, the Western Ukraine, and so on. At the present time, in Western Siberia, in spite of the shorter times for development of the territory, with a total significant magnitude of predicted gas reserves 80 percent fall in subgroup D_1. It is known that the effectiveness of the exploration work in this area is very high.

On the whole throughout the country at the present time an unfavorable ratio of categories and groups has developed in the structure of the potential gas reserves: the explored gas reserves $A+B+C_1$ make up a small part of them at the same time as the predicted estimates according to subgroup D_2 exceed 50 percent. It is necessary to consider that in the case of prospective planning, the forecasting estimate with respect to subgroup D_2 is not taken into account, in connection with its low reliability.

The prospective plan for the development of the raw material base of the gas industry up to 1990 provides for high growth rates of the explored reserves with respect to categories $A+B+C_1$. At the same time, it has been established that the confirmation of the gas reserves in category C_2 for many regions does not exceed 30-40 percent, and subgroups D_1, 20 to 30 percent. Accordingly, the available reserves in category C_2 and subgroup D_1 must be considered inadequate. For reliable planning of the development of the raw material base for the future, it is necessary to at least double the gas reserves in subgroup D_1.

In order to improve the results from the regional studies and regulate their volumes, when forming any five-year plans for gas and oil exploration work it is proposed that the conversion of the predicted estimate for subgroup D_2 to subgroup D_1 be planned and the effectiveness of the regional work with respect to the results of this conversion be estimated. In order to

organize the annual accounting for movement of reserves through subgroups D_1 and D_2, it is necessary to organize an interdepartmental commission (the USSR Ministry of Geology, the Ministry of the Oil Industry, the Ministry of the Gas Industry) with the authority to confirm the gas reserves with respect to these subgroups.

2. In many gas-prospective areas of our country, both the quantity and quality of preparation of the structures for deep exploratory drilling are inadequate. The Stavropol' and Krasnodar krays, Orenburg Oblast, the Ukraine, Eastern Siberia, Uzbekistan, the lower Volga Region, and so on are presently experiencing an explicit "structural hunger." These regions are characterized by complex geological-geophysical conditions and the low quality of preparation of the structures or poor conformation of the discovered geophysical anomalies caused by them.

The search for uplifts that are prospective for gas has been performed in recent years almost exclusively by using the seismic study methods.

Among the seismic structures discovered in the Ninth Five-Year Plan, 71 percent are small positive anomalies, the area of which is less than 50 km^2. The probable cause of this is the high background of seismic interference which is variable with respect to area and breaks up a broad territory of large tectonic uplifts (hundreds and thousands of km^2) into small sections within the limits of which the interference behaves relatively stably. In the Ukraine and Belorussia, the area of such sections is from 10 to 50, in Lithuanian and Tadzhikistan, predominantly to km^2. There are no large uplifts in the stock of prepared ones with respect to the Orenburg, Saratov, Rostovskiy, Kaliningrad and other regions of the RSFSR. The area of established seismic explorations in the Caspian Basin of subsalt structures varies from 25 to 42, and suprasalt, from 3.5 to 15 km^2, and so on.

It is clear that the "breaking up" of the united tectonic uplifts (for example, the Orenburg swell, the Astrakhan arch, and so on) into small seismic anomalies disorients the subsequent exploration work, it prolongs the time of reliable evaluation of the reserves of the large deposits and the introduction of them into experimental industrial operation. This theoretical deficiency of the seismic exploration work can be overcome by combining the latter with other geophysical methods, joint quantitative processing and optimal smoothing of the complex of data using a computer. For the districts of Saratov, Volgograd and Astrakhan oblasts, for example, where the area of each of the local structures discovered by the reflected wave method or the common depth point method of seismic exploration amounted to 3-10 km^2, it was established that the application of the set of geophysical methods (seismic exploration in different versions, seismic exploration and high-precision gravimetry) increases upto 70 km^2 and more. The areas of the submerged uplifts in the Lower Volga Region, according to the data from quantitative combination of drilling, seismic and gravimetric information, as a rule, exceed 200-300 km^2.

However, in many areas that are prospective for gas the conditions for complex analysis of the geophysical data in practice still have not been created, for the exploration work using the "easy" geophysical methods (high-precision gravimetry and magnetic exploration, electrical exploration using variable fields, and so on) lag significantly behind the seismic methods or are not implemented at all. Taking this into account, it is proposed that:

a) Plans be made to prepare the areas for exploratory drilling by a complex of geological-geophysical methods efficient for the given region and to consider this preparation appropriate only after the performance of all types of operations and joint interpretation of the results;

b) In addition to the geophysical work in natural indexes, the exploration organizations should also plan the number of prepared structures and their minimum dimensions.

3. A significant increase in the geological effectiveness and reliability of the seismic structures can be achieved also in the phase of exploring the fields where the coordination of the seismic observations with respect to area is controlled by a sufficient number of deep wells. The first experiments in performing detailed seismic studies in the Komi ASSR and the Tyumen' Oblast demonstrated that they permit the exploration times for the deposits to be reduced by one and a half to two times, no less than 10 million rubles to be saved at each site as a result of reducing the number of exploratory wells and to obtain more complete information about the structure of the investigated deposits. The seismic details included an increase in the density of the seismic profiles to 3.5-4 km per square km of structure (the density of the seismic exploration work usually is on the order of 1 km/km^2), the performance of the well type seismic observations, checking and reinterpretation of all of the available seismic materials.

The possibilities for still greater optimization of the process of exploring the gas deposits are covered in the use of the digital recording and processing of seismic oscillations, the analysis of the absorption and propagation rate of the elastic waves, and improvement of the frequency of the recordings, and so on. The complete realization of the information possibilities of modern seismic exploration by the common depth point method will in the near future provide for the solution of an entire series of such "unstructured" geological problems as: the comparative estimation of the oil and gas bearing nature of the structures, the outlining of the deposits, the investigation of the region of propagation and the uniformity of the collectors and also the integrity of the gas confining beds; a study of the parameters of the deposits (porosity, effective power, gas saturation, and so on). All of these data combined with the materials from the exploratory drilling can serve as a reliable base for estimating the gas reserves of the open deposits and compiling substantiated plans for the exploitation of them. However, at the present time detailed seismic operations have still been insufficiently developed; their specific weight

does not exceed 1 to 2 percent of the total volume of geophysical operations for gas and oil. For accelerated evolution of this research, it is proposed that exploratory and detailing seismic operations be planned by the geophysics expedition separately, and within the framework of the large geological exploration associations, it is recommended that complex (drilling and seismic) enterprises be created insofar as possible specialized in the exploration of the discovered gas bearing structures.

4. At the present time the operating system for planning the increase in gas reserves providing for the preparation of the reserves with respect to categories $A+B+C_1$ is used identically both in the old oil and gas extracting regions and in the new prospective territories under the initial stages of development. Nevertheless, there are theoretical differences in the specific nature of the preparation of gas reserves and the requirements for detailed exploration of the deposits in these areas.

In the new prospective areas where the basic goal is the creation of a raw material base for subsequent construction of gas line network, it is expedient to retain the existing system of planning increased industrial gas reserves basically with respect to categories C_1 and B in the respects provided for by the instructions of the USSR State Commission on Mineral Resources. Within the territory of the USSR, these areas include Eastern Siberia and the Far East, the Yamalo-Gydanskiy Region of Western Siberia and the Arkhangel'sk Oblast.

Wherever there are favorable conditions for fast completion of the exploration of the newly discovered deposits by experimental industrial operation and subsequent immediate introduction of them into development, it is proposed that we go over to the new system of planning the increased gas reserves with respect to categories C_1 and C_2.

At the present time the organizations of the Ministry of the Gas Industry have accumulated a large amount of experience in the application of the accelerated methods of exploring the gas deposits, the completion of their exploration by the methods of experimental industrial operation. Thus, in the areas of developed gas extracting industry (Ukraine, the Caucasus foothills, Turkmenia, the Lower Volga Region and so on), after obtaining positive results from testing the first exploration wells, the gas deposits are converted to experimental industrial operation on the basis of reserves in categories C_1 and C_2. Within the limits of the Dneprovsko-Donets Basin alone, after obtaining the first inflows of gas, more than 20 gas fields were put into experimental industrial operation, and as a result their exploration was completed without additional drilling. The gas extraction during the experimental industrial operation amounted to more than 80 billion m^3. The period of development of the open gas deposits was reduced by 2 to 3 times.

The positive experience in the accelerated introduction of the deposits based on the reserves in categories C_1+C_2 indicates the necessity for changing the

system of planning the increased gas reserves in the gas extraction regions regions.

The basic principles of the proposed planning procedure reduce to the following:

1) The basic planning index of activity of the geological exploration organization is considered to be the increase in gas reserves with respect to categories C_2 and C_1 in the following ratios: C_1--from 30 to 50 percent, C_2--from 70 to 50 percent; here category C_2 includes the gas reserves in the reliably discovered structures in the deposits, the productivity of which was established by testing the exploration wells, including the bed tester;

2) During the process of exploring the deposits, conversion of part of the gas reserves from category C_2 to C_1 is realized; the proportion of the gas reserves in category C_1 must on the average amount to 30 percent, and for the deposits with complex geological structure, it increases to 50 percent;

3) In order to increase the reliability of estimating the reserves with respect to category C_2 simultaneously with the exploration drilling, detailed seismic operations are performed (see above), which constitute an inseparable part of this phase of the studies;

4) The reserves in categories C_2 and C_1 and their achieved ratio with respect to the exploration results are confirmed by the USSR State Commission for Mineral Resources;

5) When discovering a large gas field with conditional hydrogen sulfied content which can be the base for the creation of a gas-chemical complex, the adopted procedure for planning the increased reserves with respect to categories $A+B+C_1$ is retained; in the areas of effective large gas-chemical complexes, the newly discovered fields are explored by the proposed planning system with the preparation of reserves with respect to categories C_2 and C_1;

6) The gas reserves in the structures and the prospective areas before obtaining the industrial inflows of gas are estimated with respect to subgroup D_1 and the geophysical organizations are to plan the number of prepared structures and their average size.

The proposed system will somewhat complicate the planning and accounting for the exploration work inasmuch as it requires a separate approach to the territories and the objects. However, this acceleration is justified, for the new planning system will promote increased efficiency of the geological exploration operations as a result of the following:

a) A sharp increase in the volume of exploration and parametric drilling in the old gas extraction regions as a result of reducing the number of prospecting wells:

b) Acceleration of the preparation and introduction of the deposits into experimental industrial operation and elimination of unjustified combination (overlap) of this phase with the exploratory drilling phase;

c) Ensurance of accelerated discovery of new gas reserves in order to maintain the achieved levels of extraction.

5. The classification of reserves of the oil and fuel gas fields put into effect on 13 May 1970 has a number of deficiencies. First of all this refers to the category C_2 reserves which include the most different gas reserves with respect to degree of study and preparation for industrial development. The prospective reserves in this category in the discovered fields on the average throughout the country have been approximately 30 percent confirmed. At the same time the category C_2 reserves in the new structures (in the lower lying prospective beds, in the untested blocks, and so on) are on the average no more than 10 percent confirmed, that is, they turn out to be approximately 3 times less reliable than the reserves in the discovered deposits.

The requirements imposed by the present classification on the category C_1 reserves do not always correspond to the conditions of accelerated development of the gas industry and can lead to over-exploration of small deposits with respect to reserves. In particular, it is necessary, in our opinion, to consider in category C_1 the reserves of the deposits, the gas bearing nature of which has been established on the basis of obtaining a gas inflow only in one well if no more than three or four wells are required for development. In addition, it is expedient to assign the gas reserves in the beds positively characterized by logging and with the limits of the deposit between the beds from which the industrial gas flows are obtained, in this category. For the rest, it appears to us the requirements on categories C_1 reserves should be left unchanged.

The reserves in the new structures and within the boundaries of the oil and gas bearing regions, the productivity of which has not been confirmed by testing in wells, must be considered in subground D_1 of the predicted reserves in the future. The requirements on the category C_2 reserves which must become the basis for planning the increased reserves for the exploration organizations must be more precisely determined and increased. In the old gas extracting regions the gas deposits in this category must serve as the base for the completion of exploration by the methods of experimental industrial operation and to a defined degree, the base for gas extraction. In particular, the gas reserves in the untested tectonic blocks and beds, especially in the lower-lying beds not revealed by the wells, must not be included in category C_2.

The introduction of the proposals advanced in this paper will promote a sharp increase in exploration work, acceleration of the preparation of the

reserves of the industrial categories and improvement of the effectiveness of geological exploration work as a whole.

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FUELS AND RELATED EQUIPMENT

PREDICTING OIL AND GAS RESERVES BY THE DEVELOPMENT CURVES

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 2, Feb 79 pp 7-13

[Article[1] by M. G. Leybson, VNIGR Institute]

[Text] The methods of comparative geological analysis and the volumetric-genetic analysis permitting a more or less objective quantitative characteristic of the prospects of oil and gas bearing nature to be given from the geological and geochemical points of view are widely used to predict the oil and gas reserves.

However, there is a geological-economic aspect (in the broad sense of this concept) of the prediction estimate. The direction and intensity of the geological exploration activity (just as the representation of the industrial significance of a field and the balance reserves themselves) are affected by the factors of an economic order--the demand of the country for oil and gas, the effectiveness of the geological exploration work, the scientific and technical progress during the exploration work, the prospecting and development of the fields, and so on. The realization of the predicted reserves--conversion of them to industrial categories--will always appear as the result of geological exploration work, that is, the application in an efficient sequence of defined methods and technical means with limited expenditures. Without the required consideration of the economic factors, among which it is necessary to include the substantiation of the extraction coefficients of the oil and gas, estimation of the predicted reserves of the latter can turn out to be idealized. Therefore it is necessary to supplement the traditional methods of quantitative evaluation of the prospects for oil and gas bearing by another one based on the analysis of the effectiveness of the preparation and dynamics of the development of the reserves. It must be based on the following scientific prerequisites.

The oil and gas reserves are finite. The oil and gas bearing beds are of a regional nature. The deposits are concentrated in zones of predominant oil and gas accumulation. The deposits can be encountered throughout the

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1. For discussion.

entire section of the sedimentary mantle and in the upper erosion zones of the basement, forming the oil and gas bearing complexes. As a rule, the basic industrial accumulation of oil and gas is associated with one or two such complexes within the limits of the average depth range (1.5-3 km).

The greater part of the deposits (about 80 percent) are concentrated in a relatively small number (up to 10 percent) of large and largest deposits which also determine the economic significance of the oil and gas bearing areas [4, 8, 11].

In this history of the investigation and industrial development of the oil and gas bearing provinces it is possible provisionally to isolate several time phases distinguished by the state of exploration, the relations between the search and exploration operations and the effectiveness of preparing the reserves. The large deposits usualy connected with broad contrast traps are discovered in the initial phases of operation with the proper strategy [3].

The effectiveness of the geological exploration work and also the level of extraction of oil and gas depend to a high degree on the magnitude of the potential reserves, their concentration, and the conditions of their occurrence, therefore in principle it is entirely logical to state the inverse problem--determination (more precise definition) of the potential reserves with respect to the given dynamics of the effectiveness of the exploration work or with respect to extraction.

The quantitative relation between the potential oil reserves, the dynamic nature of the increase in reserves and extraction was described earlier (M. K. Hubbert, 1949), and it was used to estimate "the probable" and "possible" reserves in the United States.

The analogous studies were performed also in the USSR in connection with the necessity for prospective and long-range planning of the search and exploration [6, 9].

The generalization of the geological-statistical materials with respect to many of the oil and gas bearing regions of the world [7] has demonstrated the significant effect of the historical peculiarities of the development of the geological exploration work and the conjuncture of the oil and gas demand on the nature of the development curves of their reserves. In the areas with different history of development, the maximum oil extraction level is 2 to 3 percent (more rarely, 1 to 1.5 percent) of the potential extracted reserves, and it is established at 65 to 75 percent of the exploration of the latter.

The effectiveness of the search and exploration work reaches a maximum at 15 to 25 percent exploration of the potential reserves, and it drops by three times at 50 percent [5].

The presented relations permit not only planning of the effectiveness of the exploration operations and their volumes, but also judgment of the reliability of estimating the potential reserves and the sign of the error.

These relations can be used reliably if the exploration of the individual parts of the region or its oil and gas bearing complexes takes place without great interruptions in time. Within the limits of the province or the region, the analyzed relations must be determined by each area and the complex individually under the condition that the latter differ sharply with respect to degree of study.

However, it is necessary to keep in mind that the disproportion between the exploration of the potential reserves and the effectiveness of the geological exploration work can be caused not only by significant errors in estimating the predicted reserves but also a number of other causes--improper planning of the search operations (concentration of them in relatively low-prospective areas), association of a significant part of the predicted reserves with the deeply submerged deposits that are difficult of access, by the inefficient method of search and exploration.

For purposes of long-range planning of the geological exploration work, there is a theoretical possibility of predicting the number of beds under the corresponding reserves which will be opened up during the process of continuous and uniform exploration of a prospective territory [2]. The curves reflecting the growth of the explored reserves flatten out as their x axes approach the magnitude of the extracted potential reserves of the given area. The probability-statistical simulation permits sufficiently highly accurate prediction of the reserves of the provinces and large regions in the presence of the required initial information about the operating efficiency and the statistical distribution law of the deposits with respect to area and reserves.

The initial potential oil (gas) reserves with respect to the area as a whole or with respect to individual prospective complexes can be determined:

1) By the coefficient of exploration of the potential reserves, corresponding to the maximum effectiveness of the exploration work or the greatest annual extraction;

2) With respect to the curves characterizing the dynamics of the preparation of the reserves or extraction (graphical method);

3) With respect to the probability-statistical models (analytical method).

The first method is the simplest and most approximate. By the actual data on the dynamics of the effectiveness of preparation of the reserves or by the maximum oil (gas) extraction in the region and the corresponding exploration factors adopted by analogy, the magnitude of the potential reserves is established.

Example. The effectiveness of the operations in the area with respect to the explored complexes of deposits has ceased to be maximal--to correspond to 20 percent exploration of the potential reserves. The total magnitude of the extracted explored oil reserves (categories A+B+C_1 extraction) on the date of achievement of the maximum effectiveness is 100 million tons. The extracted part of the potential oil reserves in the area by the same complex amounts to the following: 100:0.2 = 500 million tons.

The estimate of the potential reserves with respect to the maximum extraction level is more reliable as a result of greater reliability of the initial data. Thus, whereas the maximum annual oil extraction in the area was 2 million tons and it was assumed that this value corresponds to 2 percent potential extracted reserves, the amount of the latter is determined at 500 million tons. The reliability of the results obtained depends on the correctness of the selection and substantiation of the ratios (determined by generalization of the actual material with respect to a large number of oil and gas bearing areas of the world) between the potential reserves and the extremal indexes of their development.

The deficiency of the procedure is that it does not reflect the dynamics of the assimilation of the reserves, and it does not permit simulation of this process considering the prospects for the introduction of new equipment and technology. The most probable estimate error is $\pm$50 percent.

The second procedure is basic. It requires the construction of the curves for the development of oil and gas reserves (graphical models), the initial segments of which are drawn by the actual data, and then they are extrapolated to almost complete smoothing out. It is very important to establish the position of the characteristic points of the curves (maxima, inflections, limits of extrapolation). The reliability of the extrapolation depends above all on the objectiveness and the representativeness of the actual material. If with respect to the areas and complexes of deposits the maximum effectiveness of preparation of the reserves or the highest level of extraction are achieved, the extrapolation can be done quite reliably, and the potential reserves are determined with relatively high accuracy (error to $\pm$30 percent).

The effectiveness of the geological exploration operations is expressed by the increase in reserves and depends on the concentration of the latter in the large and largest deposits. If it becomes obvious that the largest deposits are already discovered in the area and basically explored, then it is possible quite exactly to determine the maximum efficiency of the preparation of the reserves and the highest level of extraction which in practice is also done when compiling the prospective plans.

The effort to construct the approximation model of the preparation of the reserves, depending on the drilling volumes, was undertaken previously [1]. For extrapolation of the curves for assimilation of the reserves, a model is selected or versions of the models corresponding to the geological

and economic conditions of the investigated area, the historical peculiarities and trends in its development. In the development models, the possible scientific and technical progress in the procedure, the technique and the organization of operations with respect to the preparation and extraction of the reserves, the variation of the geological conditions of performing the operations (unfortunately the scientific and technical component of the forecast remains procedurely poorly investigated) must be taken into account.

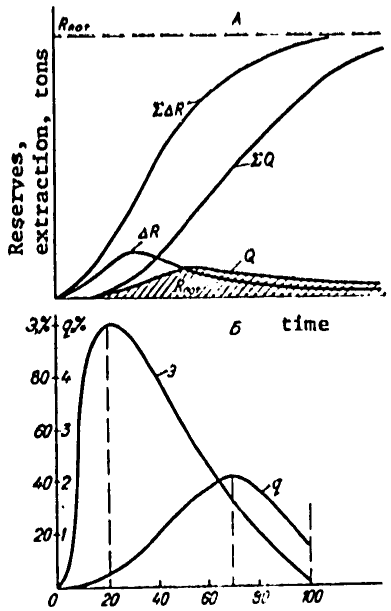

Figure 1. Standard curves for the dynamics of the increase in the reserves (ΔR), extraction (Q) as a function of time (A) and the relative effectiveness of the exploration work (E, %) and rate of selection of the potential reserves (Q, %) as a function of the exploration of the potential reserves (B). Integral curves: ΣR--total explored reserves; ΣR--total extraction. The cross-hatched area under the differential curve is numerically equal to the potential reserves (R_{pot}).

The reserve development curves depend on the indexes by which they are constructed: if the curve is integral (compiled by the summary data), then the magnitude of the potential extracted reserves is numerically equal to the y-axis of its horizontal section; if it is differential (compiled by the annual data), then it is equal to the area bounded by this curve and

the x-axis. The differential curves usually are characterized by one peak shifted in the direction of the y-axis; the integral curves have inflection points and asymptotically approach the horizontal straightline corresponding to the finite extraction of minerals (Figure 1).

The main difference in the shape of the curves for the effectiveness of preparation of the reserves and oil extraction consists in the fact that their critical points do not coincide in time: the peaks are at 15-25 and 65-75 percent respectively of the exploration of this potential reserves. Therefore the extraction reaches the highest level when the effectiveness of preparation of the reserves becomes somewhat below its maximum.

The third procedure is recommended for use in relatively early stages of preparation, in the absence of actual data for construction and reliable extrapolation of the reserve development curves, on the basis of the available data on the structure and the prospects for oil and gas bearing of the region considering its analogy with other comparatively well investigated territories, the probability-statistical model of the exploration of the reserves is selected.

The correct point of view is the proposition that the distribution (the frequency of encounter) of the deposits with respect to size (reserved) in the overall set is subject to a statistical law [2, 12]. Some of the researchers consider that the pobability of the distribution of the deposits with respect to size is subject to a log normal law.

The discovery of the deposits and, consequently, the increase in the reserves, depend on the volumes and placement (direction) of the exploration work. Being given different rates of the latter, it is possible, beginning with the adopted distribution function of the reserves, to establish the corresponding increase in them. Inasmuch as the probability of the discovery of large deposits of the greatest, they will be discovered first of all. With an increase in exploration on the average the probability of discovery of smaller deposits increases, that is, the efficiency of the operations is lower, and the integral curve for the preparation of the reserves, on leveling off, approaches the initial potential reserves on the graph.

The method of estimating the potential reserves by their assimilation curves theoretically may be used in the oil and gas bearing regions of any sacle, including the Volga-Ural and Western Siberian regions. However, the smaller the area, the more uniform it is with respect to structure and degree of exploration, the greater the regularity characterizing the reserve preparation and extraction curves and the more certainly it is possible to extrapolate them. The estimate of the potential reserves is found to be reliable when the decrease in effectiveness of the exploration work caused by exploration of the largest deposits begins. The method of the assimilation curves can be successfully also in the early stage of investigation in combination with the transitional methods if in accordance with the set of geological data and by analogy there are prerequisites for predicting the discovery of large deposits. The reserves of the large deposits predetermine the

level of greatest efficiency of the exploration work in the region, and the accuracy of estimating the reserves will correspond to the reliability of predicting the discovery of these deposits.

Thus, the main limiting factor in the application of the method is the state of geological investigation of the region and exploration of its basic deposits. The exploration of a field is determined by the volumes and the arrangement of the operations. Accordingly, it is necessary to discuss two theoretically different strategies (systems) for geological study and exploration of deposits--sliding and bunching.

The essence of the former consists in the extreme nonuniformity of arrangement of the volumes of operations which, after discovery of the first industrial accumulations are concentrated in one to two zones for the fastest growth of industrial reserve. When a sharp decrease occurs in the efficiency of the exploration, the displacement of the operations to other projects takes place. Therefore the discovery of the principal zones and regions of oil and gas accumulation and the achievement of the greatest efficiency of the exploration occurs not in the initial stage of the exploration process. The stepped nature in the study of the region can be manifested not only with respect to area, but also with respect to the section and types of traps. The dynamic of the efficiency of the operations is characterized by the curve 1 (Figure 2). The "sliding" strategy of the exploration to one degree or another holds up the discovery of the potential possibilities of the majority of oil and gas bearing provinces. The application of it often is dictated by the limited economic and production possibilities and to a great degree by the existing system of planning of geological exploration work.

The "bunching" strategy of exploration is based on the principle of studying, "from the general to the special" by uniform placement of the volumes of geological exploration work throughout the entire territory in order to discover all of the basic zones of oil and gas accumulation with respect to the entire section of the sedimentary mantle in the initial stage of the investigation. After discovery of the structure and estimating the prospectiveness of the oil and gas bearing beds by geological-geophysical operations and prospecting drilling, the exploration is concentrated in the richest zones of oil and gas accumulation, including the large and largest deposits. As the oil and gas bearing province (region) is developed, the exploration work becomes more consolidated in the less rich zones and also in the complex structures. It must be noted that sufficiently reliable information about the structure and the prospects for oil and gas bearing nature of a region as a whole is obtained in the initial phase of the investigation, which ensures optimal choice of the direction of exploration work and the highest effectiveness on the average for the entire period of realization of the potential reserves.

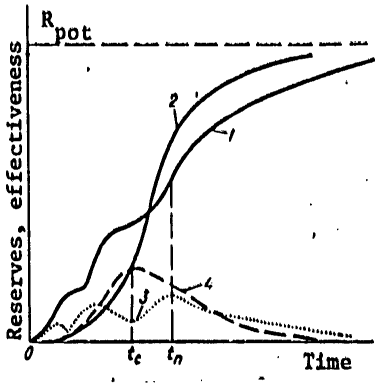

Figure 2. Characteristic curves for the preparation of reserves for different systems of exploration of a region. Integral curves for the increase in the reserves or the following kinds of systems: 1--sliding, 2--bunching; curves for the dynamics of the effectiveness of the exploration work for the following systems: 3--sliding, 4--bunching; time of achievement of the maximum effectiveness for the system: $t_п$--sliding, t_c--bunching.

In the initial phase of exploration by the "bunching" system the increases in the reserves of industrial categories are small inasmuch as the entire volume of drilling is spent on finding the deposits. As the exploration operations and their placement in the largest deposits grow, the effectiveness increases sharply and reaches a maximum appreciably earlier than for the "sliding" system. Then on making the transition to exploration of the less rich zones and deposits, the intensity of the increase in the reserves decreases regularly (see Figure 2, curve 2).

For all of the advantages, the "bunching" strategy for exploration also has deficiencies: it is not always applicable in very large, little-exploited and difficult of access regions; it requires a united, long range program of geological exploration work on the scale of the entire region, the concentration of significant means for a number of years only on geological exploration work and correspondingly, during these years, refraining from exploration and increasing the reserves of industrial categories.

In the broad territories of the type of the Siberian platform obviously the optimal strategy will be a mixed or combined strategy of exploration: "sliding" for the province as a whole, "bunching" for individual regions of it.

From what has been stated it is clear that the most favorable conditions for predicting the reserves by the method of assimilation curves are created in the cases where the strategy for studying the oil and gas prospective region is "bunching." The reliability of the estimates in this case is very

high already in the initial exploration stage. With the "sliding" system its application is expedient in a relatively later stage of exploration when the effectiveness of the latter has passed its highest level.

The method assimilation curves can play an important role in the system for separate prediction of the oil and gas reserves in regions such as the Ural-Povolzh'ye region, Predkavkaz'ye, Timano-Pechorskaya Province, Western Siberia, Central Asia, Sakhalin, and so on, not only as independent, but in combination with ordinary geological methods of predicting the reserves. For the regions and complexes of deposits with high exploration indexes the error in estimating the potential and forecast reserves by the investigated method insignificantly exceeds the average error with respect to the total category reserves. Therefore the assimilation curves are recommended for use for estimating the potential reserves of the standard sections, substantiating the densities of the reserves, improving the methods of analysis and more precise determination of the numerical values of the accumulation factors and other parameters used in the methods of comparative geological analysis and in volumetric-genetic analysis.

The method of assimilation curves of the reserves cannot replace the geological forecasting, for without discovering the laws of spatial arrangement of the oil and gas deposits, it gives an idea only of their total reserves. However, its broad use, just as the improvement as applied to various geological conditions, will undoubtedly promote an increase in reliability of predicting the oil and gas reserves and consequently, improvement of the efficiency of the geological exploration work.

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FUELS AND RELATED EQUIPMENT

UDC 553.981.6:551.762(571.1)

PREDICTING CONTENT, COMPOSITION OF CONDENSATE, CONDENSATE OUT COEFFICIENT

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 2, Feb 79, pp 33-37

[Article[1] by T. D. Ostrovskaya, Central Laboratory of the Glavtyumen'geologii Administration]

[Test] The analysis of the materials of the investigation of the gas condensate deposits made it possible to detect a number of general laws with respect to the solubility of high-boiling fractions in stratal gas, that is, prediction of the condensate content in the prospective areas. The efforts to find the relation of the potential condensate content in the stratal gas to the individual factors have been made by a number of researchers [1, 2, 4]. In particular, the dependence of the concentration of oil and gas C_5 + the higher fractions in stratal gases on the depth of occurrence of the deposits [1] and also the cumulative effect of pressure, temperature, composition of the stratal gas, condensate and oil (in the presence of margins of the latter), the conditions of formation of the deposits on the actual condensate content in the gas [2] were demonstrated.

Considering the numerous factual data, we have established the relation of the group hydrocarbon composition of the condensates with temperature and pressure in the deposit (Figure 1). The graphical dependence of the potential condensate content on the thermobaric conditions of finding the deposits and the group hydrocarbon composition of the condensate was also illustrated [4]. The discovered laws provided the basis for this paper.

Previously [3] a separate forecast was made of the phase state of the oil and gas in the deposits in the little-studied territory of the northern part of the Tyumen' Oblast; maps were constructed of the predominant spread of oil and gas condensate deposits.

The presence of oil deposits in the lower and middle Jurassic formations was proposed in the northwestern region--in the northern Yamal'skaya oil and

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1. For discussion.

gas bearing region and in the northwest of the southern Yamal'skaya Region, in particular in the Nurminskiy megaswell, in the Kharasaveyskiy Dome, in the structures of the Nakhar'yakskiy and the Ust'-Yerkutyayakhskiy swells, in the Preobrazhenskiy and Maglyginskiy local anticlinals. In the remaining regions of the northern part of the Tyumen' Oblast and the Krasnoyarsk Kray, deposits were predicted with predominant single phase (gas) content--gas condensate or gas condensate with oil margins. A forecast is made of the condensate content in the stratal gas and its hydrocarbon composition.

The procedure used in the work consisted in the following. For local uplifts, by the structural map the stratal pressure was calculated in the proposed gas condensate deposits, and by the geothermal gradient map, the stratal temperature. Then using Figure 1, the hydrocarbon composition of the condensates dissolved in the gases of the forecasted deposits was determined. The results of the calculations are presented in Figure 2. Considering the information about the thermobaric conditions of the occurrence of the deposits and the group hydrocarbon composition of the condensates, we predicted the amount of condensate in the stratal gas by the previously discussed procedure [4].

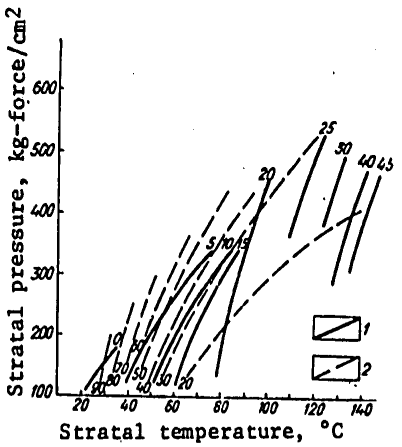

Figure 1. Variation of the group hydrocarbon composition of condensates under various thermodynamic conditions of the occurrence of the deposits. Hydrocarbons: 1--aromatic; 2--naphthene

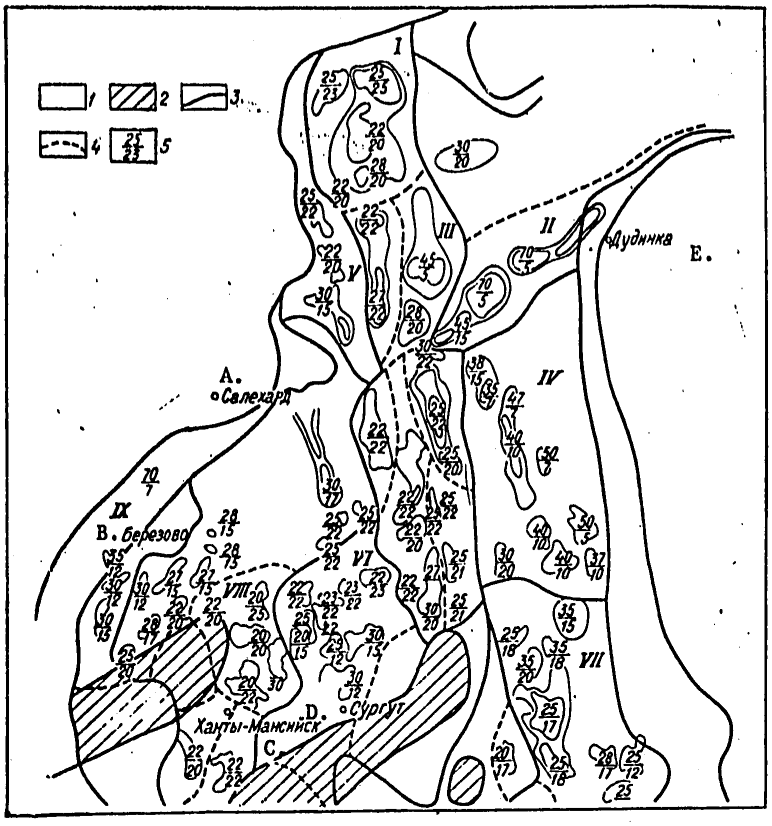

Figure 2. Predicting the group hydrocarbon composition of condensates in the deposits of the lower and middle Jurassic. Zones of predominant propagation of the beds: 1--gas condensate (including with oil margins), 2--oil; boundaries: 3--oil and gas bearing regions, 4--oil and gas bearing regions; 5--hydrocarbons (%), in the numerator--naphthene, in the denominator--aromatic. Oil and gas bearing regions: I--Northern Yamal'skaya, II--Ust'-Yenisey, III--Nadym-Purskaya, IV--Pur-Tazovskaya, V--Southern Yamal'skaya, VI--Sredneobskaya [Central Ob], VII--Payduginskaya, VIII--Frolovskaya, IX--Priural'skay [Ural Region].

Key: A. Salekhard
B. Berezovo
C. Khanty-Manskiysk
D. Surgut
E. Dudinka

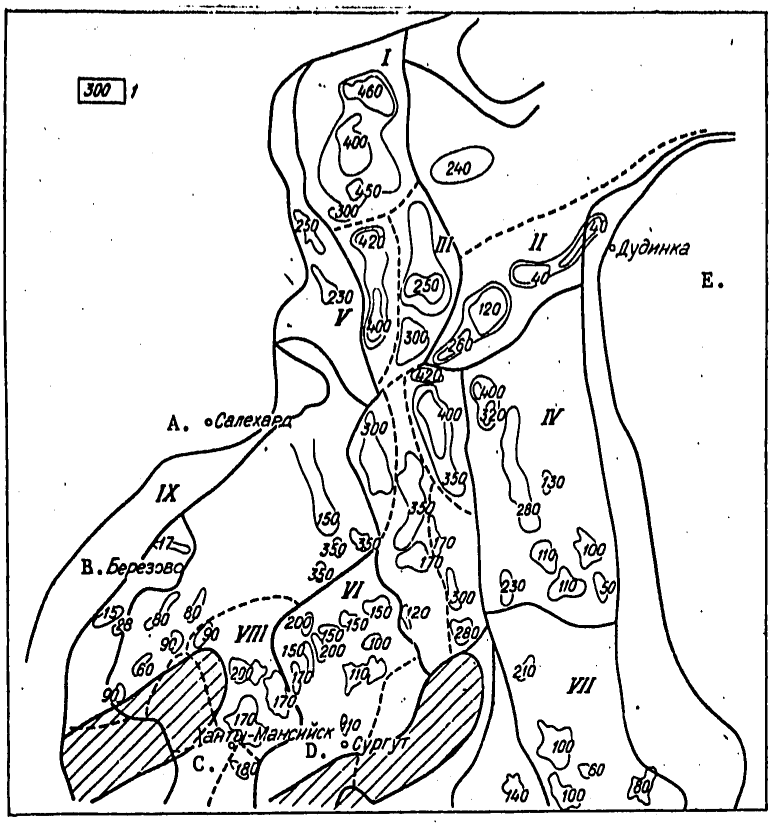

Figure 3. Forecasting map of the variation of the potential condensate content in the stratal gas of the deposits of the lower and middle Jurassic. 1--Potential condensate content in the stratal gas, g/m^3, remaining provisional notation, see Figure 2.

Key: A. Salekhard
B. Berezovo
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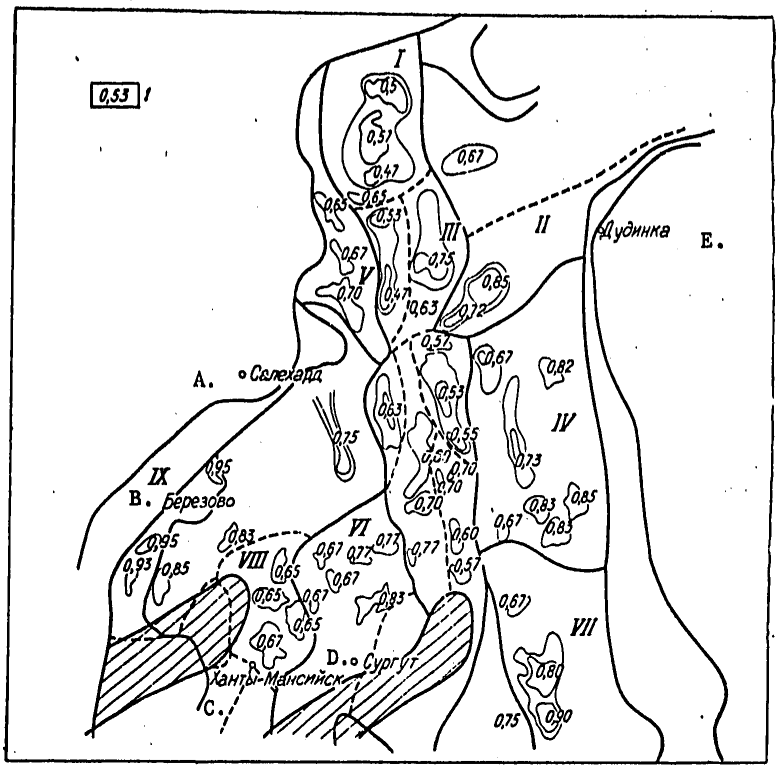

Figure 4. Forecasting map for the variation of the coefficients of condensate return of the deposits of the lower and middle Jurassic. 1--Condensate return factor. Remaining notations see Figure 2.

Key: A. Salekhard
B. Berezovo
C. Khanty-Manskiysk
D. Surgut
E. Dudinka

As is obvious from Figure 2, the condensates will be different with respect to the group hydrocarbon composition: aromatic hydrocarbons in them 5-25 percent, and naphthene 20-70 percent. Clear zonality is observed in the variation in the hydrocarbon group content with respect to area. The greatest concentration of aromatic hydrocarbons (> 20 percent) was noted in the condensates associated with the submerged zones of the investigated territory: in the Vengapurovskiy, Nadymskiy, Urengoyskiy, Gydanskiy and the Sredneyamal'skiy oil and gas bearing regions, in the northern part of the Surgutskiy (Aykhettinskoye, Verkhnenadymskoye and the collective dome uplifts) and also in Lyaminskiy. With respect to direction of the side parts of the Western Siberian platform, condensates will be encountered with low aromatic hydrocarbon content. In the Kazymskiy (Frolovskaya Oblast) and Tazovskiy (Pur-Tazovskaya Oblast) oil and gas bearing rayons, the aromatic hydrocarbons will be 10 to 20 percent. The zones impoverished with respect to aromatic hydrocarbons (< 10 percent) are predicted in Ust'-Yeniseyskiy and Krasnosel'kupskiy rayons, in the Pur-Tazovskaya oil and gas bearing oblasts and the Priural'skaya Oblast.

The nature of variation of the concentration of the naphthene hydrocarbons in the condensates is somewhat different (see Figure 2). In the submerged regions in the northern part of the Western Siberian platform, condensates can be encountered with low naphthene hydrocarbon content in the group hydrocarbon composition (to 25 percent). In the side parts of the platform, their quantity increases sharply (to 50-70 percent).

On the basis of the fluctuations in the hydrocarbon composition of the condensates, variation of the content of the latter in the stratal gas of the deposits is predicted (see Figure 3). In individual deposits it will vary potentially within the limits from 5 to 500 g/m^3. Its highest concentrations (400-500 k/m^3) are observed in the stratal gas of the Gydanskiy and the Sredneyamal'skiy rayons and the northern part of the Urengoyskiy Oil and Gas Bearing Rayon (Olikumlinskiy Swell) of the Nadym-Purskaya Oblast.

In the oil and gas bearing rayons of Urengoyskiy and Nadymskiy (Nadym-Purskaya Oblast) and also in the Tazovskiy Rayon (Chasel'skiy Megaswell in the Pur-Tazovskaya Oblast) the condensate content in the stratal gas is 300-350 g/m^3.

In the Vyngapurovskiy Ayvasedopurovskiy (Vyngapurosvskiy and Southern Ayvasedopurovskiy swells in the Nadym-Purskaya Oil and Gas Bearing Oblast) and in the Tazovskiy (Srednemessoyakhskiy and Messoyakhskiy swells in the Pur-Tazovskaya Oblast) rayons there will be 250-300 g/m^3 of condensate in the stratal gas.

The territory with condensate content of 200-250 g/m^3 occupies a significant area (see Figure 3). This includes the structures of the Solpatinskiy Swell (Bol'shekhetskiy and Verkhnetazovskiy oil and gas bearing rayons) and all of the Yuzhno-Yamal'skaya Oil and Gas Bearing Oblast.

Within the limits of the Krasnoleninskiy and Lyaminskiy rayons (Frolovskaya Oil and Gas Bearing Oblast) probably the stratal gas includes 150-200 k/m^3 of condensate.

In the deposits located in the side sections of the platform, a low content of condensate is predicted. Thus, in the oil and gas bearing rayons Kellogskiy and Kostrovskiy (Pur-Tazovskaya Oblast), Shuginskiy (Frolovskaya) it does not exceed 150 g/m^3. The lowest condensate concentration (< 50 g/m^3) is proposed in the Priural'skaya Oil and Gas Bearing Oblast and the Nizhnekhetskiy Rayon of the Ust'-Yeniseyskaya Oblast.

The extracted condensate reserves are calculated on the basis of the condensate return factor.

There is a clear graphical relation of the condensate return coefficient to the group hydrocarbon composition of the condensate in the initial potential content of the latter [5]. Considering this dependence, on the basis of Figure 2, 3, a forecasting map is constructed for the variation of the coefficients of condensate return for the beds of the investigated deposits (Figure 4).

As is obvious from Figure 4, the coefficients of condensate return will vary within broad limits (from 0.45 to 0.95). Clear zonality is determined by the magnitude of this factor. Its low value (< 0.6) occur in the deposits with the greatest potential condensate content--in the Gydanskiy, Srednеyamal'skiy and Tazovskiy oil and gas bearing rayons.

In the northern part of the Surgutskiy Rayon, in the Lyaminskiy and the Yuzhno-Yamal'skiy rayons and also in the southern part of the Nadym-Purskaya Oblast the condensate return factor is 0.6-0.7.

In the side sections of the platform--in the Priural'skaya, Ust'-Yeniseyskaya, Pur-Tazovskaya (eastern part) oil and gas bearing oblasts, high condensate return factors are predicted (> 0.8).

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