JPRS L/9435

10 December 1980

USSR Report

ENERGY

(FOUO 25/80)

FBIS FOREIGN BROADCAST INFORMATION SERVICE

FOR OFFICIAL USE ONLY

APPROVED FOR RELEASE: 2007/02/08: CIA-RDP82-00850R000300060016-5

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

APPROVED FOR RELEASE: 2007/02/08: CIA-RDP82-00850R000300060016-5

JPRS L/9435

10 December 1980

USSR REPORT

ENERGY

(FOUO 25/80)

CONTENTS

ELECTRIC POWER

SOVIET SCIENTIST REPORTS ON TIDAL POWER

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 10, Oct 80, pp 55-60

/Article by L. B. Bernshteyn, Doctor of Technical Sciences: "The Ocean's Energy at the Fourteenth Pacific Ocean Scientific Congress"/

/Text/ The Pacific Ocean Scientific Association (PSA), which is an international, nongovernmental organization that studies the Pacific Ocean, was created in 1920 in Honolulu, Hawaii. The USSR joined the association in 1926. At present there are 43 nations and 7 honorary members, representing national academies of science and scientific institutes, participating in the PSA. Every four years one of the nations that is within the Pacific Ocean basin hosts the scientific congresses. In 1979 the XIV Congress convened in the USSR in the city of Khabarovsk. Six hundred and eighty scientists from 60 nations participated. The association president prior to and during the congress was Academician A. V. Sidorenko. The slogan for the congress was the "Ocean's Resources in the Service of Man".

Questions of utilizing the ocean's energy were examined in committee F.1.10 - marine sciences. Thirty seven Soviet and foreign scientists, who discussed 15 reports, took part in the work of the symposium.

In his report V. A. Akulichev (USSR) notes that all sources of energy in the ocean, with the exception of tides, arise as the result of the accumulation of solar energy following its various transformations.

Thermal energy is the most significant. However, it can be used only when there is a large drop in temperatures at various depths. The energy of large and medium scale circulations and currents of the world's ocean is great. The use of the kinetic energy of the motion of water is possible when the current has an average speed greater than one meter per second.

As an illustration we cite the recently proposed plan, according to which to use the energy of tidal currents in one of the straits on the coast of England it is proposed to install a 100 meter diameter rotor. At a speed of tidal current of 2 meters per second this gigantic rotor with a frequency of revolution of 1 rpm could generate 10 MW.

The energy of the surface waves is of small concentration and therefor inspite of its overall high potential it cannot have any industrial significance. According to estimates of English specialists the average wave energy is 80 KW per meter of coastline. However, under conditions of permanence the installation that utilizes this energy must be rated at a capacity of 2000 KW. The installation of coastal facilities is not possible in most coastal regions which are subject to ice formation.

Five symposium reports were dedicated to hydrothermal electric power stations (GITES).

The idea of obtaining electricity from the variation in temperature was first expressed by Kako and Darsanval in 1881. Prior to World War II the French scientists Claude and Bushereau conducted research in this field and installed an experimental device on the coast of Cuba which had a capacity of 22 KW. However, the technical level at that time did not make it possible to create a profitable power device with an acceptable efficiency in the small temperature range of 18 to 20 degrees that exists in some regions of the world's ocean between the upper and lower layers of water.

The achievements of modern technology and particularly refrigeration engineering, which uses new substances with a low boiling temperature (ammonia, freon), make it possible to bring the development of hydrothermal electric power stations to a qualitatively new level. In principle it is possible to use two types of temperature gradients. In the first case the temperature gradient evolves between different layers of water. In the second - between the water of the ocean and the mass of air, which in nothern regions can have a rather low temperature. Systems, which use the temperature gradient of the water environment, were examined at the congress in the reports of foreign scientists.

G.E. Shitz (USA) gave a report that summarized work on the conversion of the thermal energy of the ocean. Analysis of various technical solutions showed that the cycle that uses a low boiling substance and circulation systems of evaporation and condensation is the most promising. The review devoted most attention to the OTEK (Ocean Thermal Conversion) program that is being developed in the USA. The program's trend is the thermal conversion of the energy of the ocean. Under this program they are developing a hydrothermal electric power station with a 1 MW capacity that consists of five units with 200 KW each. The technical-evaluations show that in view of the tendency of prices for liquid fuel to rise in the USA, the hydrothermal electric power station may be a profitable alternative within the next five years.

M.M. Horn (USA) cited data on two other experimental devices that have been under development since 1974 under the auspices of Ocean Thermal Conversion.

The first "mini-hydrothermal electric power station" with a capacity of 50 KW was created in the Hawaiian islands in May 1979. It consists of a condenser and evaporator that are installed on a floating platform 37 by 10 meters which was erected 2 KM from the shore. Ten cubic meters of cold water per minute are fed to the installation from a depth of 1000 meters. The pipeline, which is a 61 centimeter polyethylene hose, serves as a mooring for the platform.

Early in 1980 they were to have tested a marine coastal device with a supply of 242 cubic meters of cold water per minute from a depth of 640 meters. Later they will equip industrial devices, the energy cost of which will be less than the energy cost of thermal electric power stations.

In the report of T. Kajikawa and T. Homma (Japan) there was information about a program for making hydrothermal electric power stations on an industrial scale. The first part of the program is the development of a 100 MW installation. The installation includes four modules of 25 MW each and consists of a turbine, two evaporators, two condensers, two pumps for the supply of the working liquid, two pumps for the supply of thermal water and auxilliary equipment. To decrease the production cost of the energy that is produced they have determined an interrelationship between the temperature and speed of the current for all units of the installation, which has made it possible to establish the optimal characteristics of its basis systems. Since these characteristics depend largely upon the geographical location where the installation is used, they have made estimates on the cost of the installation for two regions of Japan: near the Osumi Islands and for the Toyama Bay with a capacity of nearly 100 MW.

Expenditures for the creation of the installation amount to 781,000 Yen per kilowatt for the Osumi Islands and 592,000 Yen per kilowatt for Toyama Bay. The different relative indicators can be explained by the different rated temperatures and the length of the cold water pipelines for these regions. Later they anticipate a decrease in expenditures for the creation of a carrier platform and the heat exchanger.

The second part of the program was the study of energy cycles in the hydrothermal electric power station and improvements in the heat exchangers.

V.B. Kozlov's (USSR) report examined the technical-economic characteristics of hydrothermal electric power stations, which make use of the heating of water in solar water heaters to extend the temperature interval. V.B. Kozlov's basic technical concept is as follows. The insignificant temperature gradient of 18 to 22 degrees Centigrade substantially lowers the efficiency of energy conversion in the hydrothermal electric power stations. Extending the temperature gradient is possible in two basic ways. First, by lowering the low temperature in the cycle. The opportunities for this are limited because they require the achievement of significant depths, which is connected with technical difficulties and substantially increases capital investments for the installation. Toward this end the report examines a method for an additional heat supply using solar energy. An evaluation of the basic technical-economic indicators of the power plant is cited for the variants using solar water heating and without same. The capacity of the plant is 500 KW, the substance cane be ammonia or freon, the depth of the water intake is 400 meters. The temperature gradient through heating is raised from 15 to 40 degrees Centigrade. The approximate cost is somewhere between 600 and 1100 rubles per kilowatt. The cost can be lowered by heating to 200 to 600 rubles per kilowatt; the production cost of the energy is 1.5 to 2 copecks per kilowatt-hour. Foreign hydrothermal electric power stations, with which comparisons have been made, have a greater capacity of 100 to 160 MW and quite large capital expenditures - up to $2,660 per kilowatt.

Thus, the problem of using the thermal energy of the ocean is presently technically possible but economically infeasible. In the future in appropriately favorable climatic regions industrial power stations may be created.

D. Isoake's (USA) report was devoted to systems, which use processes taking place between solutions of various concentrations of salt for the production of energy. The report noted the great possibilities for making use of such processes and cited several technical characteristics of such systems. However, in our opinion, in the near future it is still difficult to envision the development of real large-scale projects in this direction.

It is a different story with the plans to use the energy of the tides. Most of the reports at the symposium were devoted to this problem.

L.B. Bernshteyn's (USSR) report showed that the present status of the problem demonstrates the correctness of the Soviet concept, which consists of detecting the specific properties of tidal energy and using them in large power systems. Chief among these properties is the constancy of the average-monthly amount of tidal energy, which means that it does not depend upon the water content of the year and season. This dictates the advisability of executing such tidal electric power stations, which ensure the receipt of the greatest possible amount of energy with the least expenditures. The author's research showed that the division of the tidal electric power station basin into two or three parts, which was proposed previously in foreign plans, due to the direct relationship of the amount of energy upon the area of the basin, leads to a corresponding decrease in the release of energy and does not solve the problem of the necessary equalization of the tidal electric power station output during the intra-month period, requiring for this an almost complete duplication of the power of the tidal electric power station on specially rigged water storage power stations or other electric power stations. On the other hand, it was demonstrated that the isolation of entire bays from the sea and the formation of tidal electric power station basins of single- and dual-sided action ensures the receipt of the greatest amount of tidal energy. The pulsating, intermittent, but constant from year to year currents of this energy must be transformed in the reversible units of the hydrothermal electric power stations and directed to large power systems, where they can be fully used in conjuntion with the energy of river hydroelectric power stations, the reservoirs of which can compensate for the intermonth fluctuations in the output of the hydrothermal electric power stations. In addition, the reversible units of the hydrothermal electric power stations can be used during the hours of the nighttime dips in the load schedule; the accumulated energy can be sold during the peak hours of the load schedule. The need to create large capacity hydrothermal electric power stations is predetermined by the limitedness of the sections, where one can create reservoir hydroelectric power stations with the comprehensive regulation of the river flow to compensate for the intermonth irregularity of energy production of the hydrothermal electric power stations. Under this solution of the problem, the earth can accomodate 30 to 40 hydrothermal electric power stations with a total capacity of 280 million KW and an annual energy output of 750 billion kilowatt-hours. A comparison of these possibilities with the output of modern electric power stations at 8 trillion kilowatt -hours shows that the hydrothermal electric power station cannot solve the world's energy problems. However, in some areas of the world the role of tidal energy can be very important.

L.B. Bernshteyn's report also analyzed the experience of creating and the ten-year operation of the Rans (France) and Kislogubsk hydrothermal electric power stations, which demonstrated the actual technical possibility of creating large tidal power stations.

The Rans hydrothermal electric power station, which was built in 1967, has an established capacity of 240,000 KW (24 units) and produces 502 million kilowatt-hours per year (net). It has demonstrated the excellent operational characteristics of the reversible capsule hydraulic turbogenerator unit that was specially created in France for the hydrothermal electric power station; this unit ensures the possibility for the flexible operation of the hydrothermal electric power station. Of the 502 million kilowatt-hours of annual energy output, 117 million kilowatt-hours are the result of the work of pumps: the pumping and expulsion of the hydrothermal electric power station basin with the congruence of full or low level water with the time of the dip in the load schedule of the system. In view of the limited possibilities of the hydroelectric power stations for the long-term regulation of the river current and the specific conditions of the Rans section is unable to fully realize the possibilities of the reversible hydraulic turbogenerator units; they operate predominately in two modes (out a possible four): in the direct turbine and reverse pumping modes. According to an estimate of the French specialists the Rans hydrothermal electric power station is economically justified. Annual outlays for its operation amount to 4 percent of the capital investments, which is less that the amounts spent on river hydroelectric power stations. However, its cost (480 million French francs in 1967 prices) was in the conversion for one kilowatt of established capacity 2000 francs, or 2.5-fold greater than for one kilowatt of established capacity of a comparable river hydroelectric power station.

The experimental Kislogubsk hydrothermal electric power station, which was built in 1968 in the USSR, was erected to come up with a method to lower the cost of hydrothermal electric power stations. Since in the construction of the Rans hydrothermal electric power station the connectors and draining from the trench amounted to nearly 20 percent, when creating the Kislogubsk hydrothermal electric power station they decided to erect the station without connectors, using the floating method. This method of construction has been around for a long time and is used extensively when constructing underwater tunnels and floating drilling platforms. The successfully executed original design of the Kislogubsk hydrothermal electric power station, made of thin-walled (15 cm) elements, has over the 12-year period of operation passed all complicated tests. In spite of the small capacity (400 KW) of the hydrothermal electric power station, its dimensions (See Fig. 1) have made it possible to accept it as a prototype in the plans for powerful hydrothermal electric power stations not only in the USSR, but abroad, in Canada (Fig. 2) and in England. Apparently, this is why the floating method of constructing hydrothermal electric power stations has come to be called the Soviet method.

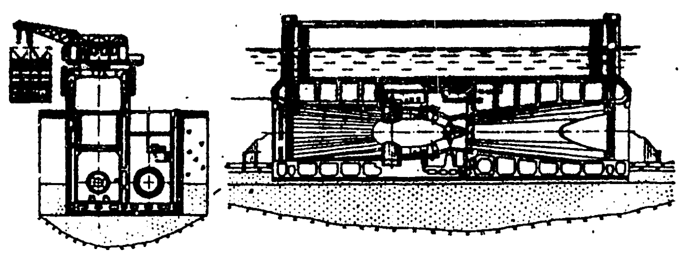


Fig. 1. Floating design of the Kislogubsk hydrothermal electric power station building.

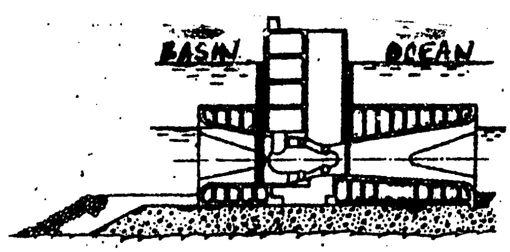


Fig. 2. Building plan for the floating design of the hydrothermal electric power station in Fandy Bay.

Based on the use of this design in the USSR they are looking into the possibility of rigging powerful hydrothermal electric power stations along the coast of the White Sea (in Mezenskiy and Lumbovskiy bays) and in the bays of the Sea of Okhotsk. In the Sea of Okhotsk the crests of the tide are the highest in the USSR (up to 13 meters). Here they are proposing to examine the sections in the Tugurskiy (Fig. 3,b) and Penzhinskiy bays (Fig. 3,c). The dam in Tugurskiy Bay is 37 meters wide, which includes the hydrothermal electric power station building constructed of floating units of a combined design with a powerful wall that withstands the influence of ice (Fig. 4), has a width of [illegible].6 km. The partitioned bay forms a basin with an area of 1800 square kilometers and provides for the output of 9 million KW of power with an annual production of energy amounting to 29 billion kilowatt-hours.

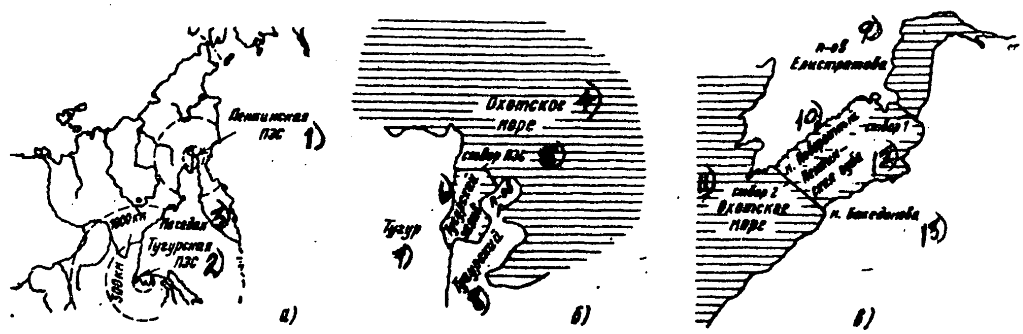


Fig 3. Diagram of the location of the hydrothermal electric power stations along the coast of the Sea of Okhotsk a); in Tugurskiy Bay b); in Penzhinskiy Bay c).

Key:

1. The Penzhinskiy hydrothermal electric power station
2. The Tugurskiy hydrothermal electric power station
3. Magadan
4. Sea of Okhotsk
5. The section of the hydrothermal electric power station
6. Tugurskiy Bay
7. Tugur
8. Tugurskiy Insula
9. Yelistratov Insula
10. Mys Povorotnyy
11. Section 2, Sea of Okhotsk
12. Section 1, Penzhinskiy Gulf
13. Cape Bozhedomov

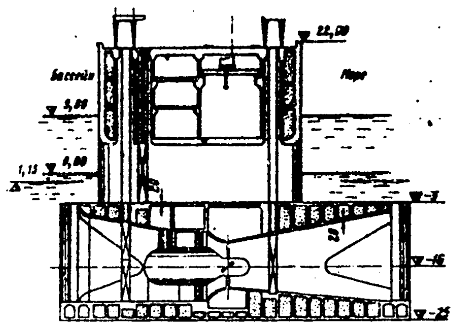


Fig. 4. The combined building of the Tugurskiy hydrothermal electric power station with one-sided operation of the turbogenerator units.

There are even greater opportunities in Penzhinskiy Bay. where its partial sectioning makes it possible to estimate the receipt of 35 million KW, with an annual energy output of 100 billion kilowatt-hours.

In sectioning the entire Penzhinsky Bay it is possible to obtain in excess of 100 million KW of power, with an annual energy output of 300 billion kilowatt-hours. Because of the great depths in this section it is possible to install floating units of the hydrothermal electric power station, using a multi-layer design of the combined type (Fig. 5). The unusually large parameters of the hydrothermal electric power stations in the Sea of Okhotsk and their lack of conformity to existing needs for energy in the surrounding areas are cause for some doubut about the urgency of these projects. However, the energy of the Penzhinskiy hydrothermal electric power station can provide for the conservation of a large amount of organic fuel in the center of the Soviet Union for the production of such power-consuming chemical products as hydrogen and oxygen.

In examining the grandiose plans for the Mezenskiy, Tugurskiy and Penzhinskiy hydrothermal electric power stations it is believed that it will be necessary to solve many more complicated scientific-technical problems before they can be built. Here we have in mind the need to manufacture hundreds of floating units and to erect many kilometers of dams to form the basins of the hydrothermal electric power stations and to manufacture thousands of hydraulic turbogenerators.

Approval of the proposed solutions is being accomplished in designing the Lumbovskiy hydrothermal electric power station. The creation of this station is to be done by sectioning the bay, which has an area of 900 square kilometers. The section includes an island; and the total length of the dams is 8 kilometers. The capacity of the hydrothermal electric power station is 300 MW; the energy output is 700 million kilowatt-hours. It should be noted that they are developing hydraulic turbogenerators with an increased diameter of the rotor for this hydrothermal electric power station; they are also studying the possibility of creating a dam using the underground concentrated blast method.

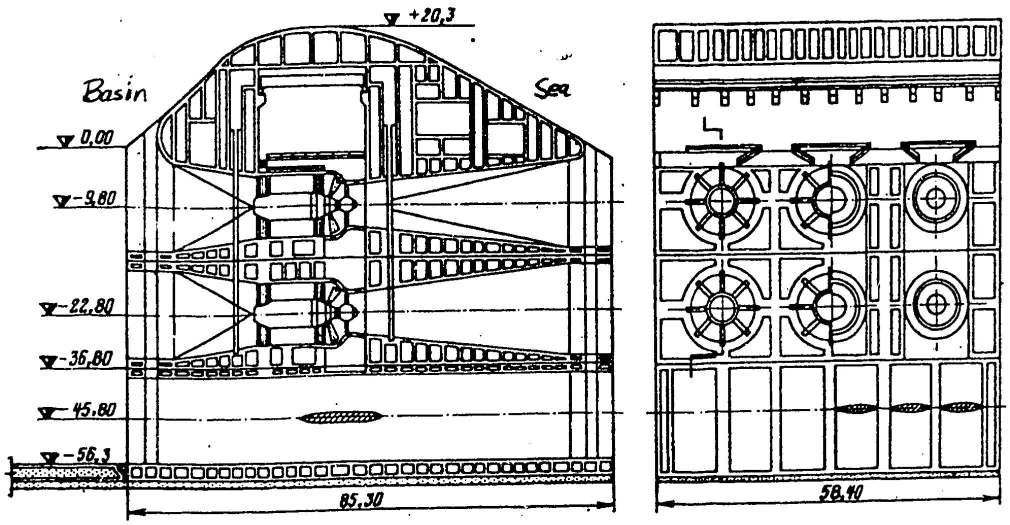


Fig. 5. Building of the hydrothermal electric power station using the combine type floating design.

In principle the solution of these problems rests upon the shoulders of modern technology. French specialists are developing an essentially new technology for the flow-line series manufacture of tidal hydraulic turbogenerators. Work is underway to increase the diameter of the rotors of the capsule turbogenerators. This will make it possible to substantially reduce the number of machines needed for the hydrothermal electric power stations and lower the cost of the hydrothermal electric power station building. The prospects of creating dams which form the basins of the hydrothermal electric power stations using the concentrated blast method are very promising. This method may result in a 10 - 20-fold reduction in their cost.

In Canada they are developing plans for several tidal electric power stations. In particular, according to these plans (report of R. Clark) there are to be two single-basin hydrothermal electric power stations built which have a capacity of 4 million KW and 1 million KW in Camberland and Koubkivid bays. It has also been decided to build an experimental hydrothermal electric power station here, which will be called the Annapolis power station and will have a capacity of 17.5 MW with a direct-flow hydraulic turbogenerator ("Straflow").

At the first hydrothermal electric power station the annual energy output will be 12.6 billion kilowatt-hours; at the second the output will be 3.4 billion kilowatt-hours. The number of turbogenerators at the first is 106 and 37 at the second. The cost of the first is 3.6 billion dollars; and the cost of the second is 1.2 billion dollars.

The plans call for a floating design of building (like the Kislogubsk hydrothermal electric power station), of the openings for the water to pass through, and capsule turbogenerators. The most interesting part of the plan is its ecological and power basis. The latter is executed on the basis of specially designed algorithms, which take into consideration the operation of the hydrothermal electric power station in a unified power system.

The justification that was conducted demonstrated the viability for the hydrothermal electric power station to operate without creating additional capacities for regulating deviations in the output of tidal energy.

Extensive ecological research demonstrated that tidal electric power stations are a source of pure energy. This conclusion is borne out by the experience of the Rans and Kislogubsk hydrothermal electric power stations.

At present they are also designing powerful hydrothermal electric power stations in England, Australia, India, North Korea and South Korea.

The symposium also examined purely theoretical questions, chief among which was determining the energy potential of tides and their estimated value in complicated conditions. The reports of A. V. Nekrasov and N. A. Sezeman (USSR) were devoted to this matter. A. V. Nekrasov's report examined the problem of determing the energy potential in certain specific natural conditions and questions having to do with the energy balance of the tidal basin.

N.A. Sezeman's report provides a solution to the problem of evaluating the change in amplitude of the tide after the erection of a dam, taking into consideration the new resonance conditions.

M.I. Zarki's report (USSR), which was devoted to the experience of operating the experimental Kislogubsk hydrothermal electric power station, noted that thin-walled designs for the hydrothermal electric power stations have a higher static and dynamic durability than comparable low-pressure massive designs because of the spatial operation of the elements. The construction materials (concrete, foam epoxy resins), from which the hydrothermal electric power station is built, demonstrated a particularly high resistance to frost and durability, having been exposed to 6,800 cycles of freezing and thawing. The basis of the hydrotermal electric power station building, which was performed using the underwater method, has a small amount of settling (only 1 mm per year). The cathodic protective covering in combination with antifouling coverings did a good job of protecting equipment. The reliability and correctness of the technical solutions outlined in the plans were proven in the rigging and operation of the hydrothermal electric power station. For this reason the extensive adoption of the experience of the Kislogubsk hydrothermal electric power station is called for in large industrial construction projects for justifying efficiency.

In B. Hervik's (USA, President of the International Association on Pre-Stressed Reinforced Concrete and Floating Structures) report it was noted that the Kislogubsk hydrothermal electric power station and the floating structures are importing for the prospecting and extraction of oil and for designing hydrothermal electric power stations. The report noted that the integration of power engineering and hydraulic engineering, building structures, shipbuilding, and concrete and construction work technologies was needed to create the Kislogubsk station. The successful completion of this construction has already had a favorable impact upon the development of similar projects throughout the entire world, while promoting the certainty and correctness of the idea and the technical soundness for further progress.

The report also cited data on the present status of using the floating method for the construction of platforms for exploratory drilling and oil extraction on the marine shelf at depths reaching 200 and even 300 meters.

In particular, in the North Sea the French firm "Sitanko" has built in the Scottish shipyard at Makalpain three floating platforms, which have been installed at significant depths:

"Brent C", with a capacity of 200,000 cubic meters, has a height of 161.5 meters, is installed at a depth of 140 meters, a volume of concrete in the structure of 100,000 cubic meters, and the weight of the steel is 15,000 tons;

"Frig" was installed in 1975 at a depth of 104 meters, the floating unit has a foundation size of 72X72 and a height of 40 meters, a volume of concrete of 45,000 cubic meters, 5,500 tons of hardware, including 500 tons of pre-stressed hardware.

The "Cormorant A" has a depth of 154 meters, a height of 175 meters, a size of 100X100; 120,000 cubic meters of concrete and 17,000 tons of steel were used.

Near Alaska they have installed platforms intended to be used in severe ice conditions, which called for the creation of special concrete that can withstand the ice load and its abrasive water activity. The report also noted the USSR's original design of floating foundations, which are made of precast reinforced concrete, for the 100-meter supports of the high-voltage electric power line accross the Dnepr River (Fig. 6).

Thus, the examination of the problem of using the sea's energy at the Pacific Ocean Scientific Congress demonstrated that the modern achievements of science and technology ensure the solution of the problem in several nations in the near future on an industrial scale.

The speedy and efficient use of the energy that is created in the expanses of the world's oceans can most fully be accomplished by extensive international cooperation.

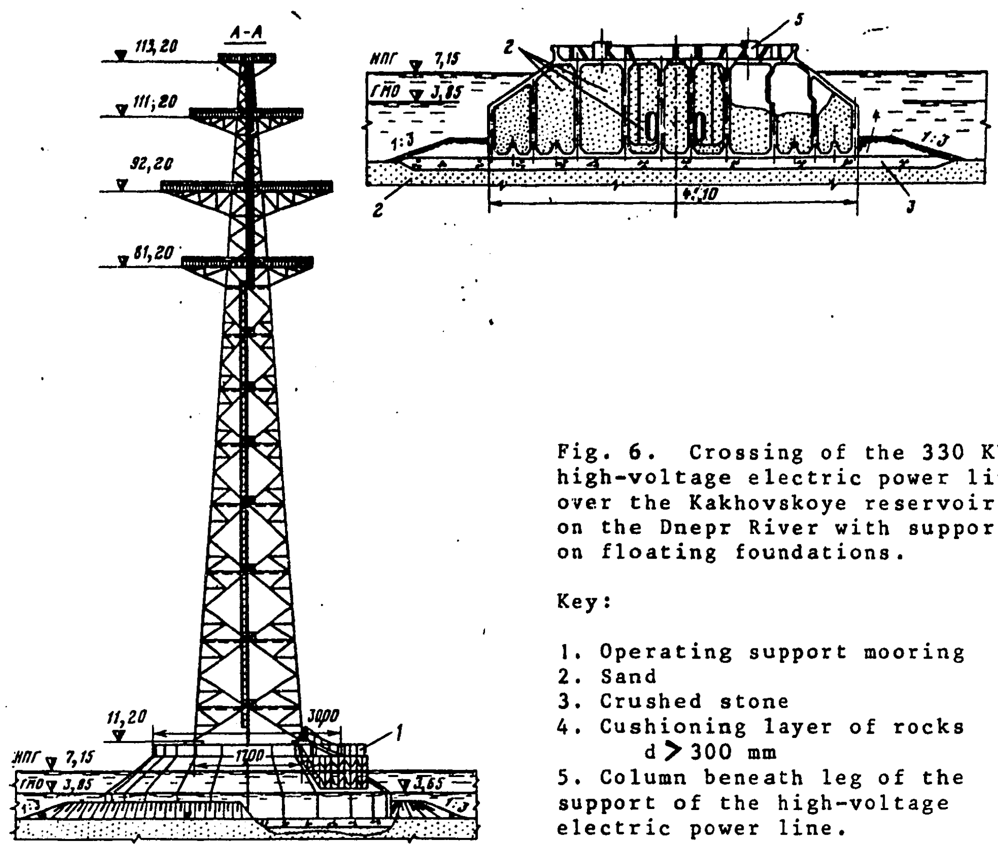


Fig. 6. Crossing of the 330 KW high-voltage electric power line over the Kakhovskoye reservoir on the Dnepr River with supports on floating foundations.

Key:

1. Operating support mooring
2. Sand
3. Crushed stone
4. Cushioning layer of rocks d > 300 mm
5. Column beneath leg of the support of the high-voltage electric power line.

8927
CSO: 1822

ELECTRIC POWER

CENTRAL HEATING SUPPLY FROM DISTRICT HEATING PLANTS

Moscow TEPLOFIKATSIYA MOSKVY in Russian 1980 pp 149-164

[Chapter 7 from the book "Teplofikatsiya Moskvy"]

[Text] The development of Moscow's heating supply in the prewar years was based primarily upon a method of central heating that connected homes and public buildings to the heating networks of the Mosenergo system's heat and electric power station. At the same time, however, the heating supply in outlying districts far from the heat and electric power station was brought about by local boiler plants using various types of fuel. Such new settlements as Dubrovka and Dangauerovka and homes along Pochtovaya Street were initially served by local sources.

The rapid growth of home construction in the postwar period considerably outran the rate of development of district heating with its expensive pipelines. It was necessary to solve the problem of creating additional centralized supplies of heat. In Moscow in the period from 1950 to 1960, group and block boiler plants with modernized type DKV and DKVR steel and sectional cast iron boilers designed by the Central Scientific Research and Planning and Design Boiler and Turbine Institute imeni I. I. Polzunov were built by Glavmosstroy according to plans from Mosproyekt and Santekhproyekt in new block developments and in those areas not encompassed by the district heating supply. The group boiler plants had outputs of 3.5 to 11.6 MW (3-10 Gcal/h), while the block boiler plants had outputs of 11.6 to 60 MW (10-50 Gcal/h). A layout drawing of a group boiler plant with Universal-3, MG-2 and Energiya-3 sectional cast-iron boilers is shown in fig. 71.

The block boiler plants were initially made to operate on solid fuel and fuel oil. Beginning in 1955, however, they operated on natural gas. In a short period of time the number of such boiler plants reached several hundred, including about 80 with DKV boilers. The basic technical and economic indicators of standardized block boiler plant installations with DKVR boilers are shown in table 7.

At this same time, tests were conducted on two of the first high-output KV-3 and KV-6 water-heating boilers (3 and 6 Gcal/h), designed by the Biyskiy Boiler Plant to operate on solid fuel and gas.

The construction of group and block boiler plants was an important step in the centralization of heat supplies from a single source, possessing an output of up to 35 MW (30 Gcal/h) and serving a microdistrict with up to 150,000 m^2 of living space and up to 20,000 inhabitants.

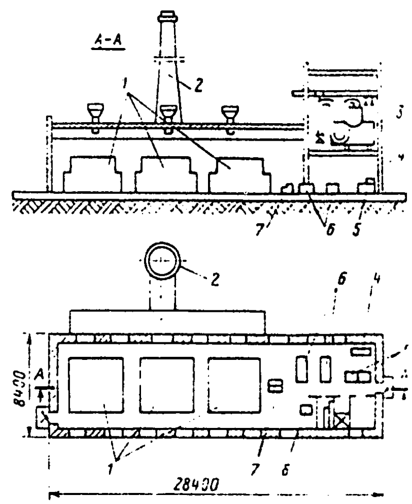


Fig. 71. Layout drawing of a group boiler plant with small cast-iron boilers

1 - Cast-iron water-heating boilers; 2 - Smokestack; 3 - Deaerator; 4 - Receiving and service tank; 5 - Pump for internal water supply; 6 - Pump for hot-water supply; 7 - Network pump; 8 - Panel for control and measuring instruments and automatic equipment.

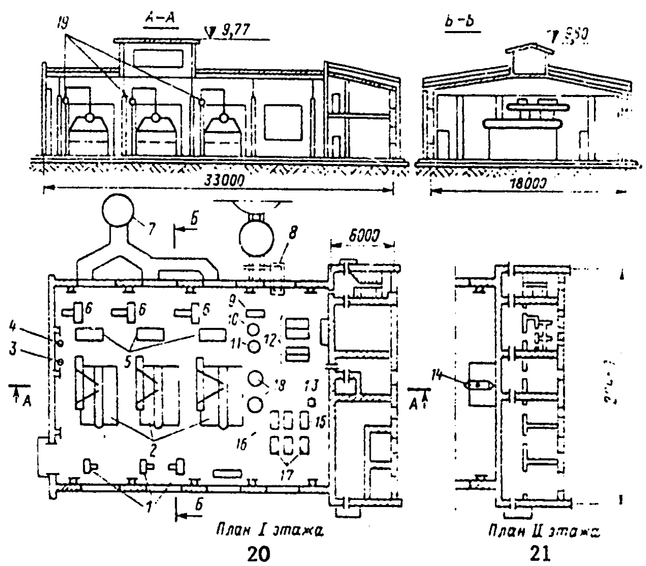


Fig. 72. Layout drawings of a standard block boiler plant with DKVR-type boilers

1 - Ventilators; 2 - Steam boilers; 3 - Continuous-drain separator; 4 - Refrigerator unit; 5 - Waste-gas heater; 6 - Exhaust fans; 7 - Smokestack; 8 - Salt-solution storage tank; 9, 12, 13, 15-17 - Acid, mains, condensate, feed-water, makeup-water and circuit-water pumps, respectively; 10 - Measuring tank; 11 - Salt-solution equipment; 14 - Deaerator tank; 18 - Sodium-cation filter; 19 - Steam-water heater; 20 - First-floor plan; 21 - Second-floor plan.

The technical, economic and qualitative indicators of heating supply had improved somewhat in comparison with decentralized heating supply from local home boilers, which at that time numbered about 8,000. By 1965 the scope of central heating supply in the housing and utilities sector had reached 35 percent.

Layout drawings of a typical block central-heating boiler plant with DKVR boilers are shown in fig. 72. The boiler room is laid out in a single interior space. Living and service quarters are located on two floors. The boiler room, transformer substation, control room, shop and living quarters are located within the building. A unique feature of this heating system is the modular construction of its main boiler and the application of central feed-water heaters. This has made it possible to simplify considerably the plant's layout and reduce its cost.

Such a method of centralizing heating supply, however, was unable to meet the ever growing demands of civic improvement and architecture. Large-scale centralization and the consolidation of heating supplies was still necessary. For this reason, starting in Moscow in 1960, large-scale district boiler and thermal electric power plants with outputs, initially, of 175 MW (150 Gcal/h) and, later, 230 and 460 MW (200 and 400 Gcal/h) began to be built in an effort to find an efficient and comprehensive solution to the questions of heating supply, gasification and the preparation of city districts for further central heating. Over a 10-year period, 19 district heating plants (RTS's) were built.

The concept of large-scale water-heating thermal power plants and the basic design decisions regarding them, as well as the creation of high-output peak-demand central heating boilers (type PTVM), were initially developed by the Moscow Engineering Institute of Urban Construction of the Moscow Municipal Executive Committee and the Scientific Research Institute of Power Engineering imeni G. M. Krzhizhanovskiy. The design development of the boilers and the thermal electric power stations was carried out by experts from the All-Union Thermal Engineering Institute imeni F. E. Dzerzhinskiy, the Orgenergostroy Institute and Mosproyekt-1.

All the best and advanced equipment in the field of heating supply built at this time found application in the district heating plants fitted with PTVM-50 and PTVM-100 boilers (designed by the All-Union Thermal Engineering Institute and Orgenergostroy in 1956-1958): high-output hot-water boilers and electronic and hydraulic governors, vacuum deaeration, powerful high-voltage equipment, automatic thermal station systems, etc.

The district heating plant building is laid out in the form of the letter H (fig. 73). The boiler room is situated parallel to the turbine room, and they are joined by a two-story connecting building. The control panel is installed on the first floor of the connecting building, while the engineering office and living quarters are on the second.

Water-heating boilers with their individual smokestacks are located in the boiler room. The boilers are gas-fired. In the turbine room, pump units are installed which circulate the water in the heating system (fig. 74). Make-up water for feeding the heating system is chemically softened and heat-treated to remove dissolved gases in it--oxygen and carbon dioxide. The water-treatment equipment occupies two floors at the end of the turbine room. Here are installed the sodium cation-exchange filters, tanks for the vacuum gas-separator (deaerator), the regenerating preheaters for the treated water and the pumping equipment.

At the other end of the turbine room provisions have been made for a large repair area with an electric overhead crane. A metal-working bench and machine tools make it possible for the personnel to eliminate troubles as they appear during operations, carry out preventive maintenance and adjust the equipment. Owing to the high reliability and quality of domestic equipment, such troubles rarely arise. Preventive maintenance and testing of the equipment is carried out once yearly--during the two-week summer shutdown of the thermal station.

On a compact control panel for the district heating plant, electronic instruments round the clock fix the operating parameters for the station, record the changes in operating conditions that take place and conduct automatic regulation and accounting of the power resources. The starting and stopping of any unit (boilers, pumps, gas regulators, mainlines, etc.) is carried out by remote control--by pushbutton.

The arrangement and composition of the equipment in the station is efficiently executed and well thought out. In addition, it is easily installed, serviced and repaired. This makes work totally safe and considerably easier for the personnel.

The layout of the district heating plant is shown in fig. 75, while an external view of the plant is depicted in fig. 76. Circuit water in the amount of 5,000 m^3/h flows from the discharge header in the turbine room through a conduit 800 mm in diameter to the PTVM-50 tower-type hot-water boilers. These boilers have an output of 58 MW (50 Gcal/h) each. The water heats up to 150°C in the water-walls and convective pipes, then proceeds along two hot-water feeder pipes to the thermal power consumers. Circuit water cooled by the consumers comes back through return pipes to the thermal power station. The temperature curve for the circuit water and the arrangement of consumer hook-ups are the same as for the release of heat from a heat-and-electric power plant.

On the basis of technical and economic calculations carried out by a number of urban organizations, Moscow was divided into three distinct zones according to the sources of the heating supply: a zone for combined heat-and-power supply, one for centralized heating and one for the gasification of local boiler plants. In order to accomplish this project, efficient zones of operation were established for the heating supply sources (heat-and-electric power plants, district heating plants, block heating plants and local heating sources). In addition, a suitable sequence for carrying out measures to change over existing boiler plants to gas and to eliminate some of the plants in connection with the hook-up of buildings to central-heating systems was implemented.

The basic prerequisites underlying the development of a zoning scheme for the capital were the maximum possible coverage of the centralized heating supply, the replacement, where possible, of solid fuel with natural gas and a reduction in the number of service personnel.

The city's zoning scheme provided for the construction of 14 district water-heating boiler plants in the period 1961-1965. These plants, with a total thermal output of 2,400 MW (2,100 Gcal/h), were built instead of 70 block steam plants. Taking into account the cost of heating system pipelines, this plan provided for savings in the amount of more than three million rubles. Provisions had also been made to convert about 1,400 small-scale boilers to gas and to eliminate up to 3,600 boiler units from heat-and-electric power plants and district boiler plants in the central

Fig. 73.

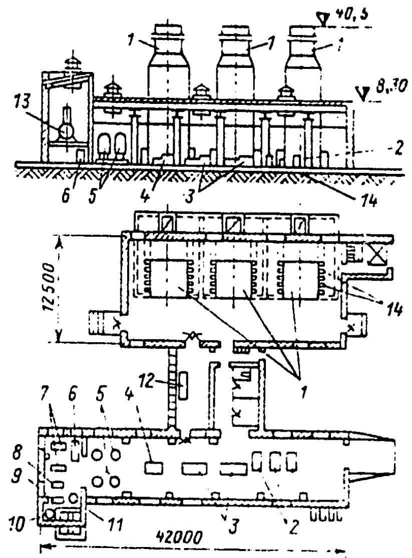


Fig. 75

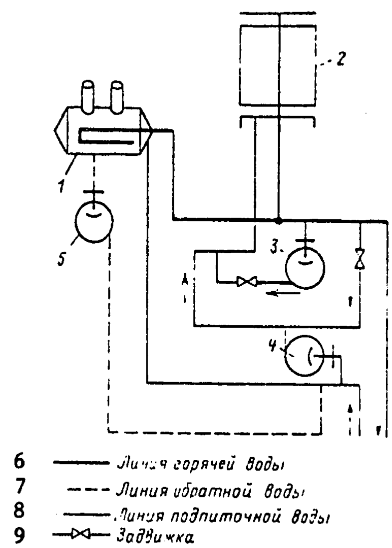


Fig. 73. Layout of district heating plant

1 - PTVM-50 boilers; 2-4, 7-9 - Recirculating, circuit-water, 12NDS centrifugal, makeup-water, 4K-18 centrifugal and acid pumps, respectively; 5 - Sodium-cation filter; 6 - Service tank; 10 - Measuring tank for dispensing salt; 11 - Salt-solution equipment; 12 - Control panel; 13 - Deaerator; 14 - Ventilators.

Fig. 75. Flow-chart for a district heating plant

1 - Deaerator; 2 - PTVM-50 boiler; 3-5 - Recirculating, circuit-water and makeup-water pumps, respectively; 6 - Hot-water line; 7 - Return-water line; 8 - Makeup-water line; 9 - Valve.

heating-supply zone. All of this has made it possible to replace more than five million tons of solid fuel in the city's power balance and free about 17 million hours of service personnel labor.

The particular features of improved central-heating systems that distinguish them from boiler units are: the high social and economic value of a central-heating supply in the day-to-day lives of the Soviet people; the harmony and synchronism, dynamism and continuity of industrial production, transportation and the demand for thermal power, which lend to these processes the nature of specific services to the population; the impracticality of accumulating significant quantities of thermal power, as a result of which it is necessary to hold back power and reserve fuel and power resources at the source in order to cover irregularities in the heating demand; and the considerable consumption of power and labor in heating supply processes. This rate of consumption exceeds the clearly defined commercial properties of these processes (the cost of fuel is 50-60 percent of the cost of heat, electric power amounts to 10-12 percent of the cost and depreciation amounts to 7-15 percent).

The variation in the cost structure of heat production as dependent upon the output of boiler units is illustrated in Table 8.

In Moscow at the beginning of the 1960's, a new branch of urban industry was added--district and new-construction centralized heating supply from large-scale district heating and block heating sources. Alongside the district heating supply from heat-and-electric power stations, this new sector developed in parallel and was formed into an independent industry. To a considerable degree this has been aided by the rapid growth of the urban gas industry and the growing share of gas in the fuel balance (50-70 percent).

A large group of talented scientists stood at the sources of district heating: C. F. Kop'yev, A. V. Khludov, M. M. Shchegolev, I. S. Myakishev, Yu. L. Gusev, I. V. Smekalin, Ye. Ya. Sokolov, N. I. Zhirnov and L. B. Krol', as well as a group of outstanding organizers of urban economy: I. M. Kolotyrkin, I. I. Chechel'nitskiy, N. N. Shamardin, V. V. Roshkov, et al.

Attaching great significance to the development of the fuel and power urban sectors, the Moscow City Soviet Executive Committee in 1958 created on its own staff the large Fuel and Power Services Administration (UTEKh) which comprised more than 10 organizations occupied with the city's power supply: the Mosgaz, Mosgazset'stroy, Mosgortopsnab and Mosgaztekhsnab trusts, the Mosgorsvet enterprise, the Mosgazproyekt Institute, the Mechanization and Vehicle Transportation Base, etc.--with about 15,000 workers.

Over 40,000 of the city's buildings at the present time are covered by the central heating supply. Out of this number, 33,500 buildings (76.6 percent of the city's heating needs) are apportioned to heat-and-electric power stations, while district and block heating plants cover 7,500 structures (16-17 percent). In the housing and utilities sector, 90 percent of the heating needs are covered.

Centralized heating supply along with extensive gasification has made it possible to improve considerably the city's public health status and has insured a high level of purity in the water basin. This is a distinctive characteristic of our capital in comparison to large cities in other countries. The purity of the city's water basin, the lack of smoke and smog, the absence of stored fuel and waste ash outside of residential buildings and the profusion of greenery and flowers have today become so accepted and natural for residents of Moscow and visitors to the capital that it is difficult even to imagine the picture of city life and the order of things that existed a few decades ago.

The growth in the number of boiler units has required that new solutions be found for the questions of organizing their operation as well as servicing the heat-transfer networks and the user installations.

During the period in which block heating plants were put into operation, they were turned over to and were serviced by the housing offices of various organizations and departments which, because of a lack of qualified specialists, engineering difficulties and the isolation of some departments, were unable to insure their reliable and competent operation. As a result, after a few years of operation the equipment in the thermal and boiler network began to malfunction often. This caused breaks and disruptions in the heating supply. In addition, the lack of a unified engineering policy during the construction of such installations and the inadequate quality of design, construction and installation work had a negative effect.

In 1961, therefore, the executive committee of Mossovet created the Board of Block Boiler and Thermal Networks on the staff of the Fuel and Power Services Administration. The Board had the rights of a self-sufficient enterprise. It initially included 50 block plants, then 20 district heating plants. In 1967 the Board was reorganized into the Teploenergiya trust. The results of the work done by the Board and the Teploenergiya trust proved to be extremely positive. Following the example of Moscow, specialized associations for the operation of boiler plants also began to be formed in other cities of our country. Now they are the basic organizational form of heating supply enterprise and are proving to be an ever-growing positive influence on the level of municipal services and the sanitary engineering status of the city.

As the thermal networks from urban heat-and-electric power plants and district heat plants grew, it became possible to make practical use of some district heating plants as reserve plants in the city's combined heat-and-power scheme. It also became possible to use them for joint parallel operations along common heating mains.

Since 1965 eight district heating plants have been connected to the mainlines of the Mosenergo thermal network, and five of them have become a part of the Mosenergo Thermal System. This has made it possible to provide heat to consumers without considerable losses or alterations and to create operational districts for Mosenergo on the basis of the district heating plants.

Beginning in 1975, connecting lines and couplings between the heating mains of the combined heat-and-power stations and the district heating plants have made it possible to transfer the summer thermal loads of many district heating plants to the combined heat-and-power plants of Mosenergo. Such a measure made it feasible to shut down district and block heating plants for the summertime period and to conserve considerable quantities (more than one million rubles) of fuel and power resources. This is how an efficient design for the city's combined heat-and-power system was realized and how one of the most urgent problems in fuel conservation was solved.

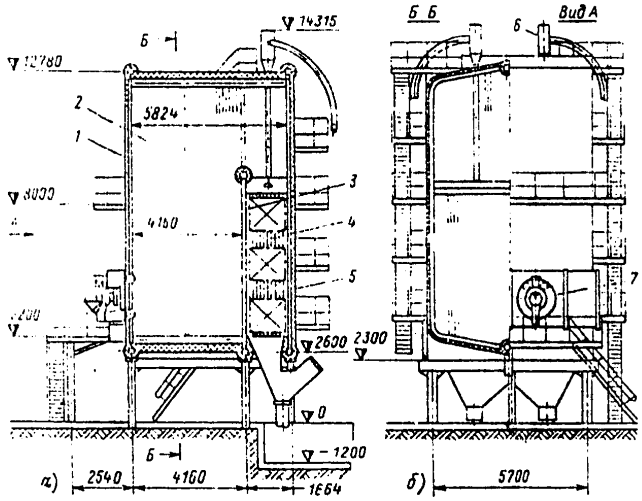


Fig. 77. Cross-section of KV-GM-50 boiler

1-3, 5 - Front, side, intermediate and rear walls, respectively; 4 - Convection cells; 6 - Shot-cleaning apparatus; 7 - Fuel-oil burner.

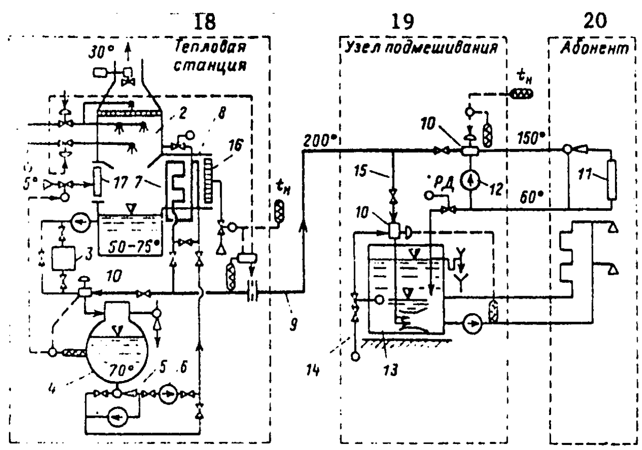


Fig. 78. Flow-chart for VKV-6 boilers, boiler-room equipment and high-temperature thermal network

1 - Water supply; 2 - Boiler scrubber; 3 - Water-softening equipment; 4 - Vacuum deaerator; 5 - Suction elevator; 6 - Circuit-water pump; 7 - Superheating tubes; 8 - Burner; 9 - Single-pipe main; 10 - Mixing apparatus; 11 - User heating systems; 12 - Mixing pump; 13 - Hot-water storage tank; 14 - Mains water; 15 - Circuit-water mix; 16 and 17 - Gas burners for winter and summer operation 18 - Heating plant; 19 - Mixing station; 20 - User.

Experience acquired during the operation of large-scale block and district heating plants with water-heating boilers made it possible at the beginning of the 1970's for planning and design organizations to develop a new series of water-heating boilers made to operate on gas or fuel-oil (type KV-GM) and on solid fuel (type KV-TS). Some of the specifications of type KV-GM water-heating boilers are shown in table 9, and the cross-section of a KV-GM-50 boiler is represented by fig. 77. The national economic impact due to the introduction of a single boiler amounts to: 84,000 rubles for the KV-GM-10, 39,000 rubles for the KV-GM-30. These boilers have been awarded the State quality stamp. New model designs for standardized water-heating boiler installations have been developed on the basis of such boilers.

At the beginning of 1979 there were 24 block and 20 district heating plants with a combined output of 6,000 MW (5,200 Gcal/h) in operation in the Teploenergiya trust. In order to transport this thermal power, 270 km of heating mains were laid. In addition, more than 450 central heating stations and 460 km of transfer and outdoor heating mains belong to and are operated by the trust.

Since 1967 the Moscow City Executive Committee has obliged the trust to render a new type of service--the adjustment and maintenance of air-conditioning and air-heating systems in public buildings. More than 500 such units have been built. Some of the Teploenergiya trust's technical and economic indicators are shown in table 10.

The trust's fixed production capital amounts to 120 million rubles. During the period in which the trust has been in operation (18 years), more than 58 million rubles have been accumulated and 50 million charged to depreciation. Thus, the city's capital investment in the thermal power industry has been repaid, taking into account those stations that had been taken out of service completely by 1975, that is, over a period of 10-12 years. This testifies to the high economy and profitability of district heating.

Rents are lower in the USSR in comparison with those in other countries, comprising only 4-5 percent of the family budget. Naturally, the capital obtained from this source cannot cover all expenditures for housing. Calculations of the RSFSR Ministry of Housing and Municipal Services have shown that rents in the republic average 1.5 rubles per m^2 of living space annually, although the state's expenditures, including major repairs, amount to 5 rubles 63 kopecks per m^2, which is almost four times as much.

A similar situation has arisen with regard to the payment for thermal power as used for residential heating and hot-water services. The cost to the population for heating 1 m^2 of living space comes to 0.9 rubles per year and hot water costs 7 rubles 20 kopecks per capita annually. These services, however, cost the state twice as much.

During the years in which the trust has been in operation, a great many scientific investigations have been carried out regarding the urgent questions of thermal engineering. In 1968, in an effort to study the engineering and operational questions involved with single-pipe once-through centralized heat supply using heat-carriers with improved parameters (180-200°C instead of 150°C), an experimental industrial installation based on a special VKV-6 water-heating water-tube and scrubber boiler was developed and put into service. It was gas-fired and had an output of 6 Gcal/h.

Table 7

Technical and Economic Indicators of Block Boiler Plants with DKVR Boilers

Indicator	Industrial central-heating boilers					
	Five boilers, DKVR-10 to 13	Four boilers, DKVR-10 to 13	Three boilers, DKVR-10 to 13	Two boilers, DKVR-10 to 13	Three boilers, DKVR-6, 5 to 13	Two boilers, DKVR-6, 5 to 13
Boiler unit efficiency, percent, when operating:						
on gas	91.3	91.3	91.3	91.3	90.2	90.2
on fuel-oil	88.9	88.9	88.9	88.9	88.8	88.8
Maximum hourly fuel consumption when operating:						
on gas, m^3/h	5650	4250	3390	2260	2200	1470
on fuel-oil, kg/h	5000	4000	3000	2000	1950	1300
Planned cost of the boiler unit, thousands of rubles	253.1	216.0	181.52	136.46	149.27	123.38
Construction cubage of boiler building, m^3	5538	4835	4266	3520	3588	3070
Specific building volume, m^3, per ton of steam produced	79.1	86.3	101.6	127.5	132.9	170.6
Specific construction cost, thousands of rubles, per ton of steam produced	4.12	4.49	4.99	5.84	6.53	8.37
Cost per ton of steam released, rubles, when operating:						
on gas (cost of gas at 15 rubles per 1000 m^3	1.46	1.47	1.48	1.55	1.59	1.71
on fuel-oil (cost of fuel-oil at 23 rubles per ton)	1.92	1.92	1.94	2.00	2.05	2.17

Table 8

Thermal power cost structure as it depends upon the type of system, percent

Type of system	Output, Gcal/h	Thermal power cost structure				Labor productivity, Gcal/man-year
		Fuel	Electric power	Water	Wages	
Home boiler units	0-1	30	12	0.4	35	300
Group boiler units	1-10	43-50	8-11	0.4	28-17	300-500
Block boiler units	10-50	55	10-12	0.6-15	11-12	1000-1200
District and central boiler units	50-300	55-70	10	1.0	8-4	3000-4000
Central heating from TETs	300 or more	65-70	2-5	1.0-1.5	3-5	8000-10000

It was built on the basis of the previously used standard twin-pipe closed network with a central heating station. The station's units were augmented with special equipment that insured operation according to a once-through design with water directly drawn at a maximum temperature of 200°C in the heating main.

The system indicated (fig. 78) was the first attempt in our country at the practical realization of the basic principles of once-through high-temperature heating supply (the hot-pipe system) and included a number of basically new solutions that insured its high economy. Operation of this system in 1968-1974 showed that the fuel savings reached 18-20 percent, the cost per unit of heat released decreased by 14-18 percent and the metal used in the system on the whole was reduced by a factor of two in comparison with twin-pipe central-heating systems based on surface-type boilers (PTVM, DKVR, etc.). The test has also confirmed the high reliability and simplicity of operation of the given system, the boiler and all the auxiliary equipment.

The block diagram for a single-pipe high-temperature heating supply using scrubber-type boilers is extremely promising and can be recommended for extensive introduction, particularly in those districts that do not have a combined heat-and-power supply.

The development and production of the Kvant-type TS-20 single-flow differential calorimeter, operating with an electromagnetic flowmeter, was a significant scientific and industrial achievement. This calorimeter is a measuring system, consisting of an electromagnetic flowmeter to determine the volumetric flow of the heat-carrier, platinum resistance thermometers to measure the temperatures of the direct and return flows and an automatic counting device.

Table 9

Specifications of water-heating boilers

Indicators	Boilers		
	KV-GM-10	KV-GM-20	KV-GM-30
Thermal productivity, Gcal/h	10	20	30
Working pressure, kg/cm^2	10-25	10-25	10-25
Water temperature, °C:			
at the inlet	70	70	70
at the outlet	150	150	150
Water flow, t/h	123.5	247	370
Temperature of exhaust gases during operation, °C:			
for fuel-oil	230	242	250
for gas	145	155	160
Gross efficiency during operation, percent:			
for fuel-oil	88.9	88	87.7
for gas	89.8	89	89.7
Boiler gas-line resistance during operation, kg/m^2:			
for fuel-oil	46	60	67
for gas	44	57	65
Resistance of air-box with burner, kg/m^2:	135	180	280
Hydraulic resistance of the boiler, kg/m^2:	1.5	2.2	1.9

Table 10

Technical and economic indicators of the Teploenergiya trust

Indicator	Years				
	1961	1965	1970	1975	1980 (plan)
Rated boiler output:					
MW	1025	3220	3880	5746	6821
(Gcal/h)	(883)	(2764)	(3332)	(4936)	(5860)
Thermal load:					
MW	582	1970	2840	4350	5704
(Gcal/h)	(500)	(1694)	(2434)	(3736)	(4900)
Release of thermal power:					
millions of GJ	2.22	19.5	27.3	38.1	50.3
(millions of Gcal)	(0.53)	(4.66)	(6.52)	(9.1)	(12.0)
Specific rates of consumption:					
fuel, kg/GJ	47.3	41.2	40.4	40.4	40.4
(kg/Gcal)	(198)	(173)	(168.8)	(169.8)	(168.5)
electric power, kWh/GJ	5.74	3.68	3.59	3.67	3.28
(kWh/Gcal)	(23.6)	(15.4)	(14.8)	(15.1)	(13.5)
water, m^3/GJ	0.2	0.14	0.093	0.092	0.085
(m^3/Gcal)	(0.85)	(0.6)	(0.39)	(0.38)	(0.35)
Cost:					
rubles/GJ	1.04	0.75	0.92	0.90	0.93
(rubles/Gcal)	(4.35)	(3.13)	(3.83)	(3.71)	(3.83)
Tariff:					
rubles/GJ	0.98	0.84	0.89	0.94	0.95
(rubles/Gcal)	(4.09)	(3.50)	(3.71)	(3.87)	(3.90)
Labor expenditure:					
man-hours/GJ	0.73	0.18	0.13	0.11	0.10
(man-hours/Gcal)	(3.02)	(0.74)	(0.52)	(0.45)	(0.40)

In addition to the TS-20, the single-flow differential calorimeter has been developed and is being readied for commercial production. It is designed for operation with a differential manometer and flowmeter. The economic impact from the introduction of these calorimeters amounts to more than 1.5 million rubles annually per 1,000 TS-20 units.

A successful solution was likewise found for the problem of regulating the combustion processes of gaseous fuel in the burners of water-heating and steam boilers. Simple and reliable gas-air ratio sensors have made it possible to optimize the burning process. This makes possible fuel savings of up to five percent.

In order to protect heating systems from internal and external metal corrosion, the Teploenergiya trust has developed an efficient and economical method of treating the water with a corrosion inhibitor (sodium silicate). An electrocathode method of protecting storage tanks through the use of cathode posts has also been developed. A new design for a prefabricated frame-end-panel stationary (fixed-foot) industrial support for heating network mains has been invented and developed.In an effort to save fuel and power resources, efficient methods of centrally regulating the release of thermal power have been developed and successfully introduced.

In recent years a coordinated and highly qualified collective of workers capable of solving any problem in the heating supply field has been formed within the trust.

The collective of the Teploenergiya trust has often placed (12 times) in socialist competition among RSFSR thermal engineering establishments and has been noted with testimonials from the Moscow City Party Committee, the Moscow City Soviet Executive Committee, the Moscow City Council of Trade Unions and the Moscow City Committee of the All-Union Lenin Young Communist League.

Complex and demanding tasks have been put before the trust in the 10th Five-Year Plan, now under way. They have been determined by the resolutions of the 25th CPSU Congress and the new General Plan for the Development and Reconstruction of Moscow, the main task of which is the transformation of our capital into a model communist city. The tasks are, first of all, the increase in the efficiency of production by raising the qualitative level of operation of all heat-supply installations, the further closing of unprofitable small-scale residential and block boiler installations, the raising of the city's level of centralized heating to 95 percent and the efficient utilization of material, power and labor resources and capacities. This dictates the further automation of all heating-supply processes, beginning with production and ending with the distribution of thermal power along user systems. It also means the introduction of automated control systems, the mechanization of labor-intensive repair operations and the creation of repair and industrial bases.

The city's centralized heat supply has today become an integral part of Soviet combined heat-and-power supply and power engineering--an integral part and the logical continuation of the GOELRO plan.

9512
CSO: 1822

FUELS

RULES FOR CATEGORIZING OIL, GAS RESERVES EXPLAINED

Moscow PROMYSHLENNAYA OTSENKA MESTOROZHDENIY NEFTI I GAZA [Industrial Evaluation of Oil and Gas Fields] in Russian 1975 pp 21-30

[Sections 2 & 3 of book by F. A. Grishin]

[Text] §2. Listing the Types of Oil and Gas Reserves

In accordance with the historically existing sequence of the detection, preparation and utilization of any type of mineral raw material (including oil and gas), the original potential resources of this raw material have been explored only partially up to the present. A portion of them have already been extracted and consumed. Because of this, it is logical to subdivide the original potential resources into accumulated recovery (the extracted resources) and current potential resources (or resources in the ground).

According to the definition given in "Metodicheskoye rukovodstvo po kolichestvennoy otsenke perspektiv neftegazonosnosti" [Methodological Guidance for the Quantitative Evaluation of Prospects for the Presence of Oil and Gas] [56]*, the original potential resources are, "...the total amount of recoverable reserves of oil and gas that were contained in known fields prior to the start of development, as well as the prospective reserves and a quantitative evaluation of predictions of the presence of oil and gas, that is, the sum of already extracted crude oil, the explored reserves (categories A + B + C_1), the prospective reserves (Category C_2), and a predictive evaluation (group D).

"These are the resources of oil and gas that have been confined in the enclosing rocks and have accumulated there as a result of geological and geochemical processes that occur in the earth's crust."

The accumulated recovery is that portion of the original potential resources that has been brought to the surface and has either been prepared for use or has already been used. With respect to oil and gas, accumulated recovery includes the total recovery of oil or gas obtained, starting from the moment of the first commercial flow until a definite date, as of which some calculation is being made that is associated with the necessity to use data about accumulated recovery.

*These definitions are identical to those cited in a work by I. Kh. Abrikosov, I. P. Zhabrev and M. V. Feygin (NEFTEGAZOVAYA GEOLOGIYA I GEOFIZIKA [Oil and Gas Geology and Geophysics], No 6, 1973).

The share of useful minerals that remain (or that remain as of that date) in the ground are the current potential resources.

Current potential resources, according to, "Methodological Guidance for the Quantitative Evaluation of Prospects for the Presence of Oil and Gas" [56], "...are a total quantitative evaluation of the oil and gas that are contained in sources for the recovery of oil and gas that are now known (explored, developed and so on) and those that are hypothesized as possible for future discovery and use. In regions where oil and gas has not been recovered, the original and the current potential resources will be identical. Quantitative evaluations of potential resources are not permanent but are reexamined periodically as notions change about the geological conditions for the accumulation and preservation of hydrocarbon deposits.

"Potential resources (current potential resources--F.G.) amalgamate two large and sharply different groups of reserves. The first includes reserves already explored and drawn to a great extent into development, while the second includes reserves that are only hypothetical and forecast for some region on the basis of existing geological and geophysical data and prevailing notions about geological structure and the presence of oil and gas.

"The fact that the presence of oil and gas has been established in an area (that is, fields have been discovered) is that basic boundary that should divide the groups of reserves being examined. In the modern classification of reserves, that boundary occurs within category C_2, dividing the hypothetical but more reliable reserves within fields and deposits already discovered from the less reliable reserves of structures that have promise for oil and gas and that have been prepared for deep drilling."

Current potential reserves can, in accordance with the cited definition, be subdivided into explored and hypothetical reserves.

The group of explored reserves include those reserves that have been discovered with some degree of reliability as a result of studies and geological exploration conducted and that have been basically prepared for later development or verification. Explored reserves are the natural base for the functioning of modern oil and gas fields.

The explored reserve is complicated in structure. This is occasioned primarily by the fact that not all explored reserves can be extracted from the ground rationally, given the contemporary development of science and technology. The latter factor necessitates that, based on the national-economic significance of explored reserves, they be divided into: a) feasible reserves--"the development of which at present is economically feasible" [38 and 73]; and b) unfeasible reserves--"the development of which at present is unprofitable but which can be viewed as a later target of industrial mastery" [38 and 73]. The unprofitability of developing unfeasible reserves is determined in particular by low quality of the oil and gas, special complexity of operating conditions or the insignificant size of the deposits, and so on.

Since the exploitation of oil and gas fields at a given stage of scientific and technical development does not provide for 100-percent recovery of the feasible reserves of oil and gas from the ground, these reserves are subdivided into recoverable reserves, "which can be recovered with the most complete and rational use of modern equipment and technology" [38 and 73], and nonrecoverable reserves, which cannot be recovered rationally by modern, advanced methods.

In the United States of America and certain other countries, recoverable reserves are sometimes subdivided into "primary reserves," which are recoverable only through the primary (natural) conditions of development, and "secondary reserves," which are extracted additionally through reservoir stimulation methods. This specific of accounting for commerical reserves in these countries is occasioned by the application of secondary methods of recovery in the later stages of development, when the reserves that are recoverable through the natural (primary) conditions have already been practically recovered. In the Soviet Union, because of the wide introduction of formation-pressure maintenance methods at an early state of development, such a categorization is difficult.

Feasible and recoverable reserves of oil and gas (and also of their accompanying components) are subdivided, as to the time they are brought to the surface, into: initial reserves, the reserves that existed in the deposit (or field) prior to the start of development, the accumulated recovery of oil or gas as of a certain date, and residual reserves, which comprise, on that corresponding date, the difference between the initial reserves and the accumulated recovery.

In accordance with "Instructions on Application of the Classification of Reserves to Fields of Oil and Fuel Gas" [38 and 73], in addition to the explored (categorized) reserves of oil, fuel gas and the accompanying components contained therein, which are calculated by individual field and area, hypothetical reserves, which the "Methodological Guidance for the Quantitative Evaluation of Prospects for the Presence of Oil and Gas" recommends be called a predictive evaluation of oil and gas [56], are defined, for purposes of evaluating the potential possibilities of the presence of oil and gas in provinces, regions and districts, on the basis of common geological notions.

In accordance with the above-indicated methodological guidance, the predictive evaluation of oil and gas is taken to mean a quantitative evaluation of the promise of the presence of oil and gas in lithological and stratigraphic complexes or in individual horizons, which is made on the basis of an analysis of the geological criteria for the presence of oil and gas.

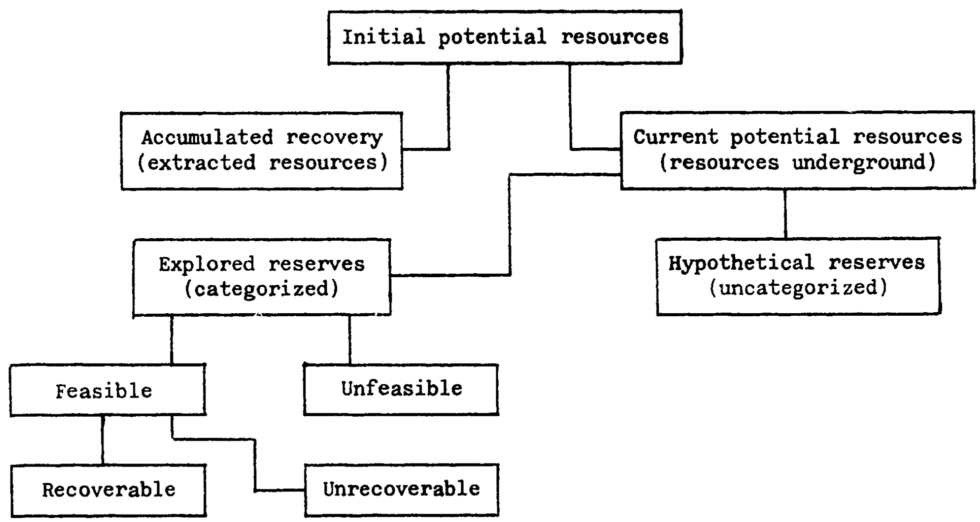
The evaluation of oil and gas is divided into two groups--D_1 and D_2, according to the extent of geological and geophysical study of the predicted territories.

It is proposed that the fact of establishment of the presence of oil and gas in a certain lithologic and stratigraphic complex within a major tectonic shape--a structure of the first rank--be considered as the main criterion for subdividing the predictive evaluation. Such structures include: domes, large swells, complex swells, troughs and small elongated depressions, as well as rim troughs and foretroughs, intermontane depressions and others. The following definition and criterion for subdividing the predictive evaluation into subgroups D_1 and D_2 were recommended on that basis.

Subgroup D_1 is the predictive evaluation of oil and gas of lithologic and stratigraphic complexes within which the presence of oil and gas has been proved for a large tectonic shape--a first-rank structure. Subgroup D_1 is the predictive evaluation of oil and gas deposits that can be contained in the following traps:

Table 4

Listing of Types of Oil and Gas Reserves



1. Structural traps that have been: a) prepared for deep drilling, whose reserves cannot be assigned to category C_2; b) discovered from the data of geological and geophysical research; and v) presumed on the basis of the consistency and the relationships in the distribution of local uplifts at adjacent well-studied (reference) territories.

2. Lithologic and stratigraphic traps that have been: a) marked out according to the data of geological and geophysical research carried out in the predicted territory; and b) presumed on the basis of analogy with well-studied (reference) territories within which the presence of oil and gas has been established for this type of trap.

Subgroup D_2 is the predictive evaluation of oil and gas that has been calculated for lithologic and stratigraphic complexes, within which the presence of oil and gas has been established at large tectonic features (first-rank structures) that are similar in geological structure, and also for individual suites in territories within which the presence of oil and gas has been proved but cannot be included in subgroup D_1 because of the lesser amount of study conducted. Subgroup D_2 should include the predictive evaluation of oil and gas deposits in the following territories:

1. In large tectonic shapes (first-rank structures) in which the presence of oil or gas has been proved, when it is impossible to include them in subgroup D_1: in lithologic and stratigraphic complexes that may be oil and gas bearing but whose productiveness still has not been established on the date of the calculation; b) in regionally productive lithologic and stratigraphic complexes that are buried much deeper than is exposed by drilling; and v) in zones of the regional distribution of lithologic and stratigraphic traps for which the presence of oil and gas is presumed.

APPROVED FOR RELEASE: 2007/02/08: CIA-RDP82-00850R000300060016-5

2. In districts presumed to be oil or gas bearing, subgroup D_2 should include a predictive evaluation for the presence of oil or gas that is calculated for lithologic and stratigraphic complexes that have not yet proved to be oil or gas bearing within the given major tectonic feature but which are presumed to be so on the basis of the similarity of their geological structure and development with well-studied analogous tectonic features that have been proved to be oil or gas bearing.

A qualitative evaluation of the presence of oil and gas is made where substantiated data for a quantitative evaluation is absent. The general scheme for the listing of types of reserves is shown in table 4.

§3. The Categorization of Reserves and the Basic Requirements for Exploring and Studying Oil and Gas Deposits.

In accordance with the modern classification of reserves of fields of oil and fuel gas, the explored reserves of oil and gas and the accompanying components thereof are subdivided as to extent of their exploration and study into four categories--A, B, C_1 and C_2, which are defined as follows.*

Category A includes the reserves of a deposit (or a portion of it) that has been studied with a comprehensiveness that provides for complete determination of the shapes and dimensions of the deposit, the thickness of it that is effective and saturated with oil and gas, the nature of change in reservoir properties and in the degree of oil and gas saturation of the pay zones, the qualitative and quantitative composition of the crude oil, fuel gas and the accompanying components contained therein, and other parameters, as well as the main characteristics of the deposit upon which the conditions for its development depend--the deposit's production mechanism, well productivity, pressure, permeability of the reservoir rocks, hydrodynamic conductibility, piezodiffusivity coefficient, and other characteristics.

Category A reserves are calculated while the deposit is being developed. They should be studied in detail by means of exploratory and production wells drilled over the whole area of the deposit in the grid that is adopted in accordance with the development plan. The borders of the category A reserves are reliably defined in this case by establishing the deposit's outline. For a deposit whose drilling over by development wells has not been completed, the category A reserves are calculated within that portion of it that has been completely drilled over in accordance with the plan for drilling production wells that yield commercial flows of oil or gas.

At an area where Category A reserves are being calculated, the following should be studied in detail and defined reliably:

1) the dimensions and shape of the deposit; where the oil and gas containing strata are broken up--the location of the tectonic dislocations and their amplitude (the shape and dimensions of each tectonic block); for traps of the

*The prerequisites for designating reserves and the basic requirements for studying them are cited below in accordance with "The Classification of the Reserves of Oil and Fuel Gas Fields," and "Instructions on the Application of Classification of Reserves to Oil and Fuel Gas Fields" [38 and 73].

lithologic and stratigraphic types--the borders of the lensing out and the displacement and covering over of permeable by impermeable rocks;

2) the consistency of change in area and cross-section of the lithological characteristics of the pay zone--its material composition, the thickness of it that is effective and saturated with oil and gas, its reservoir characteristics (effective porosity and permeability) and the degree of its saturation with oil and gas;

3) the geophysical criteria for evaluating the productiveness of the strata, which are correlated with test-core data, as well as the lower limits of the porosity and permeability of the oil and gas yielding rocks (taking their granulometric composition and carbon content into account);

4) the initial and current flow rates for oil and water, the initial and current operating flow rates of free gas and the condensate and helium content thereof, as well as change of the condensate content with time (as a function of the change of formation pressure), the productiveness coefficients of the wells, and the values of the initial formation pressures, saturation pressure and gas factors, and changes thereof with time;

5) the quality of the oil, gas, condensate and water and the content of the components that accompany them;

6) change with time of the flow rates of the oil, gas and water, the positions of the oil-water and gas-water contacts, the boundaries of the presence of oil and gas, and the formation pressure;

7) the total recovery of oil, gas, condensate and water by well and by stratum;

8) hydrogeological conditions--the hydrodynamic tie of individual pay zones and tectonic blocks, the upper-level location of the gas, oil and water contacts, and the natural reservoir drive of the deposit; and

9) the most effective methods of stimulating the stratum and the deposit during its development.

Category B includes the reserves of a deposit (or a portion of it) at which the presence of oil and gas has been established, based upon the reception of commercial flows of oil or fuel gas in wells at various hypsometric control points and on the existence of favorable oilfield-geophysics data and coring. The shape and dimensions of the deposit, the thickness of it that is effective and is saturated with oil and gas, the nature of the change of reservoir properties, the degree of saturation of the productive strata with oil and gas, and other parameters, as well as the main characteristics that determine the prerequisites for developing the deposit, have been studied roughly but to a degree that is adequate for planning development of the deposit; and the composition of the oil, fuel, gas and accompanying components contained therein under reservoir conditions and surface conditions have been studied in detail. For oil deposits, sampling has been conducted at individual wells. For gas deposits, the absence of an oily shoestring has been established or its commercial value has been defined.

With fulfillment of the indicated conditions for a group 1* deposit (or field) and the reception of commercial flows of oil or gas from at least three wells situated in different parts of the deposit, the reserves that are calculated in the contour of the isohypse that corresponds to the lower control point of the stratum from which commercial flows of waterfree oil or gas have been obtained from the wells are included in category B. For a deposit (or field), the reserves that have been computed for an area outlined by wells that yielded commercial flows of waterfree or or gas are included in category B.

At an area at which category B reserves are computed according to the data of prospecting and exploratory wells, the following should be studied and established to an extent adequate for planning development:

1) the location of the pay zone in the log and the degree of its consistency throughout the area, and the location of tectonic discontinuities and their amplitudes;

2) the lithologic peculiarities of the pay zone--its material makeup, the overall thickness that is effective and is saturated with oil or gas, the reservoir properties of the rocks that make up the stratum (effective porosity and permeability), the degree of oil and gas saturation, and the natures of changes thereof by area and by cross-section;

3) the upper-level location of the gas-oil-water contacts, according to sampling data and taking oilfield-geophysics data into account;

4) the quality of the oil, gas, condensate, water and accompanying components contained therein;

5) according to the data from sampling wells that have been drilled through and from sampling at individual wells--initial and current flow rates for oil and water, initial operating (optimal) flow rates of gas, well-flow indicators, initial and current formation pressures, saturation pressures, and gas factors; and

6) hydrogeological conditions and the natural reservoir drive.

The reserves of deposits for which the presence of oil and gas has been established, based upon commercial flows of oil or gas fuels in individual wells (a portion of the wells can be sampled by formation tester) and on favorable oilfield-geophysics data at a number of other wells, as well as the reserves of a portion of a deposit (or of a tectonic block) that is adjacent to areas with reserves of higher categories, are included in category C_1.

The modes of occurrence of oil or fuel gases have been established by geological and geophysical research methods that have been verified for the given region, and the reservoir properties of the pay zone and other parameters have been studied for various wells or have been adopted because of similarity to a better studied portion of the deposit and to nearby fields that have been explored.

*This concerns the complexity group of the geological structure of the deposit (or field).

In order to assign a category C_1 rating to the reserves of newly discovered deposits, an evaluation of the reserves of which is given only under this category, it is necessary to study and establish:

1) the construction and dimensions of the structure, the location of the pay zones in the log for individual wells, and the lithological characteristics--the material composition of the stratum, and the thickness, porosity, permeability and degree of oil and gas saturation of the pay zone;

2) the actual daily flow rates for the wells' oil and gas, and the productiveness indicators;

3) the upper-level location of oil-water, oil-gas and gas-water contacts;

4) data about formation pressures, the saturation pressures of the oil, and the condensation pressures of formation gas;

5) quality of the oil, condensate and gas and of the accompanying components contained therein; and

6) hydrogeological conditions and the reservoir drive, according to data from studying the wells or the data of similar well-studied neighboring fields.

The boundaries of the presence of oil and gas of a deposit are made in accordance with the results of well sampling and oilfield-geophysics research data, taking the geological construction of the structure into account.

For category C_1 reserves that are computed for blocks and fields directly adjacent to areas with reserves of higher categories, the size of the extrapolation zone is determined on the basis of common geological-structure constructions, taking into account the consistency of the lithological composition and the reservoir characteristics of the pay zones up to a reliably established external oil-gas-water boundary, or by no more than a doubling of the distance between production wells that is called for by the development plan or by a temporary operating scheme for development.

C_2 category reserves include oil and fuel gas whose existence is presumed, based on favorable geological and geophysical data, in individual unexplored fields and in tectonic blocks and strata of fields that have been studied, as well as the reserves of new structures (within known oil and gas bearing regions) outlined by methods of geological and geophysical research that have been proven for the given region.

For new structures, oil and gas reserves can be assigned to category C_2 if they meet the following conditions:

1) the existence of a structure, and its general outlines have been established by geological and geophysical research methods that are reliable for the given district, or, within a district, the degree of confirmability of the dimensions and shapes of these structures has been established by data from deep drilling;

2) the presence of reservoirs that are overlain by impermeable rocks is presumed on the basis of a structure-facies analysis of the district, and, in individual cases, in accordance with drilling data;

3) the possibility of reservoirs with commercial saturations of oil or gas and the coefficient of filling of structures by oil or gas are substantiated by analogy with fields that have been studied, based upon an analysis of conditions for the formation of oil or gas deposits within the given structure-facies zone;

4) are in areas within which oil and gas flows have been obtained by means of formation testers alone during well drilling; and

5) a computation of reserves has been made for individual strata, the commercial productiveness of which has been established at other fields that have already been studied, are analogous in geological structure, and are within the structure-facies zone of a given oil or gas bearing province.

Category C_2 reserves are calculated for oil and gas fields with established reserves in higher categories:

1) for pay zones--at sections that show promise, and for tectonic blocks that are adjacent to areas with reserves evaluated for higher categories;

2) for drilled-in strata that are presumed to be oil or gas bearing in accordance with the data of oilfield-geophysics studies; and

3) for strata not drilled in, whose productiveness is determined by analogy with neighboring well-studied fields.

In calculating category C_2 oil and gas reserves, it is necessary to substantiate:

a) the boundaries of the presence of oil and gas, which determine the area of computation, by an analysis of the geological structural conditions of deposition and the lithological features of the stratum; and

b) the thickness saturated with oil and gas, and the porosity and other calculated parameters at new structures, using data from studied fields that are similar in geological structure, and taking into account the consistency of the tectonic structure and change in facies in the territory of the structure-facies zone within which the given structure is located; at fields already known--by analogy with sections of those fields that have been studied, taking into account the consistencies of tectonic structure that have been found and changes in the lithological composition of the rock.

Gas reserves should be computed by component [37].

11409
CSO: 8144/0126

END