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USSR REPORT

ENERGY

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EUROPE'S FUEL, POWER CONSUMPTION STRUCTURE FORECAST

Moscow GAZOVAYA PROMYSHLENNOST' in Russian No 3, Mar 83 pp 44-45

[Article by S. I. Maysuradze (VNIIEgazprom [All-Union Scientific-Research Institute for the Economics and Organization of Production and Technical and Economics Research in the Gas Industry]): "Peculiarities in Developing the Fuel and Power Consumption Structure for the Countries of the European Region"*]

[Text] An analysis of the peculiarities of developing the fuel and power consumption structure for the countries of socialist collaboration enables the conclusion to be drawn that questions of the effective development of fuel and power consumption and the forming of an optimal structure for it can be solved successfully only on the basis of multilateral collaboration.

The fuel and power activity of CEMA member countries is being developed on a planned basis. The bases of the planning are scientifically substantiated forecasts that are being developed by specialists of the collaborating countries that take into account the characteristic trends of the modern and long-range development of the fuel and power activity of the industrially developed capitalist countries, particularly those of Western Europe. The necessity for considering these trends is determined by the weighty share of CEMA member countries in the production of fuel and power in Europe (table 1), and also by the intensifying interaction of the countries of socialist collaboration with West European countries in various areas of economics, including the power-engineering sphere.

The Development of Power Consumption in Western Europe.

One of the most important indicators of the state of development of the fuel and power activity is the production of fuel and power per capita. According to available data, in the CEMA countries in 1980 this indicator was ~5.3 tons of standard fuel equivalent per person, at a time when it was ~2.4 tons of standard fuel equivalent per person in the EEC countries.

*This is the beginning. The continuation is in the next issue.

Table 1

The Share of CEMA Member Countries* in Fuel and Power Production in Europe

Fuel	1965	1973	1980
Coal.................	60	69.4	71.2
Oil..................	91.5	97.7	83
Natural and casing-head gas...........	87.7	66.6	71.7
Electricity..........	23.3	29.2	31.3

*Bulgaria, Hungary, the GDR, Poland, Romania, Czechoslovakia and the USSR

Another most important indicator of development of the fuel and power activity is the structure of fuel and power consumption. The data shown in table 2 testify to the fact that total power consumption in Western Europe more than doubled during 1960-1980. In so doing, the highest rate of growth of power consumption in the region--more than 5 percent per year--was observed in 1960-1973.

Table 2

Structure of Fuel and Power Consumption in Western Europe

Indicators	1960	1965	1973	1980
Total power consumption, millions of tons of standard fuel equivalent.....................	898	1,164.4	1722.5	1826.1
Power consumption (in percent) through the use of:				
Coal, including brown coal.................	59	44	23	22
Oil....................................	35.1	44	59	52
Natural gas.............................	1.6	2	10	14
Hydropower and nuclear energy..............	4.3	10	8	11

The increase in the share of oil and gas in the fuel and power consumption structure is explained by a number of factors. These should include, primarily, the high customer characteristics of oil and gas for various branches of industry, agriculture and the household sector. Moreover, expenditures for the recovery of oil and natural gas are less than for the mining of coal in an amount that would be the equivalent in calorific value.

The competition among the oil, coal and power monopolies has promoted the intensive use of oil and gas for fuel and power in the industrially developed capitalist countries, as a result of which the coal industry has proved to be practically paralyzed. The buildup in every possible way of deliveries of oil from the developing countries has exerted a great influence on change in the structure of fuel and power consumption in Western Europe by increasing oil's share.

Thus, the structure of fuel and power consumption that prevailed in West European countries by 1973 put them into economic and power dependence upon oil deliveries.

The decision that the countries that export oil adopted in 1973--to reduce the amounts of export of this energy-bearer and to greatly increase prices for this fuel and raw material--caught the West European countries unawares. Their own fuel and power base, the development of which prior to 1973 was deliberately held back, proved to be in no position to meet the economy's demands for fuel and power. In 1973 a fuel and power crisis broke out in West European countries. Fuel and power consumption entered a period of slowed growth. Its pace, as can be seen in table 2, was reduced by about 2-2.5 percent per year, and in 1980 the total amount of fuel and power consumption in West Europe was ~12.8 billion tons of standard fuel equivalent.

After 1973 even the structure of fuel and power consumption in West European countries underwent appreciable changes. The following trends have been traced in its development during 1973-1980:

a reduction in the share of oil (from 59 to 52 percent);

a substantial slowing of the reduction of coal's share (from 23 to 22 percent);

growth in the share of hydropower and nuclear power (from 8 to 11 percent); and

an increase in the share of natural gas from 10 to 14 percent).

In speaking about the prospects for fuel and power consumption in Western Europe, let us note that, according to available data, its moderate pace will, in all probability, be maintained. The pace of growth in power consumption in the area will be increased in 1980-2000, as will total fuel and power consumption. In all probability, the share of oil in power consumption will be reduced considerably, and the share of coal will be increased. The pace of development of nuclear power will be the greatest of all branches of the fuel and power complex. The share of hydropower and of nuclear power during the period being examined will increase substantially. The share of natural gas will hardly change. In so doing, the absolute amount of gas consumption will grow constantly.

The reduction in the long term in oil's share in the fuel and power consumption structure in Western Europe was occasioned by the limited reserves of this energy bearer in the region, and also by the striving to reduce imports of it when world prices for this fuel and raw material were growing.

The trend toward an increase in the share of coal in the power-consumption structure during 1980-2000 is determined by the fact that, during the indicated period, it is planned to use coal more widely as a fuel in various branches of industry instead of the increasingly scarce oil and natural gas. With a view to reducing consumption of the latter, it is planned that the share of hydropower and nuclear power in the consumption structure will grow in 1980-2000. This is connected with the striving of West European countries to use the indicated energy resources as basic power resources, thereby reducing the consumption of oil and natural gas in power engineering.

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OIL AND GAS

COUNCIL RECOMMENDS STEPS TO IMPROVE MONITORING TESTS AT ACTIVE GAS FIELDS

Moscow GAZOVAYA PROMYSHLENNOST' in Russian No 3, Mar 83 p 23

[Report of Geological Section of Mingazprom [Ministry of Gas Industry] Scientific and Technical Council: "OPE and the Development of Gas Fields--Monitoring Systems"]

[Text] The wide use of industrial-test operation (OPE) has enabled the accelerated introduction into development of a large number of gas fields in areas where there is a developed trunk gas-pipeline system and increased effectiveness in the exploration of these fields.

The successful execution of OPE as a method for exploring gas fields and for speeding up their industrial conquest and subsequent rational development depends greatly upon the effectiveness of the set of measures for developing the fields.

In recent years, the geophysical and downhole gas-hydrodynamic, gas-condensate and hydrogeological study of operating wells and of key holes has been greatly developed. The results of this integrated research are enabling many problems of field geology to be solved and effective monitoring to be executed over both OPE and development of the gas fields.

The following types of work are being done under the program for implementing the system for monitoring OPE and development that has been created at the fields: observation of the dynamic formation pressure; an accounting, well by well, of the amounts of gas withdrawn; identification and tracking of the working intervals in producing wells; monitoring the advance of the gas-water contact; hydrochemical monitoring of the water in the wells' product; determination of the location of the water-ingress intervals; discovery of interformation crossflows of gas and monitoring over the constituent composition of the gas; evaluation of the technical condition of the wells; and so on.

With a view to generalizing the experience that has been gained and to developing recommendations for improving the complex of field-geology observations, the Scientific and Technical Council's section on "Raising the Effectiveness of Geological Work and of Geophysical Methods for Studying Holes," examined the matter of the status of the system for monitoring the conduct of OPE and development of the industry's gas fields.

Reports were heard about the status of: industrial test operation of gas and gas-condensate deposits and ways for improving the operation; hydrochemical, gas-condensate and gravimetric research during the development of gas fields; and systems for monitoring the conduct of OPE and the development of gas-condensate fields of the European part of the USSR, Central Asia and the northern regions of Tyumen Oblast and Yakutia.

The Scientific and Technical Council noted that in recent years Mingazprom has created and strengthened considerably the gas-field geophysical service, which is carrying out geophysical and downhole gas-hydrodynamic research of development wells. The results of the geophysical research of the wells (GIS) will enable the resolution of field-geology tasks of monitoring development of the fields. Special methods for monitoring the development of gas fields have been created. Industrial acceptance of the gravimetric method of control is going on successfully.

In all gas-recovery regions there has existed and there exists a service, based mainly at VNIIgaz [All-Union Scientific-Research Institute for Natural Gases] and the industry's institutes, which is executing a set of gas-hydrodynamic, gas-condensate, gas-analysis and hydrogeological studies.

The trust Soyuzgazgeofizika [All-Union Trust for Geophysical Work for the Gas Industry] and its subunits, VNIIgaz and its test plant, the VNPO Soyuzgazavtomatika [All-Union Science and Production Association for Automation of the Gas Industry], and SevKavNIIgaz [North Caucasus Scientific-Research Institute for the Gas Industry] are improving the equipment and standard procedures for research; samplers, level gages, lubricating devices for sealing well mouths, thermal flow meters, and so on have been developed and introduced; and the manufacture of nonstandard apparatus and equipment in small series has begun.

Along with this, the section is paying attention to the fact that research on monitoring OPE and the development of the fields is not being performed in an adequate amount. This has been caused, on the one hand, by an underestimation by gas-recovery and gas-transport associations of the value of monitoring to the maximum the recovery of gas and condensate from the ground, and, on the other, by inadequate effectiveness of the research. The system for monitoring development that is recommended in the designs often is not being fully implemented at the fields.

Further growth in the amount of research on the monitoring of OPE and development of the fields is being hindered by the poor state of supply of downhole and surface apparatus and also of equipment of the appropriate classes of precision and reliability. Major difficulties arise in organizing monitoring of the development of fields whose gas contains aggressive components.

Specialists engaged in monitoring OPE and the development of fields are not adequately trained to do this work. Positive experience in monitoring the development of oilfields is not being used adequately.

After hearing and discussing all the reports and speeches, the Scientific and Technical Council recommended:

that the positive experience of VNIIgaz and Soyuzgazgeofizika Trust in developing and using a set of geophysical and downhole gas-hydrodynamic, gas-condensate and hydrogeological research for existing development wells be approved;

that the downhole instruments, apparatus and equipment developed and manufactured by Soyuzgazgeofizika, the VNPO Soyuzgazavtomatika, VNIIgaz and SevKavNIIgaz for monitoring OPE and the development of gas fields be introduced widely at the industry's gas-recovery enterprises;

that it be noted that serious deficiencies are occurring at some gas-recovery associations in the organization and conduct of monitoring of OPE and the development of fields;

that VNIIgaz develop in 1983 instructional material that will regulate the work of monitoring OPE and the development of gas fields;

that VNIIgaz, the VNPO Soyuzmorgeo [All-Union Science and Production Association for Offshore Geology] and Soyuzgazgeofizika, jointly with MINKhiGP [Moscow Institute for Petrochemical and Gas-Industry Research] imeni I. M. Gubkin and the NPO Neftegazgeofizika [Science and Production Association for Geophysical Work for the Gas Industry] develop during 1983-1984 standard-practices supervision over the use of the complex of field-geology and field-geophysics methods for monitoring the development of gas fields; and

that Soyuzgazgeofizika, the VNPO Soyuzgazavtomatika, VNIIgaz and SevKavNIIgaz, jointly with MINKhiGP, prepare by 1 July 1983 a coordination plan for the development and production of apparatus and equipment for monitoring OPE and the development of gas fields.

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OIL AND GAS

UDC 622.691.4.054.07(1-21)

UNATTENDED ELECTRIC-DRIVE GAS-PIPELINE PUMP STATIONS PROPOSED

Moscow GAZOVAYA PROMYSHLENNOST' in Russian No 3, Mar 83 pp 2-4

[Article by M. I. Brekhman (VNIPItransgaz [All-Union Scientific-Research and Design institute for Natural-Gas Transport]): "Ways to Create an Economical System for Pumping Gas"]

[Text] By way of discussion.

> Realization of the system proposed for pumping gas will provide for a reduction of capital investment and operating costs. The useful productivity and reliability of a trunk gas pipeline will be raised.

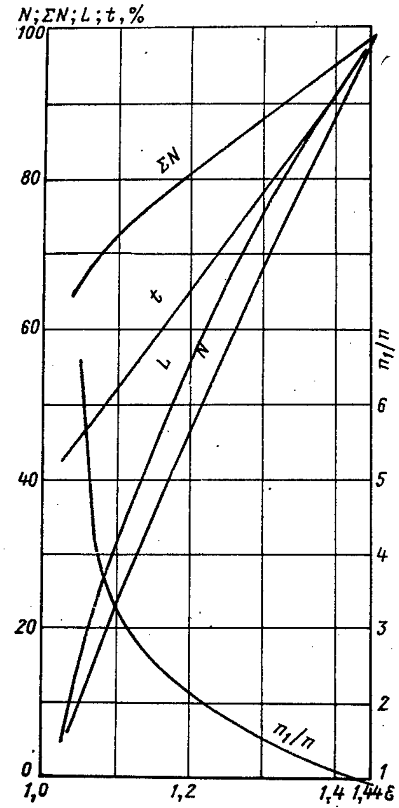
In recent years, because of the need to transport ever-increasing amounts of gas over great distances, the choice of an optimal scheme for spacing KS's [compressor stations] and compression ratio for trunk gas pipelines that are being designed, that is, the creation of a more profitable system for pumping gas, has been acquiring special urgency.

As the result of a technical and economic analysis of the economics of transporting gas that was carried out by Giprogaz [State All-Union Institute for the Design of Gas Pipelines and Gas-Industry Enterprises], it was established that the minimum expenditure of power (energy) for transporting will be found where the compression ratio is close to 1. However, in this case the erection of a large number of KS's of comparatively small power along the gas pipeline would be required.

In continuing this research and devoting attention to the possibility of creating simplified, unattended KS's with electric-drive units, in outdoor or semioutdoor versions, it was concluded, based upon a number of comparison computations, that, where a gas pipeline operates at compression ratios in the 1.06-1.10 range, a 30-percent reduction in the power of each KS and in the total operating power of the entire gas pipeline is provided for (figure 1).

The optimal compression-ratio value for unattended compressor installations (KU's) should be determined during design development. The computations should be based upon existing standard procedures and operating parameters

Figure 1. Change of Gas-Pipeline Parameters as a Function of the Compression Ratio (n_i/n is the ratio of the number of operating GPA's [gas pumping units] to the number of reserve GPA's.



and other newly found cost indicators for new equipment and for the construction of KU's and other facilities.

The KU should have a simple scheme for manifolding, and the equipment installed at it should operate under the open sky or under an awning. Beside the operating units installed at each KU, redundant units are installed that will insure full reliability of the installation's operation. The KU's automation equipment will provide for switching off a unit that malfunctions, switching on a reserve unit, and switching the appropriate valves over to the required positions, and it will quickly inform the central control post about the status of the installation. Compressor units will arrive from the manufacturing plant completely outfitted, in the form of modules. These will be easily installed and taken down, and they will be switched off and switched into operation at pressure, accepting the load right away. The manifolding of a KU can, for example, have the scheme shown in figure 2.

The provided electric motors should be of the type that are protected against explosion are sealed against dust and moisture, should have a high rpm and power that will support operation of the blowers without reduction gear, and should not require complicated auxiliary equipment (systems for cooling, separate oil facilities, and so on).

The stepdown substations should also be of the open-air type, completely automated, and have reliable dual power feed, which is executed from high-voltage power lines that pass by in the given region.

Assuming, however, that not all regions have the necessary power sources, a worst-case variant has been analyzed, where the required electrical capacity is not available over the length of the trunk gas pipeline route. In this case, in order to get power for the KS's, in-house power stations must be built and LEP's [power transmission lines] must be laid along the trunk gas pipeline.

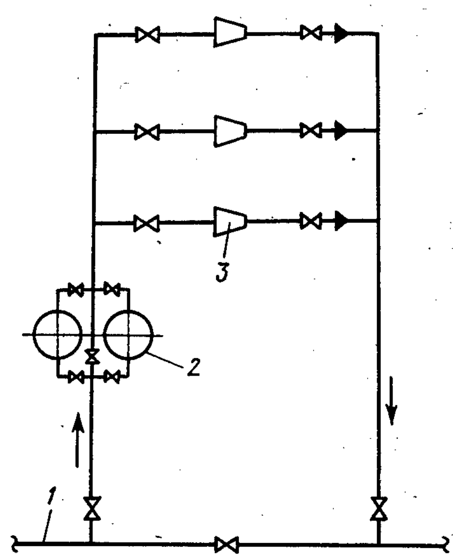


Figure 2. Manifolding Scheme for Compressor Installations:

1. Trunk gas pipeline.
2. Dust traps.
3. Gas-pumping unit.

Given such assumptions, it will prove necessary to execute a set of measures:

the construction of completely automated, remotely controlled unattended electric-drive KU's that are highly reliable and have long motor service life and small compression ratios ($\varepsilon \leqslant 1.1$);

the erection of power stations of high efficiency (primarily with steam turbines);

the construction along the trunk gas pipelines of high-voltage power lines with unattended stepdown substations where the KU's are sited;

the creation of a central-control service that will enable remote observation and control over all the units;

the development of schedules for servicing and for the conduct of planned-preventive maintenance of the unattended KU's by personnel of a mobile maintenance services unit;

the organization of a mobile emergency KU-repair service;

the creation of centralized (or regional) repair shops that are supplied with the necessary equipment, for repairing KU equipment; and

the construction of consolidated housing settlements for operating and servicing personnel.

Savings of fuel gas under the proposed system for pumping gas will depend greatly upon the correct choice of type and location of the power stations. For this purpose, a power station that works at high efficiency (36-40 percent) is suitable.

Evaluating the efficiency of transmission and of transforming the electricity at ~85 percent and assuming an actual (or rated) power consumption by all KU's, we find that fuel-gas consumption for the needs of the whole system is reduced to 60 percent, or the saving thereof is more than 180 million m^3/year for a gas pipeline 1,000 km long with a standard-equivalent diameter of 1,000 mm, or 370 million m^3/year for one with a standard equivalent diameter of 1,400 mm.

However, it is more desirable to build thermal power stations with steam turbines of the district-heating or the back-pressure type, in order to make use of the heat that they generate for supplying heat to cities or industrial facilities. Therefore, when designing a new gas pipeline, possible consumers should be determined first, including industrial enterprises that need heat energy.

It will probably turn out to be desirable to enter into cooperative arrangements with other branches of industry and to build enterprises that consume energy in large quantities. The placement of such enterprises and of the construction sites for electric-power stations should gravitate toward a terminal segment of the trunk gas pipeline, or, possibly, it should be at a certain distance from the trunk gas pipeline route. Doing so will enlarge the region of search for possible sites for erecting them and will make their construction more probable. With a power-station efficiency of 42-46 percent (depending upon the parameters and amount of heat energy consumed), fuel-gas consumption is reduced to ~50 percent. For a gas pipeline 1,000 km long made of pipe with a standard-equivalent diameter of 1,000 mm, the fuel-gas saving will be 230 million m^3/year, or, with a standard equivalent diameter of 1,400 mm, 460 million m^3/year.

Moreover, if the thermal power stations are built in regions adjacent to the terminal segments of pipelines, the useful productivity of the gas pipeline is raised 3-5 percent.

Preliminary computations indicate that, with implementation of the proposed system for pumping gas and for supplying it with power, even taking into account the construction of high-voltage power lines and servicing roads along the entire trunk gas pipeline route, capital expenditures for building the basic trunk gas-pipeline facilities, which amount to 50-60 percent with respect to the construction of a KS with a gas-turbine drive, are greatly reduced.

The use of blowers with small compression ratio at a KU will, in particular, enable the use of axial-type blowers and a further reduction in the energy consumed through a rise in the efficiency of the blowers, and it will greatly simplify the manifolding thereof.

The relatively small capacity and simplicity of design of the blowers will enable manufacturing plants to organize their output serially. This will reduce their costs and enable them to be shipped completely outfitted with electric motors in the form of modules. Doing so will allow them to be easily installed, and, during operation, will allow units that have malfunctioned to be replaced with operable units, with the malfunctioning units sent to central shops, where skilled repair services will be provided.

It is desirable to build centrally located well-supplied repair shops in areas where the power stations or communities have been located.

Concentration of the bulk of maintenance personnel in regions where power stations are built will enable a great reduction in manning by personnel who service the trunk gas pipeline and the construction of fewer but larger and, therefore, better equipped, housing settlements.

The cited advantages of operating a trunk gas pipeline with compressor installations that use small compression ratios can also be realized successfully where heat-engine superchargers are used as the drive. However, the creation of such engines requires that a large amount of test and design-development work be done and the units themselves will prove to be more complex than electric-motor drives.

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OIL AND GAS

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METHOD FOR CHOOSING STANDARDIZED GAS-TREATMENT PLANT MODULES OUTLINED

Moscow GAZOVAYA PROMYSHLENNOST' in Russian No 3, Mar 83 pp 5-8

[Article by A. V.Buyerakov, A. I. Gorbachev, L. P. Bogdanova, G. E. Garber, A. M. Palitskiy and Yu. A. Krivoguzov (VNIPIgazdobycha [All-Union Scientific-Research Institute for Gas Recovery]): "The Effectiveness of Using Standard Industrial Modules"]

[Text] The scientifically substantiated choice of a number of unitary industrial modules and the determination of a criterion for optimality of their use are of great significance in increasing the effectiveness and quality of designs for building up gas and gas-condensate fields. The choice of standard-size modules should be based upon an analysis not only of economic indicators but also of indicators of the reliability of the facilities being designed.

Two basic indicators associated with reliability exercise, along with cost indicators, an influence on the economic effectiveness of gas-treatment systems. These are: the possible shortfall of gas through breakdown of the equipment, and the expenditures for reserve equipment that will make up for the reduction of productivity.

Computations are needed in order to determine the optimal variants of gas-recovery enterprises (GDP's) for modules of various productivities. The use of a number of standard sizes for modules, including box modules, will enable GDP's of a given productivity to be built up by various methods. In so doing, several variants exist, each of which is determined by the amount of the planned productivity of the UKPG [integrated gas-treatment installation], the unit productivity of the modules, the number of operating and reserve modules, and the expenditures for the equipment.

In order to analyze the variants, a generalized criterion of effectiveness in the form of total costs to the national economy is used, enabling expenditures on the reserve to be compared with the harm done by a shortfall in gas delivery. The amount of the total expenditures is the sum of the equated expenditures on the system and the mathematical expectation of harm from a shortfall in the delivery of gas. In order to determine the value of the mathematical expectation of harm from a shortfall in gas delivery, the mathematical tool of

Markov's random processes, which enable the values of the probabilities for all amounts of productivity to be computed [1 and 2], must be used.

Presently existing data obtained by processing information on equipment that is in operation can be a basis for the calculations. The amount of the average shortfall in distribution of gas and of the total equated expenditures is determined for the given series of productivities of the modules in the planned productivity range of the UKPG that has been adopted. It is expedient to examine first a restricted range with a productivity that does not exceed 20 million m^3/day, which corresponds to a truncated series of module productivities of 1, 3 and 5 million m_3/day. Because of the large number of computational variants, the calculations are performed on a YeS-1022 computer in accordance with programs have been developed.

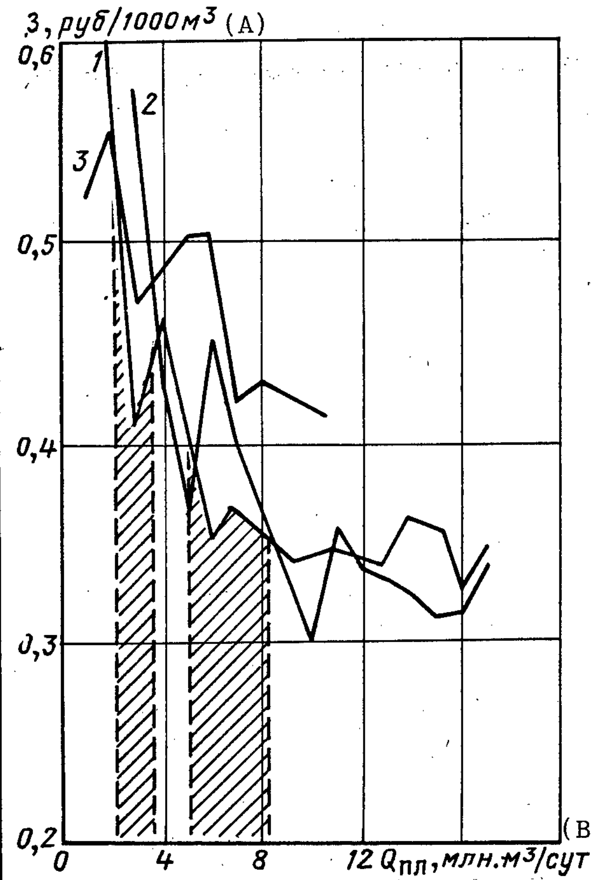

Figure 1. Specific Total Equated Expenditures as a Function of the Productivity of a System for Various Unit Capacities of Industrial Modules:

1. q = 3 million m^3/day;
2. q = 5 million m^3/day; and
3. q = 1 million m^3/day.

A. Z. rubles/1,000 m^3.
B. Q_{p1}, millions of m^3/day.

The calculated dependence of total equated expenditures on planned productivity is shown in figure 1. A comparison of the curves obtained for the various module productivity values enables the zones (indicated by color) that correspond to the minimum total equated expenditures to be singled out. In each of the zones that are found the optimum is the use of a module of a definite productivity. Thus, for values of planned productivity of up to 2.4 million m^3/day, it is desirable to use a module with a productivity of 1 million m^3/day. Then follows the zone of optimality of a module with a productivity of 3 million m^3/day, which is restricted by the value of 8.3 million m^3/day (except for a certain interval). For the remaining series of values of planned productivity, the use of modules with a productivity of 5 million m^3/day is optimal.

The indicated calculation was made for average values of the module reliability indicator, and also for the average specific harm. At present, however, substantiated data on module reliability are lacking. Therefore, the calculations were performed by a variant method for practically the whole permissible interval of module reliability indicators--from 0.93 to 0.99. Similarly, a wide interval of change of value of specific harm, from 10 to 20 rubles/1,000 m^3, was examined.

The results of the analysis of a large number of variants obtained is a confirmation of the previously determined zones for modules of various productivities.

However, it should be noted that the zones singled out correspond to definite ratios of expenditures per module of various productivities. According to existing data, the average ratio of expenditures of modules with a productivity of 5 and 3 million m^3/day is the value K = 1.45. As technical progress proceeds and advanced methods for producing standard outfitted-module equipment are introduced, a reduction of its value obviously should be expected.

An expanded analysis has been performed for the long term on effectiveness at various values of the expenditures ratio (from 1.1 to 1.6). It was established that, as the values of K are reduced, a sharp reduction in the zone of use of the module of 3 million m^3/day productivity occurs, and at values less than the critical one ($K < 1.3$), this zone is practically reduced to two isolated values of 3 and 6 million m^3/day, that is, it disappears (figure 2).

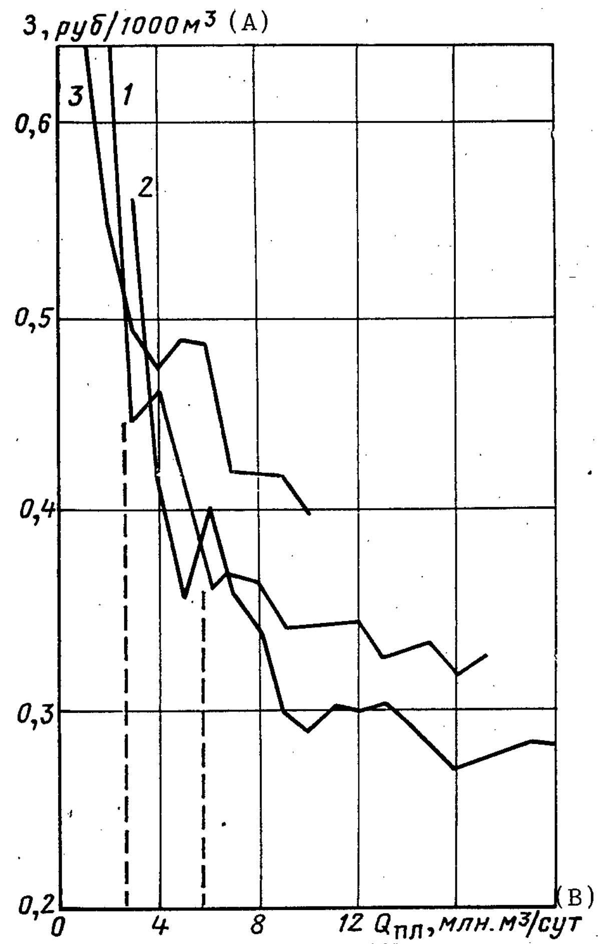

Figure 2. Specific Total Equated Expenditures as a Function of the Productivity of a System for Various Unitary Capacities of Industrial Modules (K = 1.3).

(The symbols are the same as for figure 1.)

Thus, as a result of the analysis performed on the basis of generalized criteria of effectiveness, taking reliability into account, it was established that, as the ratio of expenditures for modules with a productivity of 5 and 3 million m^3/day decreases, the zone of the 3 million m^3/day module has a tendency to deteriorate.

When a sufficiently high technical level of production of standard equipment is reached, practically the whole range of UKPG productivities examined can be covered by two standard-dimension modules--1 and 5 million m^3/day. Therefore it is desirable that the efforts of developers, designers and machinebuilders focus on the creation and output primarily of modules of the productivities indicated above and of the appropriate box modules for auxiliary equipment. Designers should pay special attention to the development of a number of standard designs and of appropriately unified schemes of master plans for UPPG's, UKPG's and GS's, which are based upon the use of outfitted-module equipment with a unit productivity of 1 and 5 million m^3/day.

Let us note that such a "rigid" unification does not cause a great rise in capital investment, since the share of expenditures on construction-site structures for gas treatment is from 15 to 30 percent, while for industrial equipment it is 2-10 percent of all expenditures at field facilities. At the same time, many currently existing design solutions that are nonrational and varied in type will, naturally, disappear. The solution of questions of choice and outfitting and the installation and operation of the equipment, and the solution of questions of long-term planning and of developing an integrated system of material and technical standards are greatly facilitated.

In connection with the preparation for operation of large new gas fields, it becomes necessary to use industrial modules of high productivity for drying gas. The series of values of unitary productivity has been expanded to 10 million m^3/day. Since the baseline data for the module with the productivity of 10 million m^3/day are not fully complete, calculations are performed by the variant method over a broad range of changes of source data.

Various calculated values have been adopted for module reliability indicators--within the 0.93-0.99 range. For values of the ratio of expenditures $K_2 = Z_{10} : Z_5$ the limits of change have been adopted as 1.35-2.

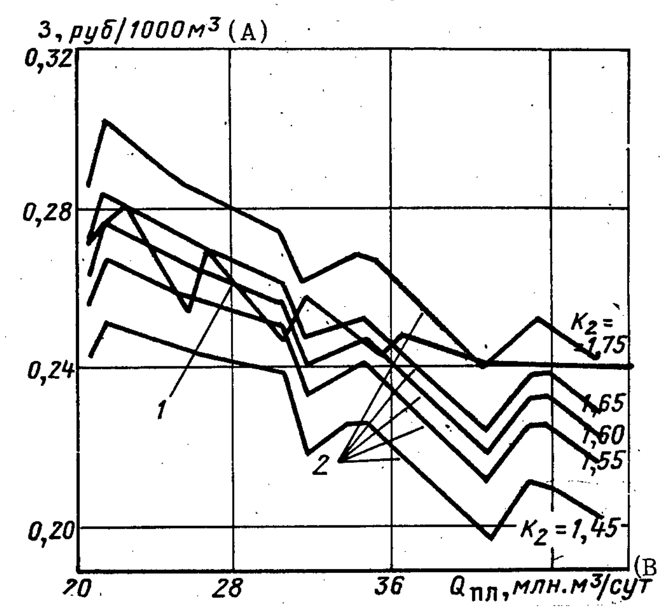

Figure 3. Specific Total Equated Expenditures as a Function of the Productivity of a System for a Unit Capacity of Industrial Modules of 5 and 10 Million m_3/-Day.

1. q = 5 million m^3/day.
2. q = 10 million m^3/day.

A. Z. rubles/1,000 m^3.
B. Q_{p1} millions of m^3/day.

Analyses of total equated expenditures that take reliability into account have been made, and a family of curves of changes in the calculated values as a function of the productivity of the whole system that is being provided for preparing gas in the interval 20-50 million m^3/day has been constructed (figure 3). An analysis of the curves obtained has enabled an interval of values to be found for the ratio of expenditures per module, in which there is a limit on the use of modules with a productivity of 5 million m^3/-day. If the values of K_2 are in the 1.55-1.70 interval and the module reliability indicator has an intermediate value of 0.95, then the limit of application of a module with a productivity of 5 million m^3/day is a value on the order of 30 million m^3/day.

Rough values for K_2 that have been obtained, particularly by extrapolating the amounts of expenditures per module with productivities of 1, 3 and 5 million m^3/day, correspond to the indicated interval of values, so the conclusions that have been drawn for them are valid.

Consequently, the use of a module with a productivity of 5 million m^3/day can be recommended for practical use where total productivity of the system for treating gas is up to 30 million m^3/day, and the use of a module with a productivity of 10 million m^3/day can be recommended where total productivity is more than 30 million m^3/day.

An analysis of other possible baseline indicators leads to similar conclusions. However, the area of use of a module of 10 million m^3/day productivity will be expanded with increase in reliability. The limiting value of total productivity of systems for treating gas, for which the use of a module with a productivity of 10 million m^3/day is desirable, can be reduced from 30 to 25 million m^3/day.

The conclusions given were obtained on the basis of an analysis of limited economic data and common consistencies of the "behavior" of zones with change of the reliability indicators, ratio of expenditures and the harm from shortfall in delivery of gas. Nevertheless, they enable a single-valued choice of industrial modules to be made over the whole interval of values of UKPG productivity that are examined. Areas near the boundaries of the zones where solution of the problem of choice between competing variants willl depend upon the actually existing state of affairs are an exception.

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MOBILE POWER PLANT PROVES ITSELF AT WEST SIBERIAN GAS FIELDS

Moscow GAZOVAYA PROMYSHLENNOST' in Russian No 3, Mar 83 pp 14-15

[Interview with Isaak Ivanovich Agayev, chief of the Administration for Material and Equipment Supply, and Anatoliy Fotiyevich Shkut, head of the Administration of the Chief Engineer [Ministry of Gas Industry], by a correspondent: "A Mobile Power Source"]

[Text] In the initial period of exploration and development of West Siberian oil and gas fields, geologists and oilfield and gas-field workers face the problem of power supply for operating facilities in the areas where the work is proceeding. A paradoxical situation has prevailed: where there was a substantial energy potential in the form of hydrocarbon raw materials, a severe shortage of electricity was being experienced. By virtue of the region's remoteness, the difficulty of access and the severe climatic conditions, the creation of traditional systems for supplying power from industrial power grids or the construction of stationary power stations was practically impossible during the first stages of operations.

The use of diesel engines for the drive of mobile electric-power stations and drill rigs posed a difficult problem in supplying the region with fuel. As installed capacity grew, the delivery into the operating regions of tens of thousands of tons of diesel fuel was required. Taking into account the complicated transportation scheme for the region and the seasonality of the scheme's operation, all this turned into enormous expenditure and loss of materials. With the shift of operating facilities to the North of Tyumen Oblast, the importance of a supply of power has risen.

Coworkers have come to the aid of the oil and gas-field workers. The motor builders who created engines for winged vehicles produced, in collaboration with the recovery branches of the economy, transportable power plants of high unit capacity that are based upon aviation engines.

The highly economical nature of this equipment is insured through the secondary use in energy installations of engines that had worked out their engine life in the air and had been rebuilt for operation on gas-type fuel.

The Ministry of Gas Industry adopted a decision to supply primarily drill rigs, and then field-support enterprises, with PAES-2500 electric-power plants. And the correctness of the decision has been confirmed completely. Right now one can say with confidence that, without the use of these power plants, it would be difficult to imagine accelerated development of West Siberia's gas deposits.

The Ministry of Gas Industry has presented, "A Complex of Operations for Creating and Introducing into the National Economy a Family of Automated Power-Engineering Installations Based on Aviation Engines" (the originators: V. F. Abubakirov, I. I. Agayev, G. Ye. Bolgartsev, V. G. Kurchenkov, V. V. Khorunzhin, A. F. Shkuta, A. G. Yugay, V. A. Boguslayev, V. L. Voronin, F. I. Ishchenko, V. A. Konstantinovskiy, N. A. Lukinykh, V. I. Omel'chenko, V. L. Starikov, N. V. Burtsev, V. N. Kolomatskiy, U. U. Mansurov, L. I. Ovsiy, V. P. Roslyakov, S. P. Chitipakhovyan, V. M. Aristov, D. S. Yermakovich, B. A. Sukhanov, O. V. Popovskiy and V. A. Shpilevoy), for participation in the competition for the 1983 prize of the USSR Council of Ministers

The journal's editorial board requested participants in this development work, Isaak Ivanovich Agayev, chief of the Administration for Material and Equipment Supply, and Anatoliy Fotiyevich Shkut, chief of the Administration of the Chief Power Engineer, to answer its correspondent's questions.

[Question] Isaak Ivanovich, you, as the chief "distributor" of supplies and equipment in the branch especially accept the importance and necessity for using them thriftily and rationally. What kind of a role does the PAES-2500 play in the solution of this problem?

[Answer] The intensive path of developing the industry's economic system on the basis primarily of more effective use of the supplies and equipment allocated to the gas industry is one of the chief indicators of the work of Mingazprom [Ministry of Gas Industry].

Great attention is being paid in the industry to questions of the economical, thrifty and rational use of resources. In considering the complicated and expensive scheme for delivering equipment and materials to West Siberia--our country's main gas-recovery region--the use of local materials and raw materials is, under these circumstances, an economically advantageous element. In particular, the constantly increasing amount of drilling in West Siberia requires the importation of tens of thousands of tons of diesel fuel from the country's central regions, although the natural gas of the fields being drilled can be used as a fuel for the drill rigs.

Therefore, the drillers of the oil and gas industries and of the geological branch are widely using PAES-2500 type gas-turbine electric-power plants as the main source of power for the BU-80E and BU-4E type drill rigs.

Experience in mastering the new fields, indicates that the introduction of industrial facilities for recovering gas outruns, as a rule, the construction of fixed power stations and LEP's [power transmission lines], and, therefore, in some cases it is economically undesirable to bring LEP's to facilities that are of a mobile nature, particularly those such as drill rigs. In these cases it is more effective to use the PAES-2500 electric-power plant as a source of electricity.

The Vyngapurovskoye field was drilled over in a short time thanks to their use. At the Urengoy field 23 drill rigs are now operating with the use of the PAES's.

The use of these rigs is not restricted to the northern regions. They enjoy no small favor in the desert regions of Central Asia that are difficult of access. For example, four PAES-2500's were introduced when the Shurtan fields in Uzbekistan were drilled over, eight were introduced when the Dauletabad gas-condensate field was drilled over.

The main benefit from the use of PAES is gained in the saving of diesel fuel. When the fields were being drilled with the use of mobile power plants, 12,500 tons of diesel fuel were saved, and the saving of motor oil exceeded 1,000 tons.

The structure of the savings of these expenditures indicates also that use of the mobile power plants influences considerably a reduction in idle organizational time caused by delays, in some cases, in the importation of the diesel fuel for the drill rigs. When drilling fields over with the PAES-2500, the net effective drilling speed is increased on the average by 26 percent.

Mingazprom's central staff has made a decision to develop the Yamburg field with electric-drive drill rigs, their electricity to be supplied by PAES-2500 electric-power plants.

[Question] Anatoliy Fotiyevich, tell us, please, about the main advantages and the areas of use of mobile power plants in the gas industry.

[Answer] Use of the PAES-2500, which operates on local fuel, as a mobile and reliable source of electricity of great unit capacity, is economically desirable from all points of view.

These power plants are compact, have comparatively small dimensions, are highly automated, do not require water for operation, and are highly maintainable. Motor service life in the North reaches 8,000-9,000 hours, which is a good figure.

The power plants mentioned are being used widely in the branch not only for drill rigs but also for starting certain compressor stations or UKPG's [integrated gas-treatment installations] that are being introduced, to which the stringing of LEP's has been delayed. Moreover, they are being used as a temporary and economical source of power at pioneering housing settlements and industrial bases.

In the gas-bearing regions of West Siberia alone, we already have more than 120 PAES-2500's in operation. The mobility, compactness, potential for delivery by air transport to any region that is difficult of access, and use of natural gas and casing-head gas as the fuel will enable these installations to be used on a still larger scale during the development of gas fields in other parts of the country that are difficult of access.

The annual increase in the number of these installations that are allocated to the gas industry is promoting the wide use of PAES's in the branch.

Thanks to the collaboration of specialists of various industries that are thriftily resolving the national economic tasks set for them, aviation equipment has acquired a second life and is solving urgent problems of developing natural resources in remote regions of our motherland that are hard to get to.

The creators of the PAES-2500 have not stopped with what they have achieved. Jointly with UkSSR Academy of Sciences scientists, they have developed special heat exchangers and noise suppressors that are being installed on the exhausts of the gas turbines. These will enable production and household facilities to be provided with heat and hot water in the Far North environment and also a reduction of the noise level to the hygienic norms for housing areas.

I want to emphasize the interindustry importance of the mobile power plants. Their use in the oil industry and in the geological prospecting sphere has saved more than 150 million rubles.

In reliability, economic effectiveness and service life, PAES-2500 installations cede nothing to the best foreign models of this type.

In the foreseeable period of developing the country's new gas-recovery regions, drill rigs with drive off a PAES will be a reliable and economical means for drilling over gas and oil deposits.

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FACTORS AFFECTING USE OF SECONDARY HEAT AT GAS TREATMENT PLANTS ANALYZED

Moscow GAZOVAYA PROMYSHLENNOST' in Russian No 3, Mar 83 pp 18-19

[Article by R. M. Makar, A. S. Patychenko, B. I. Shelkovskiy, A. N. Ostapenko and N. I. Sereda (Soyuzgazproyekt [All-Union Institute for the Design of Gas-Industry Facilities]): "The Influence of External Factors on the Characteristics of Recovery-Type Heat Exchangers of GPA's [gas-pumping units]"]

[Text] The use of secondary energy resources of trunk gas pipeline compressor stations is acquiring increasingly great importance where the drive to save all types of resources, including fuel and electricity, is being widely promoted.

Secondary energy resources (VER's) at stations equipped with gas-turbine drive gas-pumping units (GPA's) are now being recovered in heat-exchangers with a recovery module that is serially produced by the Shchekino RTO [Technical Service Company] Plant and Sysert's experimental machinery plant, Sysertgazmash.

The basic technical indicator of recovery-type heat exchangers--heat productivity $Q_т$--is determined by the flow rate and temperature of the drive motor exhaust gases, which are functions of the outside air temperature $t_{н.в}$ and pressure $p_{н.в}$ and the relative capacity of the GPA's $\overline{N}$. It should be noted that the thermal and aerodynamic characteristic of heat exchangers that are obtained during tests for specific KS [compressor station] conditions cannot be used to design systems for KS heat supply and for external requirements without making additional calculations. This is explained by the fact that the experimental characteristics of heat exchangers do not correspond to the computed characteristics at the temperature for the coldest five-day period for the given region. With a view to providing for the possibility of designing KS's for various climatic zones with use of the VER's that are recovered for the needs of the industry and the national economy, Soyuzgazproyekt has obtained by the computational method $Q_т$ as a function of $t_{н.в}$ and $\overline{N}$ for unified recovery-type heat exchangers for GTK-10, GTN-6, GT-6-750, GPA-Ts-6.3 units, and also for heat exchangers for GTN-16 and GTN-25 units of the future.

Information about the flow rate and temperature of the exhaust gases for the units at various outside-air temperatures that were obtained from the plants that make GPA's were used as baseline data for the computation.

However, the indicators presented by the plants do not, as a rule, permit consideration of change of these parameters as a function of the load on the unit at constant outside-air temperature. In order to consider this factor when making computations, analytical functions have been obtained for the flow rate and temperature of GPA exhaust gases in the form of the functions

$$G = f(\overline{N}, T_{\text{н. в}}, p_{\text{н. в}}); \; T_2 = f(\overline{N}, T_{\text{н. в}}, p_{\text{н. в}}).$$

The following equations are the bases for the functions obtained [1]:

$$\overline{G}_{\text{пр}} = \overline{N}_{\text{пр}}^{0,33}; \tag{1}$$

$$\overline{T}_{2_{\text{пр}}} = 1 - 0,165\left(1 - \overline{N}_{\text{пр}}\right), \tag{2}$$

where $\overline{G}_{\text{п.р}}$, $\overline{T}_{2\,\text{п.р}}$, and $\overline{N}_{\text{п.р}}$ are the relative equated flow rate and temperature of the exhaust gases and GPA capacity, respectively.

In using the formula for referring GPA parameters to normal conditions [2] and expressing exhaust-gas flow rates and temperatures in absolute units, equations (1) and (2) can be presented in the form

$$G = G_0 \overline{N}^{0,33} \left(\frac{T_{\text{н. в}_0}}{T_{\text{н. в}}}\right)^{0,665} \left(\frac{p_{\text{н. в}}}{p_{\text{н. в}_0}}\right)^{0,67}; \tag{3}$$

$$T_2 = T_{2_0} \frac{T_{\text{н. в}}}{T_{\text{н. в}_0}} \left[0,835 + 0,165\overline{N} \left(\frac{T_{\text{н. в}_0}}{T_{\text{н. в}}}\right)^{0,5} \frac{p_{\text{н. в}_0}}{p_{\text{н. в}}}\right], \tag{4}$$

where G is the flow rate of GPA gases, kg/force; T_2 is the temperature of the GPA exhaust gases, K; $p_{\text{н.в}}$ and $T_{\text{н.в}}$ are the pressure and temperature of the outside air, Pa and K, respectively; $\overline{N}$ is the relative capacity of the unit; and the index 0 constitutes the computed GPA parameters.

In considering that most KS's are located in a flat locality, the effect of outside-air pressure on GPA parameters can be disregarded. Therefore, $p_{\text{н.в}} = p_{\text{н.в}_0}$ can be adopted in the calculations.

Values for the flow rates and temperatures of the exhaust gases for N = 0.6–1.2 were obtained in accordance with equations (3) and (4) over the range $t_{\text{н.в}}$ from − 40 to +10 degrees Celsius for GPA's of the types indicated above by the computational route, taking into account the tolerances that had been adopted. Later these values were used in determining the characteristics of recovery-type heat exchangers for the various $t_{\text{н.в}}$ and $\overline{N}$.

The table shows the values of the rated heat productivity of recovery-type heat exchangers for some GPA's at various $t_{\text{н.в}}$ and $\overline{N}$.

For clarity and convenience of use, graphs of the heat productivity of unified recovery-type heat exchangers as functions of outside-air temperature and relative capacity for the GPA types indicated above have been constructed in accordance with the indicated tabular values.

As follows from the graphs, the curves are close to linear in nature, and they increase monotonically with increase of outside-air temperature. And the heat productivity of the heat exchanger also increases practically directly proportionally with increase in the relative capacity of the unit.

$\overline{N}$	$t_{н.в}$, °C	Возможный теплосъем с агрегата, * ГДж/ч			
		ГТК-10	ГТН-6 ГТ-6-750	ГТ-750-6	ГПА-Ц-6,3
1,0	—40	15,5	20,5	5,9	20,1
	—30	18,9	22,2	8,4	23,0
	—20	22,2	24,3	10,5	26,0
	—10	25,1	26,4	11,7	28,1
	0	28,1	28,1	13,8	28,9
	+10	31,0	29,3	15,5	28,9
0,8	—40	12,2	17,2	3,4	15,1
	—30	14,7	19,3	5,4	16,8
	—20	17,6	21,0	7,5	18,9
	—10	20,5	22,6	9,6	20,5
	0	23,0	24,3	11,3	22,2
	+10	26,0	25,6	12,6	23,0

*Possible heat removal from the unit, GJ/hr.

Because of the appearance of outside customers for recovered heat who have a daily and seasonal unevenness of heat consumption, the GPA's heat exchangers should have an adequate degree of regulation of parameters, mainly heat productivity, that is adequate for a given specific customer. The degree of regulation of heat productivity

$$\Delta = \frac{Q_{\tau_{max}} - Q_{\tau_{min}}}{Q_{\tau_{max}}} 100, \%, \tag{5}$$

where $Q_{\tau_{max}}$ is the maximal heat productivity of the heat exchanger with completely closed regulating organs, GJ/hr; and $Q_{\tau_{min}}$ is the minimal heat productivity of the heat exchanger with completely open organs of regulation, determined, for example, in accordance with equation (3), GJ/hr.

Soyuzgazproyekt has conducted a number of appropriate calculations in order to evaluate the influence of external factors on the degree of regulation of heat productivity and the aerodynamic resistance of the heat exchangers and to consider this influence during design and operation.

This was done by use of the methodology of computing the regulating characteristics of heat exchangers [3] relative to recovery-type heat exchangers that have been created on the basis of recovery-type heat-exchange modules and slide valve modules, for various types of GPA's with gas-turbine drive and for their different relative capacities. The heat productivity of a recovery-type heat exchanger as a function of the angle of installation of the regulating valve of the slide-valve module and of the outside-air temperature have been obtained. It has been established that, with change in outside-air temperature, the degree of regulation of heat productivity is changed extremely insignificantly.

The heat exchanger's aerodynamic resistance is reduced insignificantly with rise in outside-air temperature. This is explained by change in GPA parameters from $t_{н.в}$. With increase in the angle of installation of the regulating valve of the slide-valve, the aerodynamic resistance of the heat exchanger rises substantially.

The data obtained permit determination of the possible generation of VER's for specific KS conditions back at the design stage and also during the process of GPA operation.

Moreover, the process of regulating the release of heat to customers that is rationally organized and that uses the graphs obtained will enable GPA recovery heat exchangers to operate with minimum expenditure of the fuel gas of the units.

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CEMA NUCLEAR POWER DEVELOPMENT

Moscow EKONOMICHESKOYE SOTRUDNICHESTVO STRAN-CHLENOV SEV in Russian
No 3, 1983 pp 2-4

/Interview with Aleksey Antonov, deputy chairman of the USSR Council of Ministers, chairman of the International Commission for the Coordination of Cooperation between CEMA Member-Countries and the SFRY in the Production of Equipment for AES's, by the editors: "The Goal Is A Speeded-Up Development of Nuclear-Power Engineering"; date and place not specified/

/Text/ /Question/ How has cooperation developed among the CEMA member-countries in the field of machine building for nuclear power?

/Answer/ The inter-action among the CEMA member-countries in the field of nuclear-power engineering and machine building for it is based on the General Agreement dated 23 November 1977 on the Prospective Development of Integrated Power-Engineering Systems for the Period up to 1990, as well as on the Program for the Development of Nuclear-Power Machine Building, as adopted at the 31st CEMA Session.

An important role in the upsurge of this highly effective sector is played by the Agreement on Multilateral International Specialization and Cooperation in Production and the Reciprocal Deliveries of Equipment for AES's, as signed on 28 June 1979 by the heads of government of the seven CEMA member-countries--the PRB, HPR, GDR, PPR, SRR, USSR, and the CSSR, as well as Yugoslavia. It is directed at combining our efforts to speed up the creation of specialized capacities for manufacturing technically complex power-engineering equipment. And this will facilitate the implementation of extensive plans for building AES's.

The signing of this agreement was preceded by a great deal of work on setting up cooperation in producing equipment for AES's. At the beginning it was conducted on the basis of bilateral agreements between the Soviet Union and those countries which had expressed a desire to cooperate in manufacturing certain types of such equipment.

During this period a number of countries built new specialized enterprises or modernized existing ones, which were fitted out with up-to-date machine tools, welding equipment, and apparatus for quality controls. Thus, in the CSSR large workshops were built at the Shkoda Association, at the Vitkovitskiy

Machine-Building and Metallurgical Combine, the Slovatskiy Power-Engineering Machine-Building Plant, and a number of other enterprises.

In Yugoslavia the Energoinvest put into operation a large workshop for producing steam separators for reactor installations of the RBMK [high-power pressure-tube reactor] type. In the HPR at the Gants Mavag Plant a workshop has been modernized for manufacturing transport-loading machines. In the PPR at the Rafako Plant a workshop has been built for producing volume compensators and steam generators, while at the Fakop Plant a workshop was modernized for producing heat exchangers. A number of facilities were put into operation at the enterprises of other countries which are participants in the agreement.

Simultaneously with the creation of specialized capacities there occurred the process of mastering the production of special steels and materials, the technology of manufacturing equipment for power units with reactor installations of the VVER /shell-type water-moderated water-cooled reactor/-440.

The successful solution of these problems was facilitated by the broad-based, multi-faceted aid on the part of Soviet organizations. They transmitted to their counterparts plan-design and engineering specifications which had been worked out in the USSR, adapted it to the specific production conditions in the countries concerned, took part in the development of the production of special materials and equipment, as well as in the deliveries of complete sets of items and assemblies.

During this period the industry of a number of countries set up the manufacture of about 20 types of engineering equipment. AES's under construction were outfitted with biological-protection equipment from the PRB, special water purifiers from the HPR, heat exchangers from the HPR and the PPR, volume compensators, main circulating pipelines, as well as main shut-off valves and steam-super-heater-separators from the CSSR, along with collectors, pipelines, and steam separators for RBMK-type reactors from the SFRY.

/Question/ How would you characterize the present-day stage of cooperation?

/Answer/ The successful implementation of the bilateral agreements and the preparation of an industrial base conducted in these countries have demonstrated how great the possibilities are for machine building in the socialist countries; they have created the foundation for making the transition to a qualitatively new phase of cooperation--on a multilateral basis. Its task is to ensure the further significant increase in the volumes of cooperative production and the expansion of specialization among countries involved. This was dictated by the acceptance by the CEMA member-countries of a course aimed at intensifying the development of nuclear-power engineering.

The re-structuring of the industry of the CEMA member-countries which was carried out in connection with this was brought about by the characteristics of economic construction at the present time. The fact of the matter is that the further increase in production and deliveries of the traditional types of fuel have become more and more expensive. The Soviet Union, for example, has to develop new petroleum deposits which are located, as a rule, in the hard-to-reach sparsely populated regions of Siberia and the Far North; this is both complicated and expensive. Therefore, we must seek out new sources of fuel and energy, as well as ensuring their introduction into economic circulation.

It was precisely at this that the agreement of June 1979 was aimed. It provides that the participating countries must produce more than 140 types of equipment for AES's with power units having capacities of 440 and 1000 MW.

Until just recently these reactors and other complex equipment were being produced exclusively in the USSR. But now, when the need for nuclear equipment has grown significantly, the development of nuclear-power machine building has become a common cause for the eight socialist states. In fulfilling this agreement, more than 50 of their plants and associations have joined together in a close and mutually advantageous cooperation.

By the present time practically all the products list of equipment for AES's with power units having a capacity of 440 MW, as provided for by the agreement, including complete reactor installations of the VVER-440 type, have been developed by the industry of the countries participating in this agreement.

/Question/ What specific effects will this cooperation have for the immediate future?

/Answer/ As the result of joint efforts in the European CEMA member-countries, AES's with a total capacity of about 4.5 million kW have already been put into industrial operation, including 1,760,000 kW each in the PRB and the GDR, and 880,000 kW in the CSSR. Construction is nearing completion on two units of 440 MW each--one in the HPR and another in the CSSR. Another 24 units with approximately 14 million kW are in the stage of planning and construction. Of these 22 with 12 million kW will be put into operation prior to 1990. At the stage of consideration is the construction of AES's in the PRB, CSSR, PPR, and the SRR, with a total capacity of approximately 8 million kW.

During the current five-year plan, along with supplying nuclear-power equipment for AES's with reactors of the VVER-440 type, we must make the transition to producing equipment for the new generation of AES's--those with reactors of the VVER-1000 type. Well-planned work is already being conducted along these lines. However, with respect to individual types of items, the specializing countries must adopt additional measures to speed up the development and increase of capacities. What I have in mind is the production of transport-loading machines and mechanisms for servicing reactors (HPR), circling-type cranes (GDR), special reinforcement (PPR), equipment for the reactor installation (CSSR), main circulating pumps (SRR), and others.

The manufacture of such complex and important products requires a comprehensive approach. It is a matter of ensuring a high degree of quality and reliability for the equipment being exported, organizing monitoring controls over the on-schedule production and delivery, and establishing unified prices on items from the different countries.

Since they ascribe great importance to the quality of the equipment being manufactured within the framework of multilateral cooperation and take into account its direct influence on the reliability and safety of nuclear electric-power centers, the participating countries provided in the agreement that its engineering inspection will be carried out by Soviet organizations directly at the enterprises.

Experience has shown that to a considerable degree this facilitates the solution of the problem. Moreover, it has revealed the feasibility of extending the inspection by Soviet specialists to all the basic engineering equipment being manufactured by the countries participating in this agreement for AES's, regardless of whether it is being delivered to other countries or is being manufactured for domestic needs.

From our point of view such an approach will allow us to employ integrated requirements for the quality of all equipment for AES's whose production has been provided for by the agreement on multilateral cooperation. Obviously, the appropriate organizations of these countries must speed up the implementation of this principle.

[Question] Couldn't you tell us in some more detail about the activities of the commission?

[Answer] The overall coordination of cooperation between the participating countries as well as the systematic monitoring controls over the course of the fulfillment of the obligations undertaken by them have been entrusted to our Inter-Governmental Commission, which includes plenipotentiary representatives from the governments of the countries concerned on the level, as a rule, of deputy heads of government.

Taking place at the sessions of the commission is a regular exchange of information between the countries involved; they also outline measures directed at carrying out the obligations with regard to the manufacture and delivery of equipment for AES's. The commission discusses problems connected with the creation of new capacities, the provision of engineering specifications for equipment being produced, working out price lists, introducing specific adjustments to the products list, volumes of production and deadlines for the reciprocal deliveries of equipment for AES's, as well as for the specialization of countries.

In June 1982 the 36th CEMA Session considered the commission's report on the progress being made in implementing the Agreement regarding the multilateral international specialization and cooperation in the production and reciprocal deliveries of equipment for AES's during the years 1981--1990. It was noted that this large-scale agreement, which has no analogies in international practice, is being consistently implemented.

Having emphasized that fulfilling the agreement ensures the practical implementation of the decisions made by the congresses of the Communist and labor parties of the CEMA member-countries on improving the structure of the fuel-energy balances of the countries, creating reliable sources of energy supply and strengthening the power-engineering base of the countries of the socialist community, the Session approved the activity of the Inter-Governmental Commission on coordinating cooperation within the framework of the agreement. At the same time, it was recommended that the participating countries carry out a number of additional measures with regard to further developing inter-action in the field of nuclear-power machine building as well as international specialization and cooperation as follows:

--to complete in 1982--1983 the preparations for producing throughout the entire agreed-upon price list equipment for AES's with reactor installations of the VVER-1000 type and to create, within the briefest possible time period, a standardized price list for the above-mentioned equipment;

--to continue work on further improving the quality of items in order to ensure a high level of reliability and safety of the AES's, to constantly improve the engineering inspection of equipment;

--to pay particular attention to standardizing the basic and auxiliary equipment, to integrate the schematic solutions and the entire element base of the automated systems for controlling the engineering processes of AES's.

It was proposed that the Inter-Governmental Commission concentrate its attention on solving the given problems and expanding its coordinating activity with regard to implementing the agreement, extending it to all the lines of inter-action among the participating countries, including those in the field of science and technology. This will facilitate the greater concentration of efforts by the countries concerned on the most important problems of successfully implementing the program of AES construction.

The Seventh Session of the Inter-Governmental Commission, which was held in Budapest at the end of September 1982, adopted a well-developed decision, directed at implementing the tasks flowing from the decree of the CEMA 36th Session with regard to the commission's report. Examined here were the questions of countries carrying out their obligations with regard to the production of equipment for AES's in accordance with the agreement, and specific measures were outlined for ensuring its delivery within the established deadlines; proposals were approved for the further development of cooperation in the field of nuclear-power machine building and the expansion of the products list for the output of specialized equipment.

The commission adopted important decisions with regard to further improving the system of quality controls on the items; it ratified an integrated price list on the basic types of specialized equipment for AES's with reactor installations of the VVER-1000 type.

The successful implementation of a multi-faceted agreement is also of great political importance. It testifies with new force to the advantages of socialism in solving the most complex problems of modern-day economics.

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CEMA COOPERATION IN NUCLEAR POWER DEVELOPMENT

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[Article by Aleksandr Motorin, CEMA Secretariat: "Multilateral Cooperation--An Important Factor in the Development of Nuclear-Power Engineering"]

[Text] The CEMA member-countries have paid chief attention to improving the structure of the production and consumption of fuel-and-energy resources, as well as to their efficient and economical utilization. This has been reflected in the DTsPS [Long Term Goal-Oriented Cooperation Program] with regard to providing the economically justified requirements of the countries for the principal types of energy, fuel, and raw materials, where an important place in solving this problem has been allotted to nuclear-power engineering.

Within a comparatively brief time interval nuclear-power engineering has made an enormous leap in its development. The world's first AES with a capacity of 5000 kW was designed and built in the Soviet Union, and it produced industrial current on 27 June 1954. And by the end of 1981 (according to data from the IAEA [International Atomic Energy Agency]) in 23 of the world's countries 272 nuclear-power reactors were in operation with a total capacity of 152,603 MW (el.), which were producing 9 percent of all the electric power being produced in the world (approximately 720 billion kW-hrs.). According to the forecasts, by 1985 this figure will reach 17 percent.

Such a rapid development of nuclear-power engineering is to be explained by the following two main reasons. In the first place, nuclear reactors do not require organic fuel (petroleum, natural gas, or coal), which for many countries is in very short supply, and, in the second place, they do not contaminate the environment.

The CEMA member-countries on the whole have considerable resources of organic fuel at their disposal. Thus, almost half of the world reserves of hard coal and about 40 percent of the natural gas are concentrated in the Soviet Union. But territorially they are distributed extremely unevenly; their extraction in the poorly developed, complex climatic conditions of the country's eastern and northern sections, and particularly the long-distance hauling that is required, present a serious national-economic problem, necessitating large capital investments and time.

The GDR and the CSSR at the present time are basically using soft coal for producing electric power and heat. But, as a result of intensive exploitation, the economically profitable deposits of coal have been exhausted to a considerable extent. There is also a worsening in the quality of the coal being mined because of the increased contents of sulfur, ash, and moisture, and this presents electric-power engineers with a number of problems connected with environmental protection.

The fuel and energy resources of the PRB, HPR, and the Republic of Cuba are very poor. These countries have practically no petroleum. The deposits of high-quality hard coal are insignificant. The existing reserves of low-calorie lignite cannot satisfy the needs of these countries for power-engineering fuel. Therefore, these countries are compelled to import coal, petroleum, and electric power in considerable amounts, as well as to seek out additional sources of energy.

Thus, in most of the CEMA member-countries the objective conditions have been created for the development of nuclear-power engineering.

Prior to 1980 the construction of AES's in CEMA member-countries was carried out on a bilateral basis with the technical assistance of the Soviet Union. During this period 10 power units with a total capacity of 4,030 MW were introduced, including three in the PRB (a fourth was introduced in 1982), five in the GDR, and two power units were introduced in the CSSR. They provided the national economy of these countries with 25 billion kW-hrs. of electric power in 1980, and this allowed a savings of more than 10 million tons of conventional fuel per year. At the end of 1982 the pioneer of the HPR's nuclear-power engineering produced industrial current--this was the first unit at the Paksh AES with a capacity of 440 MW.

At all the AES's put into operation (with the exception of the Raynsberg AES in the GDR) water-moderated water-cooled reactors of the VVER-440 type were installed, having a capacity of 440,000 kW. Their operation has shown a high degree of reliability of the equipment. The number of hours of use at the rated capacity on the average varies from 6800 to 7100 per year, which testifies to the high degree of effectiveness of the reactors.

During this period in the Soviet Union nuclear-power engineering also developed at a rapid pace. If in 1970 only four large power units at AES's with a total capacity of 875,000 kW (not counting experimental-industrial AES's) were steadily providing electric power into the power network, in 1980 their rated capacity had reached 12.5 million kW, that is, over a 10-year period it increased 14-fold. The Soviet Union's AES's were built on a wide industrial scale, basically using the VVER-440 types of reactors and the RBMK-1000 type of uranium-graphite reactors.

In 1980 a pilot reactor of the VVER-1000 type with a capacity of 1 million kW was put into operation at the Novovoronezhskaya AES. Beginning in 1985, reactors of a similar type will be installed as well at other AES's under construction in the European CEMA member-countries (for example, at the

Kozloduy AES in the PRB). In 1983 at the Ignalinskaya AES (USSR) it is also proposed to put into operation a pilot unit with a RBMK-1500 reactor having a unit capacity of 1.5 million kW with two turbines of 750,000 kW each.

It should be noted that in the thermal-neutron reactors (VVER, RBMK) as fuel use is made of lightly enriched uranium in which the contents of fissionable Uranium-235 comprise 2--3 percent. The practical use of uranium at AES's with reactors of a similar type is not great, and it varies between 1--2 percent. Therefore, the task of effectively utilizing uranium is very important from the point of view of ensuring nuclear fuel for AES's to be built in the future.

At the same time, reactors using so-called "fast" neutrons have already been created and put into operation; here there occurs the process of the reproduction of the nuclear fuel, i.e., a new fissionable substance is formed--plutonium. The first industrial AES with a fast reactor of the BN /fast-neutron/-350 having a capacity of 350,000 kW, was built in the USSR in the city of Shevchenko; the second--with a BN-600 type of reactor, having a capacity of 600,000 kW, was built at the Beloyarskaya AES. In their creation solutions had to be found for a great many complex scientific and engineering-design problems connected with guaranteeing the safety and reliability of their operation.

At the present time AES's are being planned with fast reactors having a unit capacity of 800 and 1600 MW; after 1990 these will be constructed serially, which will allow us to increase the power output per unit of fuel obtained by tens of times.

Because they ascribe great importance to studying this trend, the CEMA member-countries have concluded an agreement with regard to conducting scientific-research and experimental-design work on the problem of "Developing High Capacity, Fast Reactor Installations."

Serving as the basis for cooperation among the CEMA member-countries in the field of nuclear-power engineering for the long-term future is the General Agreement, signed in 1977, on developing Integrated Electric-Power Engineering Systems for the period until 1990. In accordance with this, the rated capacity at the AES's in the European CEMA member-countries is scheduled to reach approximately 37 million kW. This means that the share of the electric power produced at AES's by 1990 in the individual CEMA member-countries will constitute from 20 to 40 percent of all the electric power being produced (see Table).

It may be seen from the table that in 1970 only the GDR and the USSR were producing electric power based on the use of nuclear fuel; it constituted only 0.5--0.6 percent of all the electric power being produced in these countries. In 1980 AES's were already operating in the following four countries: the PRB, GDR, USSR, and CSSR, and they were providing the national economy with from 6 to 12 percent of the necessary electric power.

Table (in Percentages)

	Record			Forecast	
Country	1970	1975	1980	1985	1990
PRB	---	10.1	17.8	28--29	42--44
HPR	---	---	---	12--14	28--30
GDR	0.6	3.0	11.9	12--14	...
SRR	---	---	---	---	22--23
USSR	0.5	1.9	5.6	11--12	20--22
CSSR	---	0.3	6.2	18--20	32--34

During the current five-year plan the construction of AES's in the CEMA member-countries is proceeding at a rapid pace. At the end of the five-year plan industrial current will be provided by the fifth power unit at the Kozloduy AES in the PRB with a unit capacity of 1 million kW. At the AES's of the GDR the rated capacity will reach 2,710 MW. The nuclear-power engineering of the CSSR will have approximately this same potential at its disposal. In accordance with the decisions of the 26th CPSU Congress, the growth of electric-power production in the European part of the USSR will be achieved primarily by AES's and GES's. The construction of AES's has gotten underway, or preparations for it are being made in the Republic of Cuba, the PPR, and the SRR.

The program adopted by the CEMA member-countries for the development of nuclear-power engineering has required the cardinal solution of the problems of material-technical supply, particularly with regard to organizing the output of the entire products list of power-engineering equipment. With this goal in mind, in the mid-1970's a great deal of preparatory work was begun to set up the production of equipment for the AES's planned for construction. In 1979 an Agreement was signed providing for multilateral, international specialization and cooperation on the production and reciprocal deliveries of equipment for AES's for the period 1981--1990. It was directed at unifying the efforts of the CEMA member-countries and the SFRY for speeding up the creation and development of specialized capacities with regard to manufacturing engineering equipment.

During the preparatory period in these countries, based on engineering specifications from the USSR, the new technology was studied and mastered, the production of special steels and materials was organized, cooperation was set up in the deliveries of complete assemblies and parts. At the same time new enterprises were built, and tens of existing ones were modernized. Among the newly created capacities a prominent place will be occupied by the very large Atommash Plant (USSR), which will produce sets of reactor installations and basic equipment for the first loop . Its first stage has already begun to turn out finished products. Specialized workshops have been created at the Vitkovitskiy Machine-Building and Metallurgical Combine and the Slovatskiy Power-Machine-Building Plant in the CSSR. The workshops for producing transport-loading machines at the Gants-Mavag Plant in the HPR have been modernized. At the Rafako Plant in the PPR a special workshop has been built for turning out volume compensators and steam generators.

The process of mastering production required the solution of a number of complex engineering operations connected with the more rigid requirements made on the quality and reliability of the equipment being manufactured. The Soviet side rendered practical aid to the countries participating in the agreement with regard to preparing operational engineering specifications and mastering the technology. Consultations of specialists were held both in the enterprises of the countries participating in the agreement and at plants and in design organizations of the Soviet Union.

In addition to the above-mentioned forms of cooperation, at the enterprises of certain countries manufacturing particularly important equipment a constant inventors' inspection has been organized by the chief Soviet designer. All these measures allowed the CEMA member-countries as early as 1980 to master and produce throughout the entire products list specialized engineering equipment for AES's with VVER-440 type reactors: complete VVER-440 reactor installations, main circulating pipelines made of stainless steel with a diameter of Du-500 mm and shut-off valves for them, pressure condensers, steam-superheater-separators, etc.

During the current five-year plan cooperative production will begin on equipment for the VVER-1000 type of installations.

Multilateral cooperation in building AES's in the CEMA member-countries is carried out primarily by means of reciprocal deliveries of equipment and spare parts for them within the deadlines agreed upon by the parties concerned, along with the performance in necessary cases of installation and sponsored installation work with regard to specialized equipment.

The Program for Building AES's prior to 1990, as adopted by the European CEMA member-countries and the Republic of Cuba, required the deepening of multileveled scientific and technical cooperation in the field of planning and operating AES's.

With this goal in mind, an Agreement was signed in 1980 providing for cooperation in the conduct of scientific-research and experimental-design projects on the problem of "Mastering Power-Engineering Units with VVER Reactors Having a Capacity of 1000 MW (Electric) and Further Improving Reactors of This Type." An inalienable part of the agreement is the program of work providing for the preparation of 31 topics within the framework of the CEMA Permanent Commissions on cooperation in the field of the use of atomic energy for peaceful purposes, in the area of electric power and the International Economic Association known as "Interatomenergo," engaged in the production of equipment for AES's. Taking part in its implementation are organizations of the PRB, HPR, GDR, the Republic of Cuba, the PPR, SRR, USSR, and CSSR, and on certain topics--organizations of the SFRY.

The basic goals of cooperation which are being carried out within the framework of the above-mentioned agreement are as follows:

--mastery and improvement of power units with water-moderated water-cooled types of reactors having a unit capacity of 1000 MW, on the basis of which AES's will be built;

--improvement of the technical-economic indicators and further increasing the safety of AES's;

--shortening the time periods required for constructing and putting into operation power units with the VVER-1000 type of reactor;

--broad-based exchange of experience in the construction, installation, and operation of AES's.

The coordinated program of work on the above-mentioned problem is directed at improving the physical and thermo-physical characteristics of reactor installations and the fundamentals of their safety, optimizing the plan solutions of the power units and working out the optimal technology for building AES's; it is also aimed at creating and testing experimental models of certain types of equipment. Its fulfillment will allow us to solve a number of top-priority tasks in planning, construction, and providing safety for AES's.

A great deal of attention has also been paid to the problem of studying and generalizing the experience of building and operating AES's. Careful and objective analysis will allow us to work out technical recommendations and normative documents by means of which the planning, installation, and industrial organizations may be guided in creating future AES's or in modernizing existing ones.

Many years of experience in operating AES's bear witness to the reliable guarantee of radiation safety of their personnel and the population. At the Second International Conference of the CEMA Member-Countries on the topic "Problems of Guaranteeing Radiation Safety in Connection with the Operation of AES's," which was held in May 1982 in the city of Vilnius, it was noted that the individual dose of external radiation of the overwhelming portion of the AES personnel does not exceed 10 percent of that allowable per year, while the collective dose, as standardized per unit of electric power produced, is less than that at the same types of AES's in the United States and the FRG. Nevertheless, this question continues to receive principal attention. High-quality conduct of start-up and installation operations is one of the most important conditions for the accident-free operation of an AES. Taking this into account, the program provides for working out recommendations on the organization of start-up and installation operations at AES's, based on a summary of accumulated, advanced experience in the CEMA member-countries. Subsequently, the results of these studies are supposed to be used in preparing normative-engineering specifications in the field of nuclear-power engineering as well as the engineering plans for AES's.

Of great practical importance are the recommendations being prepared for making revisions in the equipment for AES's and developing the technology for repairing it. The above-indicated recommendations must contain data necessary for planning and preparing the repairs, its correct organization, as well as the general technical requirements, indicators, and norms which must be suitable for the equipment after the repairs have been made. They will become the basis for creating the technical processes and normative-engineering specifications for repairs.

The speeded-up development of nuclear-power engineering is bringing about an increase in the proportional share of AES's in the total rated capacity of electric-power systems. In the immediate future increasingly greater demands will be made on AES's with regard to their utilization in a switching system. Within the framework of Section 5 regarding AES's of the CEMA Permanent Commission on Cooperation in the Field of Electric Power an analysis is being conducted on the possible use of AES equipment with VVER-1000-type reactors under the conditions of an electric-power system for the purpose of working out technical requirements for them.

Considerable attention in the program is paid to the preparation of normative-engineering specifications and, in particular, standardized instructions with regard to operating AES systems and equipment. They will ensure the compilation of national instructions and will allow the advanced experience possessed by the CEMA member-countries to be taken into account.

A notable place in the program has been accorded to creating new equipment or modernizing auxiliary equipment for AES's. Work is being conducted, for example, on improving the systems of ventilation and special water purification. They have already developed engineering plans, manufactured experimental models, and partially carried out industrial testing of the newly created high-temperature absorption mechanical filter and an automated system for the chemical and radio-chemical monitoring controls over the cooling agent of the first loop. Working drawings have been completed and models put into production of filters with de-greasing apparatus for cleaning the condenser of the evaporating units as well as scrubbers with new diffusion apparatus.

One of the forms of multilateral cooperation which has been developed in the field of nuclear-power engineering is the construction of large AES's by means of joint efforts. The first such facility will be the Kmel'nitskaya AES, which is being built with the participation of the HPR, PPR, USSR, and CSSR on the territory of the USSR. This extremely large AES, having a planned capacity of 4 million kW, will provide electric power not only for the USSR but also for the other CEMA member-countries. With this goal in mind, the joint efforts of the HPR, GDR, PPR, USSR, and CSSR are being employed to build an electric-power transmission line, LEP 750 kV, running from the Khmel'nitskaya AES (USSR) to Rzeszow (PPR). In accordance with the terms of the agreement, the amount of electric power which each participating country will receive will be directly proportional to its contribution to the construction. In absolute figures these annual amounts by 1990 will comprise the following: for the HPR--2.4 billion kW-hrs., for the PPR--6 billion, and for the CSSR--3.6 billion kW-hrs.

The experience of international economic and scientific-technical cooperation in the field of nuclear-power engineering testifies to the great vital force of socialist internationalism, as well as to the fact that cooperation will develop even further on an ascending line in the interests of the all the CEMA member-countries concerned.

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SOME TRENDS IN DEVELOPMENT OF NUCLEAR POWER

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/Article by Alexandro Bilbao, Karel Menzel, Vyacheslav Sychev, CEMA Secretariat: "Present-Day Nuclear-Power Engineering and Certain Trends in Its Development"/

/Text/ Nuclear energy has gradually come to occupy a firm place in world electric-power engineering. A great deal of attention is being paid in many countries to the creation and increase of capacities of AES's, as well as to the solution of the problems connected with this. The present article is devoted to certain trends in the development of contemporary world-wide nuclear-power engineering. In its preparation materials were used from an International Conference on the experience accumulated in the field of nuclear engineering.

At the present time there is no longer any need to seek out proofs of the good future prospects of nuclear-power engineering. They have been presented by life itself. AES's are already operating in 23 countries, and by the year 2000 they will be operating in approximately 50 of the world's countries. It is undoubtedly true that this is one of the most effective, economical, and ecologically clean methods of producing electric power.

Nuclear-Power Engineering Programs

According to data from the IAEA /International Atomic Energy Agency/ the world now has 281 nuclear reactors in operation with a total capacity of 161,000 MW. AES's produce about 10 percent of the world's production of electric power. In many countries their proportional share in the production of electric power is higher than this figure: in Switzerland--36 percent, Bulgaria--25, Japan--17, FRG--15, and in the GDR--12 percent. In 1981 alone the total rated capacity of AES's grew by 13 percent, which exceeds by several-fold the growth rate of traditional nuclear-power engineering.

It is anticipated that by 1990 the AES capacity in the world will reach 450,000 MW, and by the year 2000--approximately 700,000 MW.

The largest and most dynamic nuclear-power engineering programs are being carried out by France, the CEMA member-countries, and Japan.

FRANCE has developed nuclear-power engineering using pressurized-water reactors with capacities of 900 and 1300 MW. Every year several nuclear reactors go on line, and at the present time, more than 20 units are in operation. In 1981 these AES's produced more than 100 billion kW-hrs. of electric power (40 percent of the total production). It is anticipated that by 1990 the proportional share of electric power being produced at AES's will reach 60--70 percent.

Characteristic traits of the development of nuclear-power engineering in the CEMA MEMBER-COUNTRIES are a coordinated determination of the scope of AES construction, single types of reactor installations, centralized provision of fuel deliveries, specialization and coordination in the production of equipment, and joint decision of the individual problems of the fuel cycle. In most of these countries nuclear-power engineering is based on the VVER type of reactors, having capacities of 440 and 1000 MW. Also developed in the USSR have been channel-type boiling-water reactors with capacities of 1000 and 1500 MW. In 1981 the AES's in the countries of this community produced more than 110 billion kW-hrs. of electric power, and their rated capacity exceeded 20,000 MW. It is anticipated that during the next ten years the total capacity of the AES's will reach the level of about 100,000 MW. According to estimates, by 1990 the contribution of the AES's to the production of electric power will comprise 20--30 percent in certain countries and more than 40 percent in the PRB.

JAPAN, since it does not have its own resources of organic fuel, has intensively developed its nuclear-power engineering capacities. In 1981 there were 24 AES's operating in this country with a total capacity of 17,000 MW (17 percent of the electric power production). In 1982 a governmental program was adopted according to which the AES capacity must be increased to 46,000 MW by 1990 (30 percent of the electric power production), and by the year 2000--as much as 90,000 MW.

We must dwell on certain tendencies of the development of nuclear-power engineering in the UNITED STATES, which in the scope of its nuclear-power engineering capacities ranks first. At the present time there are 75 reactors operating in this country with a total capacity of 58,000 MW. In 1981 these AES's produced 270 billion kW-hrs. of electric power, or 12 percent of its total production in the country. Another 64 nuclear installations are under construction. Nevertheless, nuclear-power engineering in the United States does not have very bright prospects for the future. Since 1974 no orders at all have been made for the construction of AES's, and since 1972 power-engineering firms have cancelled orders for 91 units. This may be explained basically by the general decline in the economy as well as by a number of other reasons. Recently there has been a change in the United States in opinions on the problems of reprocessing fuel and the creation of fast breeder reactors: there has been a victory of the point of view on the need for building plants for regenerating fuel and developing fast reactors.

With regard to the other leading capitalist countries, the FRG is planning to develop nuclear-power engineering at a modest pace, Canada is successfully implementing a nuclear-power engineering program based on heavy-water reactors of the CANDU type, Great Britain is still seeking out new plans in order to replace its old gas-cooled reactors.

Belgium, Sweden, Finland, and Switzerland are consistently and successfully carrying out programs for developing nuclear-power engineering.

The developing countries are manifesting a rapidly growing interest in nuclear-power engineering. For example, large-scale nuclear-power engineering programs have been outlined by India, Brazil, and Argentina. It is characteristic that some of them in their nuclear-power engineering policy are striving for the maximum independence. At the present time India is already producing by its own efforts 90 percent of the equipment for AES's under construction, Brazil is planning to build not only AES's but also a complex of enterprises using a closed fuel cycle.

Despite the impressive achievements of nuclear-power engineering, the present-day scope of its development is considerably less than that which was forecast ten years ago. In many countries the nuclear-power engineering programs are constantly undergoing change, as a rule, in the direction of reduction. In Western Europe, of the AES's planned to be put into operation during the years 1973--1981, less than half were actually put into operation. Among the many causes which have led to this reduction in the pace of building AES's, the determining ones are the general recession, stagnation and crisis factors in the economies of most of the industrially developed capitalist countries.

Reserves and Production of Uranium

Present-day estimates of uranium reserves boil down to the following: at a production cost of as much as 130 dollars per kg of uranium they comprise 5 million tons; the theoretical reserves are estimated at 6.6--14 million tons, which at the moderate growth of nuclear-power engineering will provide enough to satisfy the demand for a much longer period than to the end of the century.

During the 1970's the active exploitation of uranium deposits in connection with the petroleum prices and the rise of prices for uranium led to overproduction and their subsequent decline. At the present time many unprofitable mines and enriching plants are being closed down. This pertains particularly to the United States, where the production enterprises have accumulated uranium whose reserves can satisfy the demands for the next three years. It is anticipated that the curtailment in the production of uranium and the growth of nuclear-power engineering will lead by the end of the current decade to a rise in its price to approximately 160 dollars per kg.

Australia is becoming a major producer and supplier of uranium; it has at its disposal one-fifth of the proven world reserves of cheap uranium. In

In 1982 about 5,000 tons of uranium were produced, whereas it is planned to produce 12,000 tons in 1986.

There has been a growth of uranium production in Canada. In 1981 its extraction amounted to 7,800 tons. Enterprises which are supposed to be put into operation by 1984 could increase production to as much as 15,000 tons a year.

Nevertheless, the present-day relatively favorable situation in the uranium market should not lead us astray. After the year 2000 the situation will, obviously, change significantly. The prospects for the long-term supplying of fuel to nuclear-power engineering are connected to the extensive introduction into power engineering of fast breeder reactors with a closed fuel cycle.

Operational Experience and Technical-Economic Indicators of AES's

The production of electric power at AES's is economically profitable. Nuclear electric power is cheaper than that obtained by using coal--by differences ranging from 8 percent (the United States) to 50 percent (Japan). Naturally, AES's are even more competitive in comparison with electric-power stations operating on petroleum.

Anxiety has been caused by the excessively rapid growth of capital outlays on the construction of AES's. From 1970 through 1980 construction costs in many countries tripled or quadrupled (in the FRG the growth of capital outlays amounted to 15 percent annually, while in the United States this figure was 17--22 percent). The reasons for this phenomenon lie in the general worsening of the economic situation in the world, the constant increase in the requirements for safety and environmental protection, the lengthening of the time periods required for construction, and increases in the costs of materials and manpower.

Recently the time periods required for building AES's have become considerably longer. In the United States and the FRG, for example, they have reached 8--10 years, which has sharply increased construction costs. As a positive example one could cite the experience of France and the USSR, where AES's are built during the course of 5--6 years by means of standardizing engineering solutions and a good construction organization.

Lowering capital outlays can be achieved by means of erecting stations consisting of several units. Canada's experience has shown that a multi-unit system ensures a reduction in capital outlays by 20--25 percent. A significant gain is also achieved by increasing the capacity of the units.

With regard to operational readiness, AES's do not yield to electric-power systems operating on organic fuel. The averaged-out load coefficient achieved in 1980 amounted to 62.5 percent (in the United States--59 percent, in Europe --64 percent). This is not such a bad indicator; however, it greatly lags behind the load coefficient (80 percent) which is usually set forth in almost all the technical-economic fundamentals and works on power-engineering planning. This means an annual loss of production of more than 200 billion kW-hrs. of electric power, i. e., merely by increasing the load coefficient to the designed values we could manage about 30,000 MW of nuclear-power engineering capacities without additional construction.

The best indicators with respect to load coefficient (75--80 percent) are achieved for reactor installations with fuel reloading in progress (CANDU in Canada, RBMK in the USSR). In the CEMA member-countries the VVER-type reactors have demonstrated a high degree of operational effectiveness, significantly exceeding the average world indicators with respect to operational readiness. For example, in the PRB at the Kozloduy AES the coefficient of utilization of capacity exceeds 80 percent.

On the whole, the achieved level of load coefficients cannot yet be considered satisfactory, and there are still many reserves for increasing the effectiveness of AES operation.

Statistics show that the fundamental cause of interruptions in the operation of an AES is the breakdown of the ordinary, non-nuclear equipment (the turbines, generators, and cooling systems). Such organizations as the IAEA and Euratom /European Atomic Energy Community/ have conducted systematic studies of the causes of breakdowns in the operation of AES equipment and have sent the appropriate information to the AES planners and operational services; this has been recognized as an extremely effective measure for increasing the operational reliability of such stations.

Some Questions of Guaranteeing Safety

The worldwide experience of AES operation has affirmed the sufficiently high level of their safety. To the present day there has not been a single major accident with any sort of significant radiational consequences. Radiation of personnel and the population is much lower than the tolerable level and is constantly being reduced; the radiation effects of an AES on the environment are practically nil.

There is a characteristic process of a constant increase in the complication and growing expense of systems guaranteeing safety. In Belgium at an AES which went on line in 1975 30 percent of the expenditures were accounted for by safety measures. For AES's being put into operation in 1982 and 1984 this proportional share increases to almost 50 percent. Therefore, there is an increasingly stronger point of view concerning the need to seek out simpler, more reliable, and less expensive means to ensure safety.

Analysis of the accident in the United States at the TMI /Three Mile Island/-2 AES has shown that the supposed consequences from the discharges of radioactive substances were exaggerated by a factor of approximately 10--30. Studies are continuing, and possibly corrections will be introduced into the normative documents. Over-evaluation of the role played by the operators at AES's in connection with the accident at TMI-2 has changed the approach to the question of presenting information to the operating personnel: the AES control panels should be designed in such a way that the operator can constantly receive only that information which requires action.

The accident at the TMI-2 AES has brought about considerable financial losses. Thus, every day of its idleness costs 100--200,000 dollars. Large sums have been spent on deactivation. The station will not be put into operation for at least another three years. Thus, the losses will amount to hundreds of millions of dollars.

All this testifies to the need for an extensive development of studies on AES safety. Obviously, any outlays in this field would justify themselves if they succeed in ensuring the accident-free operation of AES's; there are more and more of them, and many of them have already exhausted a considerable portion of their operational resources.

Types of Nuclear and Power-Engineering Installations and Prospects for Their Development

The foundation of modern-day nuclear-power engineering consists of light-water reactors (LWR). They account for 82 percent of the power-engineering capacities in the world. The predominance of these reactors will be maintained at least until the end of this century.

Work is constantly going on, directed at increasing the capacity of the units, improving the engineering characteristics of the equipment and systems, etc. Particular attention has been paid to improving the utilization of fuel.

For modern-day LWR's a genuine and effective means for economizing on uranium is increasing the burn-up of fuel from 27--30 to 45--50 MW kg/day. According to our calculations, this will reduce the consumption of uranium by 8--12 percent. More complex is the conversion to optimized fuel grids, which could also ensure savings amounting to 3--6 percent. The above-mentioned measures have extremely good prospects, inasmuch as they not only allow a reduction in the expenditure of uranium but also a decrease in the cost of electric power, as well as a reduction in the space required to store the fuel.

It is generally recognized that providing nuclear-power engineering with fuel for the long-term future is possible only by means of developing and subsequently introducing on a large scale FAST BREEDER REACTORS. During the last ten years substantial progress has been achieved in mastering them. Considerable experience in using them has been accumulated at the following experimental-industrial installations: Phenix (France), BN-350 (USSR), PFR (Britain). The Soviet Union has put on line and successfully operated the BN-600, the largest reactor at the present time (600 MW); it is developing plans for fast reactors having capacities of 800 and 1600 MW for the purpose of subsequently constructing a series of such installations. It is anticipated that the French Super-Phenix reactor, having a capacity of 1200 MW, will reach the critical stage in 1984.

It is necessary to take particular note of the fact that the Phenix and PFR reactors operate on a closed fuel cycle with a return to the reactor of the uranium-plutonium fuel after its reprocessing. In the very near future it is assumed that a time of one year will be reached for the external fuel cycle.

Recently in the United States there has been a change in the attitude toward the problem of fast reactors. According to the data of American specialists, the supplies of spent uranium accumulated as a result of enrichment operations, as well as their use in breeders, could be used to satisfy the consumption requirements of the entire country for electric power over the course of hundreds of years. The United States has finally begun work on construction of the Clinch River AES with a fast reactor.

Slowing down the rate of increase of nuclear-power engineering capacities, as well as the improvement of utilizing fuel in the reactor types which have been mastered, has postponed somewhat the time for the mandatory large-scale introduction of fast reactors into the nuclear-power engineering system. Evidently, this process will be actively carried out during the first quarter of the next century.

At the present stage of development of the breeders the principal tasks are: reducing their cost and increasing their competitiveness (as of now, they are 1.5--2 times as expensive as the light-water reactors) and the solution of many problems connected with implementing the closed fuel cycle.

At the present time a number of countries are considering the problem of using nuclear fuel for a heat supply. Evidently a new major trend will take shape quite rapidly--nuclear heat-and-power engineering.

The greatest achievements in this field have been made by the Soviet Union. For a long time now steam by-products have been used at many AES's; since 1973 the Bilibinskaya ATETs /Nuclear-Power Heat-and-Electric-Power Station/ has been in operation. In the cities of Gorkiy and Voronezh pilot nuclear-power stations providing heat supply (AST) with reactors having a capacity of 500 MW are under construction. A plan is being developed for an AST with a capacity of 300 MW. Construction has begun on a large ATETs with VVER-1000-type reactors not far from the city of Odessa. Studies are being conducted on the possibility of creating nuclear-power plants for industrial heating (ASPT).

After their start-up and mastery, the pilot projects of the nuclear-power plants producing heat supply which are being built in the USSR will become the prototypes for analogous installations in the other CEMA member-countries.

Some limited experience in utilizing the heat of AES's has been accumulated in Sweden, Switzerland, and Canada. France, Sweden, and Finland are developing plans for AES's with a heat-supply capacity ranging from 100 to 400 MW. The PRB, GDR, and CSSR are planning to use nuclear sources of energy for supplying heat to cities.

Studies have shown that nuclear sources of heat are economical, and safe; nor will their use have any adverse consequences from an ecological point of view.

High-temperature gas-cooled reactors for producing high-potential heat have not yet emerged from the stage of research and experimental-industrial processing.

In the FRG they are continuing to use the AVR reactor with a capacity of 15 MW with a temperature of the helium-type heat carrier at 850-950°C. It is planned to put on line in 1984 a prototype reactor with a capacity of 300 MW for producing electric power. Work is being conducted on developing industrial reactors for gasifying coal. In the United States the Fort St. Vrain reactor has been in operation since 1976, having a capacity of 300 MW. A commercial reactor for producing electric power and steam is being planned. Japan's immediate goal is to create an experimental reactor with a capacity of 50 MW and a helium temperature of 1000°C for work with engineering processes in metallurgy and chemistry (construction to begin in 1986). In the USSR a reactor is being planned with a heat capacity of 1000 MW for producing electric power, hydrogen and ammonia.

Fuel-Cycle Problems in Nuclear-Power Engineering

The proposals for deliveries of enriched uranium, as well as for natural uranium, exceed the demand, and the existing capacities are considerably underloaded. This is explained by the fact that the mining and enriching capacities developed underlimited and, as it turned out, inflated estimates of the rate of AES construction.

The principal method of enriching uranium remains that of gas diffusion. At the present time, however, enriching is also beginning to utilize the centrifuging method; its use is estimated to be more economical.

In the United States gas-diffusion plants are loaded only up to 35 percent of capacity. The improvements made on the installations have allowed an increase in their capacity of as much as 27.3 million units of fissioning operation (YeRR) [Separative work unit--SWU] per year with a reduction of specific power outlays by 23 percent. The first two installations with centrifuges are supposed to start up in 1988-89 with a rise to a capacity of 2.2 million SWU per year.

Built on a multilateral basis, the Eurodif Gas-Diffusion Plant (Tricasten, France) has come up to its planned capacity of 10.8 million SWU per year and is becoming a very large supplier of enriched uranium.

The trilateral URENCO [Anglo-Dutch English] project is being successfully carried out: two installations with centrifuges are already in operation (in Britain and the Netherlands), and construction of a third installation is being planned in the FRG. At the end of the 1980's the capacity of these installations will reach as much as 2 million SWU per year.

There is a steady increase in the amount of processed fuel. Most of it is stored at the reactors, a lesser amount is hauled to storage facilities at reprocessing plants or to storage facilities outside of the reactors. Only an insignificant portion of the fuel is reprocessed.

The most widespread type of storage facility consists of water pools at reactors. In connection with the slowdown in the construction of reprocessing plants, the initially planned storage period of three years has almost everywhere been increased to approximately ten years; in connection with this the capacity of the existing storage facilities has proved to be insufficient. Increasing the capacity of storage facilities is being carried out by means of a more compact placement of the fuel assemblies and building additional pools at reactors. Some countries are considering the possibility of creating centralized fuel-storage facilities.

The transportation of spent fuel is regarded as a practically mastered process. Use is made of water (Britain, France, Japan), railroad (the CEMA member-countries, the United States), and for hauls over relatively short distances--motor-vehicle transport. Both wet and dry systems of transportation have been worked out. Transport means ensuring reliable and safe hauls have been created; international regulations for transporting processed fuel have been agreed upon.

In most countries which have large-scale nuclear-power engineering programs the basis of the technical policy in the field of handling processed fuel is the closed fuel cycle, providing for the reprocessing of fuel, the repeated use of uranium and plutonium, the solidifying and burial of radioactive wastes. However, practical activity in all these fields has notably lagged behind the requirements of a harmonious development of nuclear-power engineering. For example, in Europe it will not be possible to reprocess more than 6,500 tons of fuel before 1990; approximately 10,800 tons will not be reprocessed and will remain in storage.

By now considerable experience has already been accumulated with regard to fuel regeneration; it has demonstrated that the technology and equipment are sufficiently reliable and safe. Nevertheless, the putting into operation of large plants for reprocessing the fuel of light-water reactors is anticipated only at the end of the 1980's and in the 1990's. Thus, in France two plants with a capacity of 800 tons per year are now under construction and are scheduled to go on line in 1987; in Britain permission has been granted to build a plant with a production capacity of 1200 tons a year. In the FRG planning has begun on two plants which are calculated to reprocess 350--700 tons of fuel a year. Finally, the United States has also announced the renewal of work on fuel regeneration.

For reprocessing the fuel of light-water reactors the purex-process is considered to be the most acceptable. The utilization of this method for reprocessing the fuel of fast reactors requires additional research and check-ups at experimental plants.

The technology of handling low-level and medium-level wastes is considered to be mastered on the whole. The problem of handling high-level waste which are formed basically in the reprocessing of fuel is the main and most complex factor. Projects are being conducted, for the most part, along the lines of enclosing the wastes in glass and their subsequent long-term burial in deep geological formations.

Nuclear-power engineering has attained such a level that without it the most important national-economic problems of many countries could not be solved. The paths of the further development of nuclear-power engineering have been defined with sufficient clarity: steady and intensive growth of capacities and the mastery of news fields of application, improving the already-mastered types of reactors, the gradual conversion of nuclear-power engineering to the breeder system, effective solution of the problems of reprocessing fuel and handling radioactive wastes, the steady increase of economies and competitiveness.

Solution of these problems will ensure the uninterrupted growth of the role played by nuclear-power engineering in the world fuel-and-energy balance.

2384
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AVIATION DRIVE COMPRESSOR UNITS INCREASE EFFICIENCY

Moscow PLANOVOYE KHOZYAYSTVO in Russian No 4, Apr 83 pp 107-109

[Article by A. Aver'yanov, candidate of economics: "Effectiveness of Enlarging Gas-Pumping Unit Power."]

[Text] The gas industry belongs to the national economy's rapidly developing sectors. Gas extraction increase is rising annually. Whereas in 1980 it was 28.6 billion m^3, in 1982 it was 36 billion. This high increment was attained because of the introduction of advanced technology for building main gas pipelines, creation of domestic, highly productive gas pumping units which guarantee construction and start-up of gas compression stations in very short time.

Starting in 1974, for example, gas pumping units GPA-Ts-6.3 with power of 6,300 kW with aviation drive began to operate on the country's main gas pipelines. Their main advantages as compared to stationary units are: high degree of transportability because of block design, small overall dimensions and weight of the blocks. In West Siberia where the main gas pipelines are built under harsh climate conditions, lack of roads, swampy locality, and in zones of permafrost, transportability of the machines and mechanisms is one of the main factors of economic efficiency. The block design permits the unit blocks to be delivered in a state of complete plant readiness and the minimum installation operations are needed at the gas compressor station. The use of block and by-assembly methods of repair result in higher repair suitability of the units. If necessary, the aviation drive is completely replaced and centered in 8 h, the supercharger rotor in 24 and the main oil pump in 4 h. Introduction of this system created a large fund of the most important assemblies and set-forming items and permitted their rapid replacement without disrupting the operating mode of the gas compressor station because of automatic connection of the reserve unit. Subsequent major repair of the assemblies is done at the manufacturing plants. This excludes the need for repair workshops with highly skilled service personnel at the gas compressor stations. It permits a more than 50% reduction in the number of service personnel. It allows the engines to run on gas transported on the gas pipeline, excluding the need for additional heat and water supply sources, as is needed in stationary gas pumping units.

The introduction of the special maintenance method which consists of careful observation of each engine, taking emergency design-production measures to eliminate revealed defects, as well as daily training of the personnel in the rules of maintenance and operation of the new equipment without taking them away from production fostered an efficient solution to questions of improving reliable running of the compressor stations which were equipped with GPA-Ts-6.3 units. The annual conservation of alloyed metals from using series-manufactured parts and assemblies of the base aviation engine is 7,000 T. These units are used in practically all areas of the unified system of gas supply in the country, including with ambient temperature from -50 to +45°C and high level of dust content. During the 10th Five-Year Plan, they pumped over 300 billion m^3 of gas. The natural gas extraction of 1980 was 435 billion m^3. This was considerably promoted by the introduction of these gas-pumping units.

It is not easy to create a unit based on an engine used in aviation. The engine cannot be simply employed, it must be converted to gas fuel and equipped with new systems of regulation, air purification, preheating, noise abatement, altered elements of the circulating section, etc. The new method of maintenance together with the large experimental base of machine builders, including test stands and a unique testing station with gas production ring in the Sumi Machine Building Production Association imeni M. V. Frunze allowed the gas-pumping unit GPA-Ts-6.3 to be included among the best after a short period of operation. With close cooperation between the gas industry workers and the machine builders, reinforced by work on this unit, problems of creating and developing new, highly efficient gas-pumping units were solved in a short time. Their use allowed gas transporting from the fields in the country of difficult access to be set up, accelerated start-up the gas-compressor stations and guaranteed development of main gas pipelines. The economic effect from this was R 1.5 billion in the 10th Five-Year Plan.

The extant doubts as to the technical and psychological compatibility of equipment taken from aviation, with the equipment traditionally used in the gas industry have been completely removed. This is largely due to the creators, manufacturers and operators of the GPA-Ts-6.3 unit who not only played a large role in accelerated construction and start-up of the compressor stations at the main gas pipelines, but also changed the psychology of the people who believed in the broad potentialities afforded by using this advanced equipment in the gas industry.

These units are operating on main gas pipelines made of pipes with diameter 1,020 and 1,220 mm with working pressure of 56 and 76 atm. The optimal for these gas pipelines are gas-pumping units with power of 6,000 and 10,000 kW. Gas pipelines in the 11th Five-Year Plan are predominantly built of pipes with a diameter of 1,420 mm with working pressure of 76 and 100 atm. It is expedient to use gas-pumping units with power of 16,000 and 25,000 kW for gas pipelines with these parameters. Analysis shows that the introduction of gas-pumping units of this power will reduce the relative specific cost of the gas compressor station by 28 and 36 percent, and the relative operating outlays by 16 and 19 percent, respectively.

Successful operation of the gas-pumping units with power of 6,300 kW with aviation drive confirmed the correct selection of the new trend in making gas-transport equipment which guarantees accelerated scientific-technical progress in the gas industry, and permitted work to be started to make units of this type with power of 16,000 kW. The GPA-Ts-16 gas-pumping unit with aviation drive was developed and successfully passed state tests in a short time. Starting in 1982 the industry of chemical and oil machine construction began series production of these units. It is remarkable that their power drive was developed on the basis of an aviation engine which had used up its flight service life on Tu-154 and Il-62 aircraft.

The Basic Directions of Economic and Social Development of the USSR for 1981-1985 and for the period up to 1990 provide for forced development of gas extraction, bringing its volume to 600-640 billion m^3 in 1985. In order to fulfill this program, it is planned in the 11th Five-Year Plan to develop the gas fields of Urengoy, Vyngapur, and Medvezh'ye. West Siberia will become the world's largest supplier of natural gas. It remains during the 11th Five-Year Plan to construct and start-up five of the largest main gas pipelines of West Siberia-center of the country, as well as the Urengoy-Pomary-Uzhgorod gas pipeline. These are the central construction sites of the 5-year plan and they should be completed on time.

The grand program is being successfully implemented. At the end of 1981, the gas pipeline Urengoy-Gryazovets-Moscow was put on rated output almost at the same time that all the construction and installation work ended at it. Competing for a worthy meeting of the 60th anniversary of the formation of the USSR, the collectives of the Ministry of Construction of Oil and Gas Industry Enterprises completed construction of the linear section of the Urengoy-Petrovsk gas pipeline ahead of schedule. In the near future it will reach rated output. Construction is ending on the Urengoy-Novopskov route. Work is underway at unprecedented rates to build the Urengoy-Pomary-Uzhgorod gas pipeline: an average of 8-10 km of trunkline was laid every day in the summer months.

Over 200 billion m^3 of natural gas per year will travel on the fuel and energy arteries connecting West Siberia to the center of the country. Starting in 1984, some of it will be used for export, while the rest will be used domestically to provide for the needs of industry and for further improvement in the welfare of the people. Introduction into the gas industry of gas-pumping units with aviation drive considerably promotes the fulfillment of this important national economic task.

In recent years the energy equipment machine builders have built gas-pumping units with power of 16,000 and 25,000 kW. These are the GTN-16 and GTN-25 units. They are made with a single block, completely assembled at the plant, and are several times more productive than their predecessors. However, these units also require construction of individual buildings or installation in the common machine room of the industrial building.

Comparison of the GTN-16 and GPA-Ts-16 with aviation drive reveals great advantages of the latter. The duration of construction of the gas compressor station for northern conditions is thus reduced 3-fold. The GPA-Ts-16 units are supplied in a state of complete plant readiness and completeness, while the GTN-16 shipment set does not include a number of types of auxiliary equipment. Specific metal consumption of the GPA-Ts-16 units is 9 T/kW, while in the GTN-16 it is 14.9 T/kW. Overhauling of GPA-Ts-16 motors is performed at the manufacturing plant which allows to reduce the number of maintenance personnel at the gas compressor station and accordingly, the costs for housing construction. Overhauling of GTN-16 motors is performed at the gas compressor station, as a result of which the unit is down in maintenance for no less than 30 days.

It is very important to maintain the efficiency of the turbine at the rated level for the entire prescribed motor service life. Experience of operation and repair indicates that the efficiency of the stationary gas turbines in 1 year of operation diminishes an average of 2 percent, and is not restored during repair. This decreases the efficiency of the units by 15-20 percent in a 5-year period as compared to the rated amount. Rapid corrosion wear of the gas turbine blades and warping of the housing parts also promote decreased gas turbine efficiency. A number of GTK-10 units, for example, now require replacement of the first stage blades. A significant advantage of the units with aviation drive is that their repair is centralized at the manufacturing plant, without disruption in the operating mode of the gas compressor station. As a result, the power and the efficiency of the turbine are restored to the rated level.

A similar approach to repair-restoration operations also permits solution to the questions of renovating the main equipment of the gas-pumping units. Calculations indicate that the introduction of gas-pumping units with power of 10,000 kW as compared to the units with power of 6,000 kW will decrease the relative specific cost of the gas-compressor station by 16 percent, and the relative operating outlays by 8 percent. One can develop a gas-pumping unit of 10,000 kW with full-pressure supercharge output to 18 million m^3/day (output of the GPA-Ts-6.3 supercharger is about 11 million m^3/day). It is based on the series-manufactured GPA-Ts-6.3 unit. The annual economic saving from updating one of the compressor stations by introducing GPA-Ts-10 units with aviation drive instead of the stationary GTK-10 units manufactured by the power machine builders exceeds R 1.5 million.

Several hundred GPA-Ts-6.3 units are currently operating at the gas-compressor stations with power of 6,300 kW with aviation drive. Having developed specific replacement stock of gas-pumping GPA-Ts-10 units, one can start to replace the GPA-Ts-6.3 units with GPA-Ts-10 at the active gas pipelines as they use up their service life. This can be started already in the 12th Five-Year Plan. By reducing the number of units to be installed at one compressor station while preserving its power, the state will obtain an additional saving of capital. Replacement of the GTK-10 units with the GPA-Ts-10 with aviation drive will simplify the problem of renovating the worn-out and obsolete gas turbines manufactured by the power machine builders.

Thus, these examples demonstrate that the introduction of gas-pumping units with aviation drive is a new trend in the creation and use of advanced gas-transport equipment by the gas industry which considerably improves the efficiency of gas transport. Enlarging the unit power of the gas-pumping units, in particular, units with aviation drive, will guarantee a rise in output of the gas pipelines. The task of the ministries of the gas industry, aviation industry and chemical and oil machine building, as well as the corresponding departments of the USSR Gosplan is therefore to create in the

11th Five-Year Plan a gas-pumping unit with unit power of 25,000 kW with aviation drive. The power machine builders need to be armed with the leading experience of the aviation industry and the chemical and oil machine building industry, and based on unification of the construction-planning solutions of the gas-compressor stations, single type of spare parts and technology of the repair service, set up production of gas-pumping units of this type with power of 16,000 and 25,000 kW.

At the November (1982) Plenum of the CPSU Central Committee, General Secretary of the CPSU Central Committee Yu. V. Andropov stated that we have great reserves in the national economy. We should search for these reserves in accelerated scientific-technical progress, broad and rapid introduction into production of the achievements of science, technology and the leading experience. The use of gas-pumping units of increased unit power with aviation drive in the gas industry will be a worthy contribution of the machine builders toward fulfillment of the decisions of the November Plenum of the CPSU Central Committee.

9035
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GENERAL

PETROLEUM, GAS DEVELOPMENT IN WESTERN SIBERIA

Moscow ZNAMYA in Russian No 4, Apr 83 pp 208-216

[Interview with Yu. G. Erv'ye, Hero of Socialist Labor, Lenin Prize Recipient, deputy minister USSR Ministry of Geology as told to correspondent Edvard Maksimovskiy; date and place not specified]

[Text] Based on the deposits in Western Siberia, the country has produced a record level of gas--501 billion cubic meters last year. The Tyumen' people are approaching a daily production of a million tons of petroleum--this will be an event for our economy. Every day newspapers print messages from Tyumen'; you switch on the TV or radio--you will surely hear about Tyumen'. This is quite understandable: we now talk about petroleum and gas the way we talk about bread. Energy stored for millions of years in the depths of the planet moves machine tools, machines, tractors, illuminates cities and villages, lifts planes and rockets.... Our civilization is a hydrocarbon one--I think no one will object to this definition. Even a superficial analysis of the power balance makes it clear immediately that all remaining sources of heat, motion and light cannot even be compared to petroleum and gas.

However, this is nothing to be proud of. It is infinitely more important to utilize petroleum and gas as chemical raw materials rather than as fuel. I want to remind us of the famous words of Dmitry Ivanovich Mendeleyev: to burn petroleum in fire boxes is like kindling a stove with bank notes. In fact, hydrocarbons, without which modern chemistry could not exist for even a day, cannot be replaced by anything. Their reserves are not replenished--the geological youth of the earth has passed. In the future, man will obtain more and more energy from other sources--radioactive materials, thermonuclear synthesis, the sun.... Very promising investigations are being carried out directed toward the creation of hydrogen fuel whose resources from the world standpoint are practically inexhaustible--every puddle, every raindrop contains hydrogen! At the same time, this ecologically clean fuel burning in oxygen, produces water again. Anticipated or totally unanticipated discoveries will free our descendants forever from the threat of power hunger. However, there is another question; will this superproblem be solved in principle before the deposits are depleted?

The words "Irreplaceable resources of petroleum and gas" sound extremely melancholy. However, it is one thing if one overspends and stretches to the next pay and goes, where possible, into debt. It is another matter if the earth's population were suddenly deprived of basic kinds of natural fuel and raw materials. Here there would be no one to come to the rescue.

The volume of prospecting in the country is increasing. More and more money is being spent on searching for new deposits. We can say that in this 5-year plan period the Tyumen' geophysicists will prepare many promising petroleum and gas bearing structures and hand them over to drillers of northern expeditions. And, while the number of discovered deposits is not endless, there is no cause for alarm. In spite of the impressive summaries in which numbers with eight zeroes became customary for petroleum and with 11 figures for gas, we are, so far, producing only a small part of the natural resources--just enough for our own use. And another thing. Sometimes we simply forget how big, how truly immense our country is--one-sixth of the earth's surface!

Let us take Western Siberia only. Fifty years ago, Ivan Mikhaylovich Gubkin, the founder of petroleum geology in our country, at a meeting of the USSR Academy of Sciences in Sverdlovsk, appealed for a search for petroleum on the eastern slope of the Urals. At that time, the country produced about 14 million tons of liquid fuel and 300 million cubic feet of gas. Today, Kazakhstan's Mangyshlak alone produces more. That speech by Ivan Mikhaylovich is commonly known and popular to this day and I would like to remind you of his interview a few days after the meeting: "The prospects and importance of developing petroleum production in these krays are immense. Production in these regions may provide for the needs not only of the Urals-Kuznetsk Combine, but of the entire USSR economy."

The whole country gave thought to how to obtain more fuel. Significant in this connection is a letter sent to the Minister of the USSR Petroleum Industry by Ivan Grigor'yevich Vikulov, tractor operator of the Shevyrinskaya MTS [Machine-Tractor Station]: "In our Tyumenskaya Oblast...there is an acute shortage of fuel, as well as lubricants. Is it not possible to explore the resources of our Abatskiy rayon? Not far from my village I began to notice the seepage of an oily liquid to the surface of the ground.... Also water was seeping from the mountain slope with, it seemed, something like fuel poured on it, covered with a layer of violet color. Of course, I do not know the exact signs of petroleum deposits, but from these signs I assume that there is petroleum here...." It is very pleasant to read such a letter--you can see for whom a geologist, a geophysicist and a petroleum worker work. Vikulov's observations were, of course, no discovery for scientists. However, basic events developed in other regions of the Tyumenskaya Oblast.

The first commercial petroleum in these huge areas, covered with innumerable swamps, lakes and rivers, was obtained by the drilling brigade of Semyon Urusov. I recall him very warmly. Very bright man! He had only a sixth grade education--but not every engineer knew so much. In 1963, he was awarded the title of Hero of Socialist Labor.... The first petroleum was beautiful--a miracle! Greenish-brown trimmed with a golden foam like a school girl in her ball gown. Fragrant. It was scooped up by the handful and tasted. The joy was indescribable. And, suddenly, the well stopped flowing. As if it had been cut off by a knife. What disappointment what aggravation! It once again came to life after 2 hours but the flow of oil proved to be insignificant. After several months on a well, also drilled by Semyon Urusov's brigade, there was a powerful gusher. So that there would be no confusing of minds with large figures, Mikhail Shalavin, chief of the expedition and an old Baku man, coded with data on the gusher force as "iki-yuz-ali-uchyuz," which, translated from Azerbaijan, means 250 to 300 tons. Thus Shaim reached its full strength and with it began the history of commercial Siberian petroleum and all subsequent successes of the geologists. Shaim confirmed our conviction in the presence of oil in Tyumen' soil. Samotlor, with many times greater reserves, did not leave such a happy feeling. We expected Samotlor, we went for it. It was calculated by using a pen, as once was one of the planets of the solar system. Of course, the radiogram about Samotlor's discovery was recorded in the economic history of the country. The date was 22 June 1965: "At Samotlor R-1, after drilling through the entire thickness of the seam, a gusher of waterless petroleum was obtained with a visual daily yield of over 1,000 cubic meters. Nobody was afraid to scare off success--discoveries were made more and more often. We accumulated experience, knowledge and believed in the strength of the earth and in our strength.

Of course, if anybody thinks that the discoveries were marching with a brass band, he is wrong. And the difficulties were not even in the climatic conditions of Tyumen'. In some 15 years, Western Siberia was converted to the main fuel-power and raw materials base of the country. This was a difficult matter for millions of people. What did we geologists have to start with? Almost zero. There was practically no scientific or production base. The first explored wells were drilled directly in cities and settlements--it was easier to deliver heavy equipment there. No one even dreamt then about swamp buggies and air-cushioned platforms. By the way, it should be taken into account that the unknown locations of mineral resources and the weakness of the geophysical methods made no difference about where to start sinking wells. A drilling derrick appeared even in the city of Tyumen' on Republic Street to the joy of the local boys. It stood there for a long time. It was suggested that it not be dismantled and remain there as a memorial....

Derricks also appeared in Surgut and in Kanty-Mansiysk.... But not one well was productive. As if they were hexed. Republic Street, for example, had a gusher of mineral water with a small quantity of the simplest hydrocarbon--methane. This was an unimportant find. In other wells, films of oil were found, but that was all. Surprisingly it was found that all the old settlements in the oblast were located outside the deposit limits. But as soon as we moved away from places which have been populated for centuries, discoveries began.

It should not be forgotten that it was necessary to fight to prove that we did not look for petroleum in swamps for nothing. It was also necessary to defend ourselves, for at times situations arose not favorable to us. The longer the depths were silent, the more the Tyumen' geologists were crowded by scientific opponents. When I was the chief of the Tyumen' Geological Prospecting Administration, a young dark-haired man with dark burning eyes, an assistant professor, a science candidate, came into my office and said: "I'm studying the paleoclimate and I'm ready to prove that your administration wastes state money searching for petroleum. It cannot be found north of the 60th parallel. This cannot be refuted." But, in fact, the 60th parallel passes south of Samotlor. But then Samotlor was not in the project.

With the stubbornness of one obsessed, going to the highest level of authority, this science candidate tried to prove his theory. Even when petroleum gushers were found in Shaim and Megion, he continued to affirm that this is a local phenomenon. Imagine a man who comes to the zoo and, having seen a giraffe, states that there cannot be such an animal in nature. They tell him: "Here he is, a giraffe!" And he replies: "No, this is impossible." What can one say? Even after petroleum deposits were discovered, one responsible worker of the RSFSR Gosplan stated: "What petroleum can there be in Tyumen'...."

I recall battles for the Nizhne-Obsk GES. The Obsk water reservoir would cover 113,000 square kilometers, literally burying petroleum-gas bearing areas. Specialists, the public and noted Soviet writers argued against the project. Thus, at times it was necessary not only to prospect for petroleum and gas in Tyumen', but also to save our work from zealous people.

In the middle fifties, disappointments were not too rare. Seven years separated the first large discovery from the second. This tells us something: stamina and confidence were necessary. But even when things began to move we again were blamed, but this time for inefficiency. Here is one episode. Twenty years ago, a seismic survey discovered a large rise, called Salymskoye, between Khanty-Mansiysk and Nefteyugansk. Of course, the rise is an important criterion of a deposit, but not entirely compulsory in each individual case. A very respectable geologist visited the Salymskaya well, looked at the well logging charts and immediately concluded that the well was very promising. However, tests disappointed everyone. It happens...

This failure--geology does not always guarantee absolute victories--prompted a noted petroleum worker who had worked for a long time in an area between the Volga and the Urals, to blame the Tyumen' people for shortsightedness. No more and no less. He appealed to higher authorities with a categorial statement: a great discovery was made at Salym, and the Tyumen' people, the so-and-so's, could not recognize it.... The results of some more tests were received that gave rise to no doubts and this person retreated, at the same time calling the Tyumen' petroleum prospectors, including me, adventurists.... As you see, not only scientific but purely human passions boil around geologists. I do not want to contrast the profession of the geologist with other professions but I am convinced that this business is not for everyone.

Mountain ridges and peaks, glaciers and rivers, squares and streets and steamers, and entire deposits were named in honor of pioneers, remarkable Soviet geologists and geological prospectors. The name of Andrey Fedorovich Tarasov, drill foreman, is carried by a street in the Tarko-Sale settlement and by a petroleum deposit in the Purovsk rayon. There is a street and a petroleum-bearing area named in honor of geologist Viktor Petrovich Fedorov who participated in important discoveries in the Surgut Priob'ye. The chart of mineral deposits carries the names of geologists Vadim Dmitriyevich Bovanenko and Nikolay Borisovich Malik-Karamov. The memories of I. M. Gubkin, Ye. V. Sutormin and V. I. Muravlenko are immortalized--large deposits of petroleum and gas were named for them.

In the fall of last year, several days before the 65th anniversary of the Great October, a memorable event occurred in Tyumenskaya Oblast: the trillionth cubic foot of gas was obtained. That took 16 years. The next trillion judging by calculations, will take only one-third that time. We recall that the first billion was produced at Tyumen' in 1964. In 1980--it is already 131 billion! By the end of the 5-year plan period, and perhaps before, I think sooner than later--the Tyumen' workers will start producing a billion cubic meters a day. I cannot help recalling the words of Aleksandr Nikolayevich Radishchev: "How rich Siberia is in natural resources. What a powerful kray it is! More centuries are required, but as soon as it is settled it will play an important role in the chronicles of the world!"

How much gas is there in this earth? Five Siberian deposits are considered the largest--Urengoy, Medvezh'ye, Yamburg, Zapolyarnoye and Bovanenkovskoye. Until now over 10,000 gas deposits on earth were discovered including some very small ones. World production exceeded 1.5 trillion--or converting conditionally to petroleum--1.5 billion tons (a ratio of 1,000 between gas and petroleum is assumed). And yet, we have only begun increasing the gas fields. I think a small summary of reserves should be of interest. We will take only thoroughly explored reserves according to data as of 1 January 1979. The United States--5.7 trillion cubic meters; Central and South America--2.3; Western Europe--over 4; the Near and Middle East--14; Africa--5.3 trillion cubic meters. A total of about 46 trillion cubic meters. At present it has possibly passed 50 trillion.

Our gas program is actually only developing. The greatest load falls on Urengoy. By the most approximate estimates, its reserves exceed by several times the total gas reserves of such producing countries as Mexico, Algiers, Canada, England and the Netherlands. Yet the first well began producing only 5 years ago. Urengoy is a gas Samotlor. We walked to it through dark and bright days. But even in the minutes of the most bitter disappointments, the Tyumen' geological prospectors did not blame nature or fate but themselves. If a man recognizes his errors, it means that he hopes to find a way out and does not lose faith in success. Of course geology, like any other science, strives to use mathematics in its area of activity, but geology also needs luck... Yes, the same everyday luck, the lack of which we complain about every time something did not happen that should have happened.

I think that success is most frequently achieved by those who are prepared for it either intuitively, or where they feel it is close. Only thanks to the painting, "Menshikov in Berezovo" painted by Surikov 100 years ago did I, like a majority of others surely, know that such a village as Berezovo existed in Siberia, although it had already been established in the 16th century. And here, on 21 April 1953, Berezovo was added into the economic reports of the world--there was a powerful gas gusher there. This discovery equaled the discovery of the petroleum at Shayma in importance.

Now any young specialist, when glancing at the logging diagram of the Berezovo well, will say with assurance that a gas-filled seam was discovered. Yet, in those days, even prominent specialists could not persuasively interpret the logging diagram. But this is another topic. When drilling a well, geologist Aleksandr Bystritsky (later he was awarded the Lenin Prize), grossly violated regulations and, as is customary, was penalized for that. The situation was that the well was planned near the taiga river Kazym, a right-hand tributary of the Ob', but it was not possible to transport the equipment there. Then it was decided to drill the well at Berezovo. At the last moment Bystritskiy decided not to deliver the equipment to the designated area as is usually done, but to drill the well at the point where the equipment was unloaded--on the bank of the Vogulka River. Arbitrarily he had shifted the point 2 kilometers. Thus, modest Vogulka became famous.

It was so long ago that perhaps it does not need to be recalled. Yet, in 1956, a well was drilled where it was originally planned. What happened? Only water was obtained. Such luck for a geologist! Of course, there are examples quite the contrary. The history of the discovery of the Punginsk gas deposit is well known. The place for drilling the first well was calculated theoretically. On the way to it, the brigade strayed; Malaya Sos'va--a river meandering in the taiga. One section cannot be told from another--it would be easier to discriminate between twins. The brigade went 2 kilometers farther up the river than was necessary. The well was found to be dry. Yet when a well was drilled where it was planned earlier to drill, commercial gas was obtained. So there it is! No matter what the preliminary results are, one should not prematurely panic or be delighted. It is not in vain that they say: the drill bit is the best professor.

The more we learn, the more we realize how little we know. The near-earth space is better investigated than the upper strata of the crust of the earth. Even the mineral deposits of Western Siberia where we have extracted millions and billions of tons of petroleum and cubic meters of gas for many years have yet to uncover all their secrets. But why complain where here there are only 12 meters of exploration wells per 1 square kilometer--several times less than in old petroleum regions.

Actually, prospecting is only beginning at the Yamal and Gydansk peninsulas, that are highly interesting from the standpoint of geology. Only a few wells have been drilled here, but they disclosed curious information. In the United States, results are produced in only up to 30 percent of prospecting wells and in up to 60 percent of operational ones; the remaining ones are dry. In North Tyumen' the picture is considerably more gratifying.

The northern seas' shelf is equal to one-fifth of the territory of the Soviet Union, i.e., it is more than double the area of the West Siberian plane. In time, we will come out to the littoral waters of the Arctic Ocean and here there is something to think about! It is believed that about 60 percent of the world's reserves of petroleum and gas will be found in the shelves. Over 100 countries are searching for these resources in the seas and about 40 of them--produce them. The West Siberian plane is huge: from the area of the low rounded hills of Kazakhstan and the Altay Mountains to the Arctic seas--2,500 kilometers, and from the Ural Mountains to the Yenisey--1,500 kilometers.

And what about beyond the Yenisey? Say in West Siberia, the annual volume of exploring-prospecting drilling is over a million meters, while on the Siberian platform about 2.8 million meters have been drilled in the last 40 years. These meters are practically nothing compared to the immensity of the space: the average density of the exploration drilling is 70 centimeters per square kilometer--one-seventeenth that for the country. As was once done in Tyumen', drilling is basically done where it is possible to overcome the difficulties in delivering equipment--mainly along rivers. For example, in the immense Tungus syneclise work has only begun.

The work here is considerably more complicated than in Tyumen' even though there are no muddy swamps with permafrost underneath; the topography is very rugged with hills and in the northern part, it is mountainous with canyons, gorges and rocky talus.

Nobody will say that great geological discoveries ended in this same Tyumenskaya Oblast. And what can one say about the gigantic spaces between the Yenisey and Lena Rivers? With very little deep prospecting 22 petroleum and gas deposits were discovered and encouraging results were obtained at 25 more places.

Let us take, for example, Evenki. In area the autonomous okrug exceeds such a union republic as the Ukraine. Yet its population is 1/2500 that of the Ukraine. The mining industry can give a powerful momentum to the development of this remote taiga kray. Geologists who roamed Evenki extensively speak enthusiastically about its underground treasures. It is possible that in the future a question about creating a new fuel and raw materials base here will be posed. Meanwhile, Tura is the center of the autonomous okrug and a small settlement of the city type on the lower Tunguska River where the Kochechum flows into it and is not famous for anything. Perhaps these rivers can be used to transport fuel, equipment, food and other freight people in Evenki need. This is very expensive. Geologists testify that delivery of devices is two to three times more expensive than the devices themselves. Economists testify that to take care of each worker and his needs it takes up to 20,000 rubles per year--several times more than in the populated regions of Siberia.

The time will come when Soviet geological prospectors will develop work widely beyond the Yenisey, unafraid of the rugged nature or difficulties of everyday life; the same as they now work on the unpopulated banks of Ob's bay and in the inhospitable Yamal. When will this time come? Between the Yenisey and the Lena, so far, there is no gas Berezovo or a petroleum Shaim which, at one time, assured us of the great potential possibilities of the Tyumenskaya Oblast. There are fairly numerous deposits on the Siberian plateau, but they are not especially bountiful. They are of interest as forerunners of future geological discoveries and, perhaps, the Siberian ocean of energy will extend here.

Gas is gaining a more and more solid position in the economy of the country--it is convenient to transport, is a cheap and efficient fuel and raw material. The Soviet gas program, calculated for a long period, made an immense impression on many foreign specialists. We are rightfully proud of it. In the current 5-year plan period, six transcontinental gas pipelines will be built with a total length of up to 20,000 kilometers. The first of these, the Urengoy-Gryazovets-Moscow is already operating at full capacity. The second gas pipeline, the Urengoy-Petrovsk (this is an ancient city on the Medveditsa River in Saratovskaya Oblast) was built ahead of schedule. The third line from Urengoy to Pskov will begin operation soon. About 3,000 kilometers of 1,420 millimeter pipe was welded for main Urengoy-Pomary-Uzhgorod export main pipeline.

Eleven pipelines are starting from Urengoy alone. They carry energy equal to several tens of such very large hydroelectric power plants as the Krasnoyarskaya. The development rates of North Tyumen' are remarkable. Up to 2.5 billion rubles must be invested annually for the construction of surface field facilities alone at the deposits to maintain the assimilation rhythm of the virgin gas soil--this not counting the cost of the large pipes. I think it is necessary to mention what the unified automated gas supply system of the country is--an interconnected network of main lines with an overall length of 3.5 earth equators.

Say, in Moscow, a considerable part of the electrical power is produced by gas. Over 200 million Soviet people use this convenient, cheap fuel in their everyday lives. One cubic meter is sufficient to prepare dinner for 10 people. Gas is used to produce almost 90 percent of the steel, 25 percent of nonferrous metals, 40 percent of the rolled stock, 60 percent of cement and 85 percent of mineral fertilizers. The chemical industry uses gas to produce synthetic materials, plastics, organic acids, rubber, medicines and detergents, toxic chemicals, hydrogen, ethylene and acetylene, carbon monoxide, alcohol, paints.... We may say: all this and not only this do we obtain from the depths of Siberia. Look around your apartment, your clothes, the equipment of the working position--there is hardly anything in one way or another that was not made with the participation of gas. It seems that humanity is entering the age of gas faster than the age of the atom. There is a very simple explanation for this: the low cost.

The gas age began in Siberia. In his time, Gleb Maksimilianovich Krzhizhanovskiy stated: "The question of mineral resources in Siberia and utilizing them--is not even a USSR question, but a world one." Complying with the iron laws of profitable economic policy, we built a gas bridge from Siberia to the European states. Of course, of no small importance is our interest in the industrial progress of the Council for Mutual Economic Assistance [CEMA] countries in the mutually beneficial trade with them.

Our natural gas was being sent to Poland already in 1944. In 1967, the "Bratstvo" pipeline with its destination point Czechoslovakia was placed in operation. In 1973, the GDR began receiving gas. Since 1974--Bulgaria; since 1975--Hungary. In 1979, the international "Soyuz" gas pipeline, the largest in Europe, was placed in operation--an event outstanding in the development of economic cooperation between the CEMA countries. It is 2,667 kilometers long with a pipe diameter of 1,420 millimeters (these figures will be of use to us for comparison with the Western-Siberia-Western Europe export gas pipeline). At present, Austria, Italy, the FRG, Finland and Yugoslavia also receive gas from the USSR. Several countries purchase it in liquefied form.

What do we get in exchange? From Czechoslovakia -- gas turbines, refrigerating equipment, cranes. From Poland -- diesel generators, RR cisterns, diesel engines. From the GDR -- deep well pumps, transformers, distribution cabinets. From Hungary -- radio stations, telephones, remote controls. From Bulgaria -- electric cars, electric filters, pumps. From the FRG -- large diameter pipe, gas pumping machinery, shut-off valves. Cooperation is mutually beneficial. It is precisely for this reason that Western Europe repulsed attempts to disrupt the construction of the gas export pipeline. Gas will arrive in Western Europe on schedule as stipulated by the agreements and perhaps sooner.

Here are several curious extracts from foreign newspapers from the time of their introduction of "sanctions" until their abolition. On 29 December 1981, 30 American firms, among them General Electric and Caterpillar Tractor, were forbidden to sell equipment for producing and transporting gas to the Soviet Union. In June 1982, an embargo was placed on the same equipment of affiliates of American firms abroad and on foreign enterprises using American licenses. In August, sanctions were applied which were called "insulting, unjust and dangerous," by F. Mitterand, the president of France. The French Economics Minister, J. Delor, said positively, "They treat us like servants." The West German newspaper, "Handelsblatt" printed: "That which at the start appeared to be a harmless diplomatic argument grew into one of the saddest crises of the NATO countries since its inception." From the American weekly, NEWSWEEK: "The international trade tactics changed fully. Now Reagan's administration does not hesitate to strike until blood flows." THE NEW YORK TIMES -- "First of all we must stop making it appear that we have achieved success and acknowledge that we were beaten, lashed and had our heads broken."

Deiter Mayer, director of the West German firm "Mannesman" who came to Moscow recently said that the firm "is faithful to its obligations and will fulfill them, no matter what." According to the contract concluded with the "Promsyr'ye eksport" foreign trade organization, "Mannesman" is to supply 1.5 million tons of pipe. This will be laid on 1,500 kilometers. The firm signed the first contract for delivering large diameter pipe to the USSR in 1959. However, the powers that be in the FRG imposed a ban. The firm suffered losses and we were able to organize the production of such pipe in Chelyabinsk and Khartsyzsk. We are now producing up to 1.5 million tons of pipe per year. Sometime ago, someone wrote with chalk on domestic high pressure pipe: "Our reply to Adenauer." Last year they wrote: "Pipe -- to sanctions." The word "pipe" in this context, as you and we understand perfectly, does not signify a steel pipe.

It is naive to assume that Soviet industry would not be able to cope with the orders of the gas industry. And if we turn to foreign firms, it is only from considerations of efficiency and profitability and not at all for technological reasons. Sometimes it is more profitable to get something from neighbors on this earth than to develop our own production facilities further. We are not capitalists, but we can figure out what our advantages are. Between countries, division of labor on such projects is mutually advantageous and it is in the Helsinki spirit.

Let us get acquainted, although cursorily, with the situation at plants and design bureaus that meet the orders of the builders of the export route.

When Reagan attempted to "plug" the gas pipeline, our machine builders created specimens of entirely new gas pumping machines for compressor stations. External events only accelerated their development and transfer to production. In power capacity, complexity of technological equipment and size, stations could be fully comparable to small plants. On the average, there is one such gas pumping station every 100 kilometers of the route.

What is new about that? A fully automated 25,000 kilowatt "GTN-25" gas-turbine machine pumps over 50 million cubic meters per day. In quality, it exceeds a similar machine of the same class produced by the American firm General Electric. The "GTN-25" was created by three associations, well known in the world -- the 'Leningradskiy Metallicheskiy Zavod' (the power turbine and gas pump), the Nevskiy Zavod imeni V. I. Lenin (turbine) and the Leningradskiy Zavod Turbinnykh Lopatok imeni 50-letiya SSSR." They were placed in series production very quickly. A 25,000 kilowatt machine was also created by the power machine builders in the Urals. The Scientific Research Technological Design Institute of the Turbine-Compressor Building of the Nevskiy Plant is developing a 40,000 kilowatt machine. There are no such machines abroad; we can only compare it with ours. Thus, as compared to the "GTN-25" there will be a reduction of about 30 percent in the cost of capital construction and of about 40 percent in operational costs.

The collective of the "Turbomotornyy Zavod imeni K. Ye. Voroshilov" completed the assimilation of gas pipeline turbines ahead of schedule. The new turbine made by Sverdlov builders weighs half as much as the previous ones and the high level of finishing by the plant makes its installation faster--on the principle of children's cubes. Production of gas units has begun at Sumy. My colleagues joke that one of the hottest sections of the gas pipeline passes through a quiet Moscow street where the "Gazstroymachina" special design bureau is located. It is precisely here that a special design rotary trench excavator was created: it digs a trench in permafrost up to 5 meters wide and up to 3 meters deep. A number of new in principle solutions have been patented in the United States, Canada and Japan and licenses have been sold. The same design bureau also designed the "TG-502" pipe-layer which is manufactured by the Sterlitamak Building Machine Plant. Created on the basis of the Cheboksar industrial tractor, it is simpler to control and better equipped with safety devices than the American Caterpillar. In life, as in poetry, "economic sanctions" and "technical progress" do not rhyme.

Technical progress does not exist in itself. It is brought to life by the growing needs of the national economy. Its heart and motor are large projects. The gas program of the 11th Five-Year Plan period gave a considerable push to the development of power machinery. The Electric Welding Institute imeni Ye. O. Paton of the Ukraine Academy of Sciences has developed an original unit that welds 6 to 8 seams per hour (without it a worker would take a week to do it) and increases the alignment of the pipes by 10 times. The Kazan Motor Building Production Association manufactured the first gas-turbine engine for pumping fuel. Do you know how much time has passed since the assignment of the task for seeking an idea until its embodiment into metal? Slightly over 30 days! Such were the rates of several other industries of ours. The problem was complicated but it was solved brilliantly. The power heart of the engine -- the Tu-154" turbine, formerly designed to use kerosene was switched to burn gas.

Plants of the Ministry of Construction of the Petroleum and Gas Industry are now manufacturing over 70 types of new machines and devices for mainline gas pipelines for any climatic zones. These zones differ greatly from one another! Let us take North Tyumen and Turkmen Karakums -- where the temperature difference is frequently over 100 degrees... I cannot refrain from mentioning the "Tyumen " all-terrain, four-wheel drive vehicle. It is used to transport large excavators and as a mobile industrial platform. The capacity of the "Tyumen " is several tens of tons and it can run where Canadian all-terrain vehicles used to sink. The pressure on the ground is no greater than that of a skier.

Welding, digging trenches, insulation, laying pipe, covering -- all this over 4451 kilometers, including 150 kilometers of permafrost, 700 -- over swamps, 2000 -- through forests, 543 -- over the Urals and Carpathian Mountains. It will be necessary to cross paved roads and RRs 417 times, rivers -- 561 times and go under water -- 200 kilometers. I will name only the biggest rivers: Ob , Volga, Kama, Don, Dnepr and Dnestr.

I will clarify the cost of building the gas pipeline by the example of the already existing Urengoy-Moscow mainline. Its length is 2900 kilometers. For simplicity we will round it out to 3000. It required 3 million tons of pipe and 3 million kilowatt compressor stations. It cost 3 billion rubles. The export mainline will be somewhat more expensive -- 7.6 billion rubles. But it is much bigger and has a larger capacity. The total capital investments in the gas program in the current five-year plan period exceed the total cost of building the Baykal-Amur Mainline, the Kama and Volga Motor Vehicle plants and the "Atommash." This is quite a range! Corresponding profits are expected.

I will note that our specialists surpassed their transoceanic colleagues. The Transalaska pipeline is shorter and smaller in diameter than the pipeline from Urengoy to Moscow and was built in 33 months, i.e. it took much longer and cost considerably more.

The assault on Siberian mineral resouces is continuing. Recently, a decision was adopted to break through into the depth of the earth. The first Tyumen superdeep well will be drilled to the 10th kilometer from the surface. This event is of prime importance for geology. The drill will pierce the northern part of the Urengoy gas deposit with which we are acquainted and then will get into the unknown. The ancient rocks are of special interest. Perhaps they contain hydrocarbon raw materials? Simultaneously there will be an exhaustive study of the mysterious strata... We hope to obtain answers to many questions that have excited geologists for a long time. We must assume that, as usually happens in science, new knowledge may open new perspectives.

How Tyumen changed in only 30 years! It grew not only cities -- it grew people and immense collectives. Their labor is converting an ocean of energy into the energy of the accomplishments of the Soviet people.

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