17 JULY 1979 (FOUO 18/79) 1 OF 1

JPRS L/8574
17 July 1979
(FOUO 18/79)

USSR Report

RESOURCES

FBIS FOREIGN BROADCAST INFORMATION SERVICE

FOR OFFICIAL USE ONLY

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100070019-3

NOTE

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

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

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

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

For further information on report content call (703) 351-2938 (economic); 3468 (political, sociological, military); 2726 (life sciences); 2725 (physical sciences).

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100070019-3

FOR OFFICIAL USE ONLY

JPRS L/8574

17 July 1979

USSR REPORT

RESOURCES

(FOUO 18/79)

CONTENTS PAGE

FOR OFFICIAL USE ONLY

CONTENTS (Continued) Page

ELECTRIC POWER AND POWER EQUIPMENT

UDC 621.311.21.002.1

BOGUCHANSKAYA HYDROELECTRIC POWER STATION DESCRIBED

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 11, Nov 78 pp 1-5

[Article by engineers Ye. A. Biond and D. A. Ragozin]

[Text] The Boguchanskaya Hydroelectric Power Station is the sixth and next to the last step of the Angara GES Cascade. It will be located within the limits of Boguchanskiy Rayon, Krasnoyarskiy Kray, 375 km below the Ust'-Ilimskaya GES.

Its installed capacity will be four million kW and its long-term average output of electric energy will be 17.8 billion kWh.

The electric power of Boguchanskaya GES will be transmitted chiefly to the Krasnoyarsk and, partially, to the Irkutsk energy systems which are within the energy association of Siberia (OES [Integrated Power System] of Siberia).

Boguchanskaya GES, which is situated in the area of rich deposits of useful minerals and unique timber resources of the middle Angara area, will make it possible to create the Boguchanskiy Territorial Power Industry Complex (TEPK) in accordance with the plan for further integrated development of the productive forces of Krasnoyarskiy Kray.

Boguchanskaya GES will serve an area of 148,000 km^2 with a population of about 46,000 people. At the present time, it is a sparsely populated taiga-covered area with a relatively low level of the development of productive forces and populated centers of the rural type.

The climate in the area of the construction site is sharply continental with a long severe winter and a short hot summer. The annual average temperature of the air is -3.2 degrees C, the absolute minimum is -57 degrees C, and the absolute maximum is +38 degrees C. The average duration of the frostless period is 112 days, and the total precipitation is 358 mm/year.

The long-range average water flow rate in the span of the hydraulic unit is 3410 m^3/sec. The maximum (summer-autumn) water flow rates under present conditions are: probable excesses of 0.01% (with a guaranteed correction) -- 16,700 m^3/sec, 0.1% -- 15,190 m^3/sec, and 1% -- 14,380 m^3/sec. The hydrological regime of the Angara River is characterized by a stable low-water level in winter and two flood periods in the spring and summer-autumn. Ice-jamming phenomena occur in the spring and autumn.

The water flow rate and levels in the span of the Boguchanskaya GES are determined, chiefly, by the operation mode of the GES situated upstream, because the lateral affluence in the section of the river between the Ust'-Ilimskaya GES and Boguchanskaya GES is relatively small.

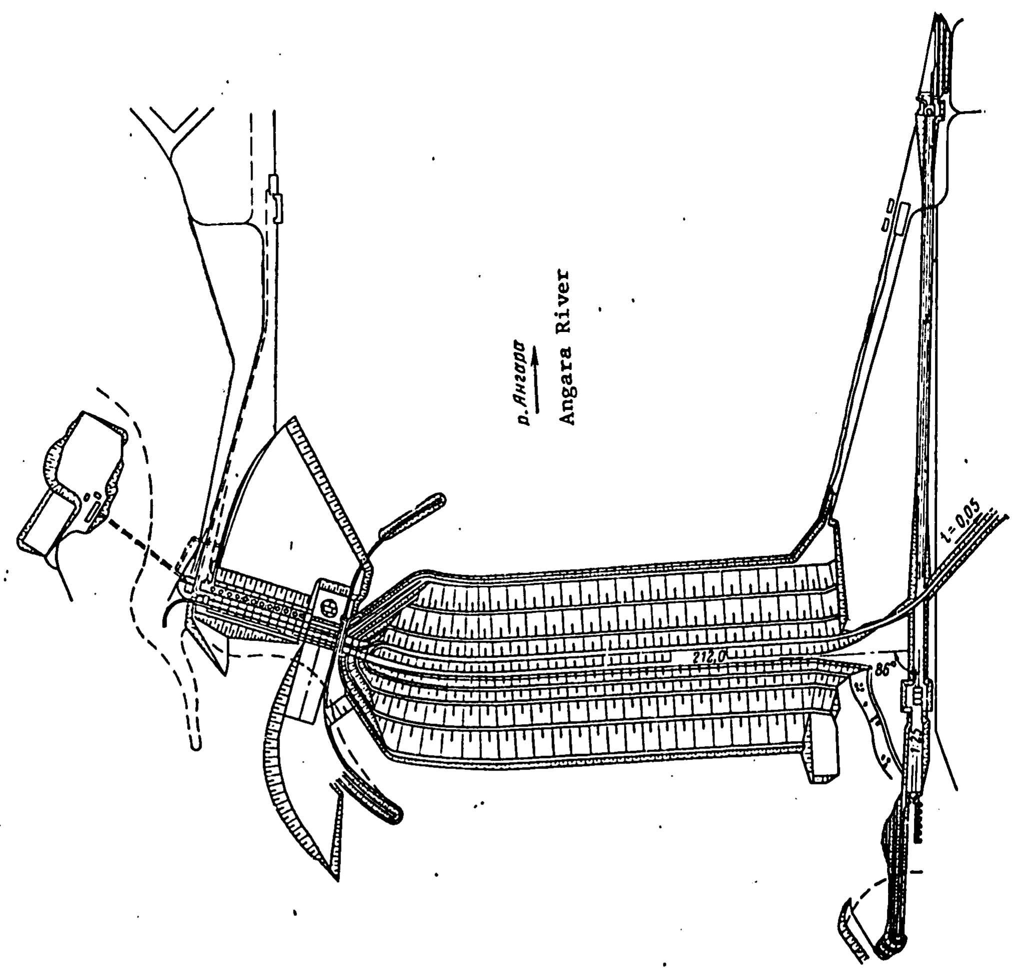


Figure 1. Plan of the Boguchanskaya GES

In the area of the Boguchanskaya GES span, the Angara River runs in the sub-latitudinal direction and crosses a rocky massif composed of the Cambrian and Ordovician sedimentary rock (limestone, sandstone, aleurolite, argillite) broken through at spots by the intrusion of igneous rock (dolerite) whose physical and technical properties are close to the diabase of the bedding of the pressure structures of the Bratskaya and Ust'-Ilimskaya GES.

The intrusive rock crosses the river bed at an acute angle and determines the narrowing of the valley in this section to 2-3 km, the average river bed width being 1.9 km. In this section, low terraces pass in a narrow strip only along the left bank. The undermined right bank and the right-bank part of the river bed are composed of sedimentary rock. The higher left bank and the left-bank part of the river bed are composed of igneous rock. The stratum of the sedimentary complex is nonuniform with respect to the rock composition and the degree of weathering and fracturing. Near the right bank, the rocky mass is broken by a number of tectonic cracks. The entire zone adjacent to the right bank is subjected to some degree to the shore gravitational processes which show themselves in the form of cracks, settlement ditches, and landslide cirques.

During the first stage of the planning and surveying work, two possible locations were examined for the hydroengineering complex: Murskiy and Kodinskiy rayons. As a result of integrated evaluation of all factors affecting the conditions of the construction and development of the Boguchanskiy TEPK, it was decided to build Boguchanskaya GES in the Kodino section.

During the development of the general plan, the main structures of the hydroengineering complex were places in the Nizhne-Kodinskiy area, where the engineering, geological, and topographic conditions were found to be most favorable for construction.

The structure of the general plan of the construction site includes four first-priority objects for industrial and civil purposes: hydroengineering complex, construction base, city of the builders of the hydroengineering complex, and industrial area on the right bank.

The arrangement of the structural units of the general plan is coordinated with the location of the main structures, external transportation routes, electric power transmission lines, relief of the terrain, and considerations of the ecological plan.

It is planned to build a modern city in the vicinity of the hydroengineering complex for the builders and the operating personnel of the GES, as well as for the workers engaged in the construction and operation of objects of the Boguchanskiy TEPK.

The first-priority left-bank part of the city with a population of 32,000 people is intended for the builders of the complex with their families, the operating staff of the GES, and the population moved from the zone of the water reservoir of the rayon center of Kezhma. This part of the city will

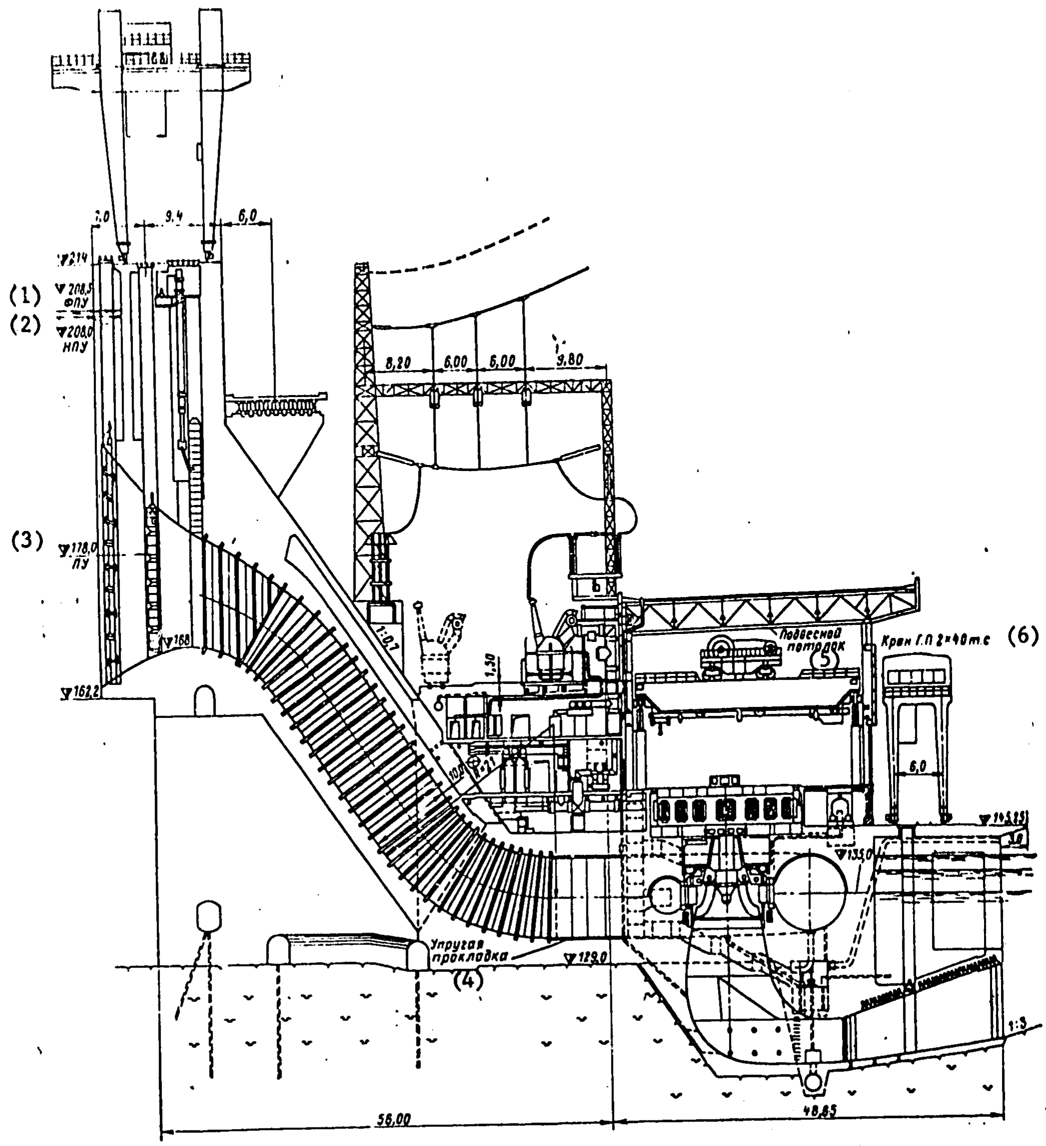


Figure 2. Cross Section of the Main Structures of Boguchanskaya CES

Key:
1. FPU [expansion unknown]
2. NPU [normal affluent levels]
3. PU [affluent level]
4. Cushion
5. Suspended ceiling
6. Crane G.P 2 x 40 t.s

be located to the south of the line of the hydroengineering complex on the banks of the picturesque coves of the water reservoir. The city will have multistory residential buildings. It is planned to provide the residents with all types of cultural facilities and amenities, including television.

Electric power of 110 and 10 kv is supplied to the construction site of the Boguchanskaya GES from the municipal step-down substation of 220/110/10 kv. During the construction period, the substation will be fed via two overhead lines of 220 kv from the switching station of the Bratsk -- Ust'-Ilimsk electric power transmission lines in the area of the town of Sedanovo. The residential buildings, cultural facilities, and amenities of the city, the construction base, and other objects will be heated from electric boiler rooms.

In the plans for the Boguchanskaya GES, it was proven on the basis of detailed technical and economic computations and analysis of two variants of heat supply (boiler rooms using solid fuel and electric boiler rooms) that the variant with electric boiler rooms produces greater economic effect for remote areas which have no railroads.

The main structures of the Boguchanskiy hydroengineering complex are: a concrete dam 756 m long, an earthen dam 1,833 m long, hydroelectric power station building of the type located beyond the dam, administration and production building (APK), outdoor distribution systems(ORU) of 220 and 500 kv with technological maintenance building (STK), structures for delivering power from the GES to the ORU, temporary lock (for the passage of lumber in rafts and vessels during the construction of the hydroengineering complex) and a permanent structure for the passage of lumber rafts and vessels. The total length of the structures of the affluence front is 2,589 m.

A concrete gravity dam with a maximum height of 87 m is being built in the left-bank part of the valley partly on the flood terrace and partly in the channel of the Angara River. Strong igneous rock, dolerite, serves as its foundation. Functionally, the dam is divided into a station part, a spillway part, and a blind part. The blind part and the station part are located on the left-bank flood land. The spillway part of the dam with openings for passing water used for construction and with a temporary lock is located in the left-bank part of the river bed. This arrangement of the parts of the dam makes it possible to minimize the volume of construction cofferdams and to construct all concrete structures in one trench without organizing a second trench, as well as to reduce the volume of concrete to be placed prior to the spanning of the Angara River bed, reducing the work to the construction of the "comb" of spillway openings and adjoining structures. The spillway part of the dam will have five bottom openings with spans of 14 m for the passage of water used for construction before the beginning of the filling of the water reservoir. During the period of the reservoir filling, the Angara water is passed through openings situated above the bottom openings. The same openings are used for the passage of flood water during regular operation of the hydroengineering complex.

The station part of the dam includes the water intake facilities of the GES building from which water is fed to the hydraulic turbines through reinforced concrete-steel pipelines built into the dam.

According to the plan, the hydroelectric power station will have 12 RO75-VM-750-type radial-axial turbines (rotor diameter 7.5 m) with VGS 1560/240-66-type hydrogenerators with a capacity of 333 MW. The power of the hydroelectric power station will be supplied to the power system at 500 kV and to local consumers at 220 kV.

The main electrical connection diagram provides for connecting three unified blocks each consisting of three individual generator-transformer blocks to the 500 kV buses. The transformers are three-phase transformers with a capacity of 400 Mva each. Three individual generator-transformer blocks are connected to the 220 kV buses. These are also three-phase transformers of 400 Mva each.

The 500 and 220 kva ORU are located at high elevations of the left bank. The 500 and 220 kva ORU are coupled by two autotransformer groups of 3 x 167 Mva. The ORU site has a technological maintenance building.

In order to select an optimal layout design for the main structures of the hydroengineering complex, a number of layout variants were developed.

One of the main considerations in developing the layout variants was to minimize the cost of the main structures, to reduce the metal and labor input, and to reduce the amount of imported materials.

The last two factors are particularly important for the construction of Boguchanskaya GES due to the fact that the construction area is very sparsely populated and is very far from material and technical supply bases and construction industry.

Moreover, the layout and design of the main structures of Boguchanskaya GES must conform as much as possible to the severe conditions of the construction region, to the peculiarities of the hydrological and ice conditions of the Angara River, to the engineering and geological conditions of the Nizhne-Kodinskiy area, and to the availability of local building materials.

The layout plans developed on the basis of the above prerequisites can be divided into two groups:

a layout with a dam of ground materials along the entire head front;

a mixed layout in which a part of the head front is covered by concrete structures, and the rest (a greater part) by a dam of ground materials.

After the analysis of all technical and economic data, including those on work procedures and organization of construction, the mixed layout with the

GES building next to the dam was accepted in the plan. In solving this problem, the experience accumulated during the construction of Bratskaya GES and Ust'-Ilimskaya GES was also taken into consideration.

In this layout, the head front is created by a concrete dam and a dam of ground materials spanning a large part of the river bed (about 70% of the head front).

In this connection, special attention was given in the plan to the selection of the structure of the dam of ground materials. A total of eight variants were developed and thoroughly studied. As a result of studies on the aggregate of constructional, technical and economic indexes, two dam designs were found competitive: a homogeneous hydraulic fill dam of fine-grain sand and a rock-filled dam with a central core of nonground materials (asphalt concrete and metal) which were studied in the project with the necessary completeness and the same degree of thoroughness.

The conjugation of the concrete dam of ground materials is achieved by a concrete cut-off wall.

A complex of special landslide-prevention measures was developed for reliable adherence of the dam of ground materials to the right bank and for ensuring a stable shore slope both during the construction period and during operation.

A temporary lock is built into one of the sections of the concrete dam in the form of a bottom opening of a greater height. The chamber of the temporary lock along part of the length is formed by the semipiers of the bottom opening, and beyond the dam section -- by a reinforced-concrete structure of the dock type.

A permanent structure for the passage of timber rafts and vessels is located on the right bank and is designed in the form of a timber-carrying road along which moves a self-propelled latticed flat car, obstacles for the maintenance of the head and tail water areas, breakwater dams, and a lower level approach channel.

The volume of construction jobs for the main structures of the hydroengineering complex will be:

Excavation of soft soil, million m^3	3.9
Excavation of rocky ground, million m^3	6.8
High quality filling, million m^3	17.1
Sand aggradation, million m^3	35.9
Concrete and reinforced concrete, million m^3	2.5
Reinforced steel, thousand tons	50.0
Drilling of holes, thousand m	129.9
Assembled steel sections, thousand tons	17.3
Metal facing, thousand tons	10.8
Mechanical equipment, thousand tons	13.6
Hydraulic power equipment, thousand tons	37.5
Electrotechnical equipment, thousand tons	6.7

The following jobs have to be done to prepare the water reservoir:

-- to develop-forest occupied land in an area of 31,000 hectares, i.e., in a volume equivalent to the area of agricultural lands flooded by the water reservoir and used for the construction needs;

-- to remove 31 populated centers with a population of about 12,200 people from the zone of the water reservoir;

-- to build aerial and cable lines for external telephone and telegraph communications;

-- to provide for electric power supply to newly created settlements, sovkhozes, and lumber industry farms by constructing 35-110 kv overhead lines;

-- remove 10.7 million m^3 of timber and clear an area of 18,200 hectares (it is planned to create seven logging enterprises for performing this volume of work);

-- to develop fisheries in the water reservoir;

-- to carry out work on developing transportation facilities for the water reservoir;

-- to implement the necessary sanitary measures;

-- to perform archeological excavations and studies;

-- to remove four rural populated centers from the lower water area of Boguchanskaya GES in connection with the changes in the stream-flow regime of the Angara River.

The construction base of the hydroengineering complex is located on the left bank 1-2 km below the location of the main structures on a terrace above the flood land which widens from 200 m to 3 km. The topography and the engineering and geological conditions are favorable for placing the facilities of the construction base there. Since the construction base which is created for the Boguchanskaya GES will be used in the future as a base of the construction industry of the Boguchanskiy TEPK, it is designed with factory-made fundamental structures.

The production and auxiliary shops of the main bases of the construction, installation, and specialized organization are grouped in four buildings. Gravel-sorting and concrete-mixing plants are also combined into one complex.

The auxiliary enterprises of the construction base will perform the entire complex of jobs for the construction of the hydroengineering complex with an annual volume of the construction and installation jobs of about 125 million rubles.

The plan provides for the development of the deposits of non-metallic materials which are present in the construction area on both banks and will fully satisfy the construction needs.

The total construction period of Boguchanshaya GES is estimated in the plan to be 10 years (not counting the time necessary for the construction of a highway and a 220 kV overhead power lines between Sedanovo and Boguchanskaya GES) which includes a preparatory period (before the beginning of the earth and rock excavation for the main structures) of 2-2.5 years, and the length of the construction of the main structures to the start-up of the first unit is six years.

(1)	(2) (3)	(4)	(5)	(6)	(7)
(8)	4000	4320	4500	6000	6400
(9)	17,8	21,7	22,6	20,0	23,4
(10)	0,63	0,98	1,19	1,04	1,[illegible]2
(11)	0,14	0,20	0,21	0,31	0,42
(12)	12,5	15,0	16,6	17,5	23,4
(13)	2,8	2,8	3,0	5,2	6,4
(14)	11,6	14,9	9,4	15,2	17,9
(15)	2,6	2,8	1,7	4,6	4,9
(16)	16,4	2,44	3,67	3,78	1,81
(17)	3,7	0,5	0,7	1,1	0,5

Key:
1. Indexes
2. Hydroelectric power station
3. Boguchanskaya
4. Ust'-Ilimskaya
5. Bratskaya
6. Krasnoyarskaya
7. Sayano-Shushenskaya
8. Installed capacity, thousand kW
9. Long-term average output, billion kWh
10. Concrete consumption per one kW, m^3
11. Concrete consumption per 1000 kWh, m^3
12. Reinforcement metal consumption per 1 kW, kg
13. Reinforcement metal consumption per 1000 kWh, kg
14. Consumption of metal per 1 kW, kg
15. Metal consumption per 1000 kWh, kg
16. Earth and rock excavation volume per 1 kW, m^3
17. Earth and rock excavation volume per 1000 kWh, m^3

The construction work has already been started on a 220 kV overhead power line between Sedanovo and Boguchanskaya GES, a settlement for the builders of the hydroengineering complex, a special base for the construction of residential facilities and buildings of the construction base.

Major jobs on the hydroengineering complex will start after the opening of the approach road to through traffic.

The technical and economic indexes of Boguchanskaya GES (planned) are:

installed capacity, thousand kW	4000
electric power output, billion kWh:	
maximum (for a wet year)	24.3
long-term average	17.8
minimum (for a dry year)	16.6
consumption time of installed capacity, hours	4450
proportionate capital investments:	
per 1 kW of installed capacity, rubles	253
per 1 kWh of long-range average energy production, kopecks	5.7
cost of 1 kWh of electric energy, kopeck	0.09
period of investment recovery, years	7.7
profitability	0.124

With respect to its technical, economic, and energy indexes, Boguchanskaya GES ranks with the largest hydroelectric power stations of the Angara-Yenisey Cascade which have been completed and are under construction: Bratskaya, Krasnoyarskaya, Ust'-Ilimskaya, and Sayano-Shushenskaya GES.

Comparable data for these hydroelectric power stations are given in the table.

The construction of the Irkutskaya, Krasnoyarskaya, and, particularly, Bratskaya and Ust'-Ilimskaya GES played an exceptional role in the development of the country's largest power industry complexes using the unique natural resources of the Angara River region.

The construction base and the builders of Boguchanskaya GES will become a basis for the creation of industrial centers of the Boguchanskiy Territorial Power Industry Complex in the remote taiga region.

The engineering problems to be solved at the construction site of Boguchanskaya GES are difficult and important, which is chiefly connected with the complex natural and industrial conditions of the region.

Utilization of the extensive and valuable experience in the construction of hydroengineering structures on the Angara and Yenisey rivers will contribute to successful solution of these problems.

10,233
CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

MEETING AT CONSTRUCTION SITE OF SAYANO-SHUSHENSKAYA GES*

Moscow GIDROTEKHNICHESKOYE STROITEL'STVO in Russian No 12, Dec 78 pp 3-7

[Article by M. F. Skladnev, member of the Presidium of the NTOEiEP Central Administration, and O. D. Kudryavtseva, Scientific Secretary of the NTOEiEP Central Administration]

[Text] On the initiative of the Krasnoyarskiy Kray CPSU Committee, Central Administration and Krasnoyarskiy Kray Administration of the NTOEiEP [Scientific and Technical Society of the Power and Electrification Industry], Department of Physical and Technical Problems of Power Engineering of the USSR Academy of Sciences, a meeting of the Presidium of the Central Administration of NTOEiEP was held in the city of Sayanogorsk at the construction site of the Sayano-Shushenskaya GES.

The tasks of the scientific and technical community in connection with putting into operation the first unit of the Sayano-Shushenskaya GES and the development of power engineering in Eastern Siberia and the Far East were discussed at the meeting jointly with the builders of the hydroengineering facilities. The work experience of the Leningrad and Krasnoyarsk coordination councils of the creative scientific and technical alliance for the creation of the Sayano-Shushenskaya GES was also discussed.

About 200 persons participated in the meeting: scientists, designers, builders, and operating personnel of electric power stations, representatives of the USSR Ministry of Power and Electrification, USSR Gosplan, USSR Academy of Sciences, Krasnoyarskiy Kray Committee of Trade Union of Workers of Electric Power Stations and Electrical Engineering Industry.

Opening the meeting, N. N. Kovalev, Chairman of the Presidium of the NTOEiEP Central Administration and Corresponding Member of the USSR Academy of Sciences,

*On the meeting of the Board of the USSR Ministry of Power and Electrification at Sayano-Shushenskaya GES, see GIDROTEKHNICHESKOYE STROITEL'STVO, 1978, No 9, p 43.

APPROVED FOR RELEASE: 2007/02/09: CIA-RDP82-00850R000100070019-3

stressed the importance of the problems on the agenda and pointed out the important role of the scientific and technical community in their solution.

Sayano-Shushenskaya GES is another pearl of the power engineering of Eastern Siberia. It is being built by the entire country, and it will play an important role in supplying power to the territorial industrial complex which is being created in this region. Many scientific and technical problems have been solved in the process of the construction of Sayano-Shushenskaya GES. However, much is to be done during the remaining time until the start-up of the GES unit in 1978 and until the start-up of the entire station in the beginning of the eighties. The scientific and technical power engineering community must be the leaders in solving the most important problems in the fulfillment of construction jobs, installation of hydraulic and electrical equipment, and preparation of the station for operation.

Here, everything is unusual: the dimensions of the structures, the power of the station, the work volumes, and the unique equipment. It is here that a new form of socialist competition was born: creative scientific and technical cooperation of the planning, scientific research, construction, and production organizations of the country. This made it possible to solve many technical and organizational problems in short periods of time and at a high level. The creation of the Sayano-Shushenskaya GES is the next stage in the development of the power industry of the country and in the development of rich hydraulic power resources of Siberia and the Far East.

During his tour of Siberia and the Far East, Comrade L. I. Brezhnev, Secretary General of the CPSU Central Committee and Chairman of the Presidium of the USSR Supreme Soviet, gave important instructions regarding speedy development of the energy resources of Siberia, the development of hydropower engineering, and speedy creation of the Sayanskiy territorial industrial complex with the use of the inexpensive energy of the Sayano-Shushenskaya GES. He appraised highly the creative cooperation directed toward early introduction of this extremely necessary power facility.

The scientific and technical community of power engineers views its active participation in the creation of Sayano-Shushenskaya GES and other power facilities of Siberia as one of the most important first priority tasks.

Yu. Ya. Makarov, head of the industrial department of the Krasnoyarskiy Kray Committee of the CPSU addressed the participants of the meeting on behalf of the committee. He stressed the importance of the implemented measure for further concentration of the attention of the scientific and technical community on the solution of the problems of the development of the power industry in Siberia, including Krasnoyarskiy Kray, and as one of the important problems, of ensuring the start-up of the first unit of Sayano-Shushenskaya GES in 1978.

N. M. Ivantsov, Deputy Minister of Power and Electrification of the USSR, reported "On the Development of the Power Industry of Eastern Siberia and the Far East and on the tasks of the scientific and technical community in connection with this."

He pointed out in his report that, among a large group of problems, recommendations, and instructions given by the leaders of the Communist Party of the Soviet Union and Soviet Government, Comrades L. I. Brezhnev and A. N. Kosygin, during their visit to Siberia and the Far East, special attention was given to the problems of the development of the power industry as a basis for the creation of large industrial complexes, development of cities of Siberia, satisfying the domestic needs of the population, and development of agriculture and transportation. In the near future, it is planned to increase considerably the energy consumption and, accordingly, to accelerate the development of the power industry in this region.

In this connection, the preparation of an optimal fuel and energy balance with the use of the rich natural reserves of gas, oil, coal, and hydropower resources of Siberia is a very complex scientific, technical and economic problem. There are many various opinions and proposals in connection with this problem, however, the role of the hydraulic power resources in the fuel and energy balance of Siberia and the entire country as a whole has been underestimated in the course of many years. At the present time, it is found necessary to use the rich hydropower resources of Siberia to the maximum in the shortest possible time. Thus, the hydropower engineers of the country are faced with a very important and responsible task of active participation in the creation of a complex energy base in a huge region of our country. This problem can be solved only on a new scientific and technical basis with the use of all latest achievements in the construction industry and a highly effective use of capital investments.

Then the speaker dwelled on a number of concrete problems connected with the development of hydraulic power engineering in Siberia. The first-priority problem for Eastern Siberia is the utilization of the hydraulic power resources of the Angara-Yenisey basin whose solution, in combination with the construction of GRES at the Kansk-Achinsk coal fields, will make it possible to provide electric energy for the developing industrial and agricultural complexes in the southern part of Krasnoyarskiy Kray.

The development of the hydraulic energy resources of the Angara-Yenisey Cascade can be divided into several stages.

During the first stage of development, which ends during the current five-year plan, five hydroelectric power stations will be operating: Irkutskaya, Bratskaya, Krasnoyarskaya, Ust'-Ilimskaya, and Ust'-Khantayskaya GES.

During the second stage, the following hydroelectric power stations which are under construction now will start operating: Sayano-Shushenskaya, Boguchanskaya, Maynskaya, and Kureyskaya GES.

During the third stage, it will be expedient to build the following six hydroelectric power stations: Sredne-Yeniseyskaya, Nizhne-Angarskaya, Osinovskaya, Podkamenno-Tungusskaya, Nizhne-Tungusskaya (Turukhanskaya), and Tuvinskaya.

Maximal utilization of the water resources of the Angara-Yenisey basin in the shortest possible time must progress in two directions, namely: accelerated completion of Sayano-Shushenskaya and Maynskaya GES, as well as Boguchanskaya GES, and accelerated construction of new highly effective hydroelectric power stations of the Angara-Yenisey basin. Such hydroelectric power stations could be Sredne-Yeniseyskaya GES in combination with Angarskaya, Osinovskaya, and Nizhne-Tungusskaya.

In order to accomplish this construction program, it is planned to implement a number of organizational and technical measures, such as organization of flow line construction, wide introduction of specialization, and acceleration of surveying, planning, and scientific research work. Due to the fact that the hydroelectric power stations planned for construction will be located in regions with a severe climate and that water transportation will be used chiefly during their construction, provisions should be made for such designs of the main structures of hydroengineering complexes which would require a minimum amount of imported materials, which would require the least amount of labor input, and which would ensure the possibility of conducting construction work under the conditions of low temperatures all year round. It should be kept in mind, that the volume of the main jobs for each of the above-mentioned hydroengineering complexes is, basically, close to that performed in the construction of the main structures of the Bratsk hydroengineering complex in 8-9 years.

The proposed program for the development of the hydraulic power resources of the Angara-Yenisey basin in the shortest possible time will make it possible to utilize 80-85% of them.

The problems connected with the development of power engineering in the Trans-Baikal area and the Far East are no less important and complicated. The construction of the Baikal-Amur railroad line opens up considerable possibilities for the development of the productive forces in these regions. Hydropower engineering also plays an important role in this region. The large pioneer stations here are Zeyskaya GES, Bureyskaya GES which is under construction, and a number of other hydroelectric power stations planned for construction.

At the present time, it is impossible to enumerate organizational and technical problems which will have to be solved during the implementation of the program for the development of hydropower engineering of Siberia and the Far East. However, it is clear that the present level of hydropower construction work is unsatisfactory. It is necessary to search for new ways of improving it, primarily, by accelerating and increasing sharply its economic effectiveness, and by lowering the material and labor input. The scientific and technical community must play an important role in this respect. They must participate in the discussion of plans and programs for the construction of power facilities, plans for large hydroelectric power stations and equipment for them, to introduce new technical solutions and new equipment in the plans and construction of concrete objects, to spread widely the initiative of Leningrad workers in the organization of creative cooperation for the construction of the Angara-Yenisey hydroelectric power stations with the use of the available experience in creative cooperation in construction of the Sayano-Shushenskaya GES. It is necessary to develop creative contacts with the Siberian branch of the USSR Academy of Sciences, which, evidently, should supervise hydropower construction work in Siberia and in the Far East in all aspects of this important problem.

In conclusion the speaker expressed his hope that each specialist will display great patriotism in the implementation of the far-reaching plans for the development of Siberia, will contribute his knowledge and experience, and will show his strong will in the creation of new hydropower engineering facilities as it is now observed at the construction of the Sayano-Shushenskaya GES.

S. I. Sadovskiy, head of the Krasnoyarskaya GES construction project, and V. I. Bryzgalov, director of the Sayano-Shushenskaya GES which is under construction, presented their reports.

S. I. Sadovskiy told about the main organizational and technical problems which had to be and are to be solved during the construction of Sayano-Shushenskaya GES. Special attention was given to the peculiarities of the construction technology of the main structures and installation of equipment for the GES. He pointed out that, although the problem of "big concrete" has been essentially solved and the builders are confident that the first unit will be put into operation in 1978, there still remain many problems connected with ensuring the start-up of the subsequent units, particularly in 1979, due to the large volume of work and the necessity of ensuring regular deliveries of equipment, etc. Special problems have to be solved by the builders in connection with the beginning of the construction of the Maynskay GES preparations for which are already in progress.

V. I. Bryzgalov reported on the problems which operating personnel have to solve in connection with the introduction of new hydraulic and electrical equipment. He gave special attention to the necessity of having an observation system for the unique structures and equipment of Sayano-Shushenskaya GES and creating an automated observation system. He also stressed the necessity of ensuring high quality construction and installation jobs, particularly now during the installation of the generator and electrical equipment.

A number of specialists participated in the discussion of the reports. M. F. Skladnev (VNIIG [All-Union Scientific Research Institute of Hydraulic Engineering] imeni B. Ye. Vedeneyev) stressed the timeliness of the meeting of the presidium of the central administration of the NTOEiEP and the importance of the problems discussed at the meeting which directed the attention of the scientific and technical community toward solving concrete problems of the development of the hydropower engineering of Siberia. He emphasized the validity of the main proposals presented in N. M. Ivantsov's report for the development of the hydropower engineering of Siberia and the Far East and, as a first-priority problem, for the development of the water resources of the Angara-Yenisey Cascade. These proposals are in agreement with Comrade L. I. Brezhnev's instructions and recommendations for further strengthening of the energy base of the Siberian region. Soviet hydropower engineers have sufficient experience in the construction of hydropower engineering complexes in Siberia with its complicated natural and climatic conditions. The largest project of the Soviet hydropower engineering of the Eighth Five-Year Plan was Bratskaya GES imeni Fiftieth Anniversary of the Great October Revolution, the largest project of the Ninth Five-Year Plan was Krasnoyarskaya GES imeni Fiftieth Anniversary of the USSR, and the largest project of the Tenth Five-Year Plan is Sayano-Shushenskaya GES which is under construction. Each of the above-mentioned projects signified a new stage in the scientific and technical progress. Sayano-Shushenskaya GES is being built with the use of the latest achievements in the creation of designs of main structures and equipment, the hydraulics of structures, and the solution of a number of technical problems.

As is known, the problems of scientific substantiation of construction, design, and creation of the unique equipment for Sayano-Shushenskaya GES constitute one of the most important tasks of the complex program of the Tenth Five-Year Plan in the area of hydropower engineering. Due to creative cooperation, there is every reason to believe that this task will be fulfilled.

However, the year of 1979 and the subsequent years of construction will be extremely strenuous considering the proposal to speed up the start-up of all units at Sayano-Shushanskaya GES. The problems of the quality of the construction and installation jobs must be in the center of attention of the scientific and technical community.

M. F. Skladnev pointed out the necessity of timely preparation and training of operating personnel for the GES with consideration of its temporary and regular operation. Approving the program for the construction of first-priority structures of the Angara-Yenisey complex, he pointed out the necessity of expanding and speeding up the surveying and the research work on these structures and the necessity of strengthening the East Siberian branch of Gidroproyekt [All-Union Planning, Surveying, and Scientific Research Institute imeni S. Ya. Zhuk] and the Siberian branch of VNIIG.

N. A. Dodogorskiy (Ministry of the Electrical Equipment Industry) pointed out the unique nature of the generators and electrical equipment of Sayano-Shushenskaya GES and special characteristics of their installation and operation. He addressed the builders with an urgent request to prepare the area for the installation of the generator as soon as possible. Approving the planned program for the development of hydropower engineering of Siberia and the Far East, he pointed out the necessity of timely presentation of requisitions and specifications for the development of electrical equipment for the future objects. He made a special point of speeding up the creation of a production base for manufacturing electrical equipment for power engineering.

These problems were discussed by V. V. Romanov (LPI [Leningrad Polytechnic Institute] imeni M. I. Kalinin), V. F. Fedorov (VNIIelektromash [All-Union Scientific Research Institute of the Technology of Electric Machinery and Equipment Manufacture]), and V. M. Kamyshev (Production Association "Elektrosila" [electric power].

P. I. Kiselev (USSR Gosplan) pointed out the necessity of increasing the effectiveness of the use of capital investments allocated for the creation of hydropower facilities, including Sayano-Shushenskaya GES. Speaking about the planned program for the development of water resources of Siberia and the Far East, he stressed the importance of the problem of correctly determining the size of the installed capacities at the future objects with consideration for the interests of the energy systems and integrated utilization of water resources.

M. V. Kostenko (corresponding member of the USSR Academy of Sciences, LPI imeni P. I. Kalinin) mentioned the far-reaching nature of the planned program for the development of power engineering in Siberia and pointed out the necessity of giving much attention to the development of a new power technology. In creating large hydropower systems in Siberia, including those in the Angara-Yenisey basin, special attention must be given to the problem of the protection of nature and timely and rational utilization of forest resources which happened to be in the zone of future construction sites.

N. N. Tikhodeyev (NIIPT [expansion unknown]) noted the originality of the designs developed for the RU [expansion unknown] and electrical substations of Sayano-Shushenskaya GES in creative cooperation of designers, researchers, and production organizations of the Ministry of the Electrical Equipment Industry and proposed to organize help from the designers and manufacturers of this equipment to the operating personnel of the new equipment in order to make it fully operational as soon as possible. He pointed out the necessity of organizing public discussions of projects for large power engineering facilities on a wide scale in the future.

D. P. Velikanov (corresponding member of the USSR Academy of Sciences, Department of Physical and Technical Problems of Power Engineering) reported that at the end of this year the department is planning to examine long-range problems of the development of power engineering in the USSR and that it will be appropriate to present a report on the planned development of hydropower engineering of Siberia and the Far East. Then he dwelled on the problems of providing motor vehicle transportation for the large power systems under construction including by supplying BelAZ vehicles with a carrying capacity of 75 and 120 tons, and later up to 180 tons. Special attention could be given to the condition of highways and approach roads. Their condition should become an obstacle for using large-capacity dump trucks and other vehicles.

G. A. Klimenko (Institute of Electrodynamics of the Ukrainian SSR Academy of Sciences) discussed the planned program for the development of hydropower engineering of Siberia and the Far East. He proposed that NTOEiEP should take a very active part in the realization of the planned measures and that this problem should be discussed at the next NTOEiEP Plenum. It is necessary for the NTOEiEP organizations to participate more widely in the discussion on the programs being developed in the area of power engineering and plans for large power engineering complexes. The leading NTO workers are ready to share their experience and help the workers of the Sayano-Shushenskaya GES in making the equipment fully operational. He also proposed that Krasnoyarskiy Kray Administration of NTOEiEP should help the primary organization of NTOEiEP in their work at the Sayano-Shushenskaya GES.

The work experience of the coordination councils for the participation in creative cooperation for the construction of Sayano-Shushenskaya GES was described by M. G. Aleksandrov, secretary of the Leningrad Coordination Council and by O. G. Grek, on behalf of the Krasnoyarsk Coordination Council. They told about the work done by the coordination councils and about the practical results of this work. Among other things, this form of socialist competitions among planning, research, construction, installation, and production organizations made it possible to ensure effective coordination of work on the creation of Sayano-Shushenskaya GES, to achieve early fulfillment of a number of studies, designs, and deliveries of hydraulic and technological equipment, to ensure savings in materials and creation of more rational designs of structures and equipment, thus ensuring the solution of one of the main problems: the start-up of the first unit at Sayano-Shushenskaya GES in 1978.

The high appraisal of this creative cooperation given by Comrade L. I. Brezhnev in his speech during his stay in the city of Krasnoyark inspires the participants of socialist competitions in their activities and obligates them to complete the construction of this unique hydroelectric power station ahead of schedule and obligates the scientific and technical community to utilize the experience of the Leningrad and Krasnoyarsk organizations in creative cooperation in the construction of power engineering objects in their work*.

This problem was discussed by N. N. Kovalev (Central Administration of NTOEiEP), N. N. Tikhodeyev (NIIPT), V. P. Chubar' (Krasnoyarskiy Kray Committee of the Trade Union of Workers of Electric Power Stations and Electrical Equipment Industry), and M. F. Skladnev (VNIIG imeni B. Ye. Vedeneyev). They noted the exceptional effectiveness of this type of socialist competition and made some suggestions and remarks about the work on creative cooperation and its further development.

In connection with the problems discussed at the meeting of the Presidium of the Central Administration of NTOEiEP, it was resolved to obligate the scientific and technical community of power engineers to activate their work in the creation of new power engineering facilities in Siberia and in the Far East, in the realization of the plans of power engineering construction and plans for the creation and introduction of new technology, in the fulfillment of the tasks of the complex program of the Tenth Five-Year Plan in connection with the most important problems in the area of hydropower engineering, and in further development of socialist competitions in creative cooperation.

The participants of the meeting familiarized themselves with the progress of construction at the Sayano-Shushenskaya GES and with the implementation of measures for ensuring the start-up of the first unit of this GES in 1978.

---

*Work experience of the Leningrad Coordination Council is described in the book "Leningrad. Agreement 28. Sayano-Shushenskaya GES", Lenizdat, Leningrad, 1978. Also see GIDROTEKHNICHESKOYE STROITEL"STVO 1975, No 11; 1977, No 11, and in the section "Socialist Competition in Action" in each issue in recent years.

They also visited Krasnoyarskaya GES, examined the structures of the hydro-engineering complex, and talked with the operating personnel.

10,233
CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

UDC: 621.311.4.001.2:621.311.4.002.2

IMPROVING DESIGN OF 110 kV SUBSTATIONS

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 4, Apr 79 pp 2-4

[Article by Engineers L. L. Peterson, A. S. Zelichenko, V. V. Karpov, and N. V. Murashko: "Principal Trends in Improving Design Solutions for Substations of 110 kV and Higher"*]

[Text] Increase in the production and consumption of electric power requires further development of high and extremely high voltage power transmission networks, and in particular construction of substations handling voltages of 110 kV and higher.

The following figures indicate the number of substations of various voltages put into operation in the Ninth (numerator) and under construction in the Tenth (denominator) Five-Year Plan.

Voltage, kV	750	500	330	220	110—150
Number of substations	4/1	22/30	38/45	134/180	1130/1450

Substations of 110 and 220 kV comprise 95% of the total number of substations of 110 kV and higher under construction. Volume of construction work on substations of these voltages also comprises a considerable share of the total volume. In connection with this, principal attention should be focused on improving design and construction of the most mass-construction substations of 110 and 220 kV, particularly since in the future the number of 110 kV substations to be built will increase by 50 to 100% (the number of 220 kV substations will remain at approximately the same level).

We should particularly note problems of design and construction of 500 and 750 kV substations. In the future their percentage share in this country's power systems will increase, and the first 1150 kV substations will appear.

* Continuation of publication of a selected series of articles (for earlier articles see No 2, 3, 1979)

Construction of these substations demands allocation of considerable land, since equipment size and isolation distances are increasing. In designing 500-1150 kV substations it is essential to provide biological protection for operating personnel from electrical field effects. Efficient resolution of the aggregate of these problems will make it possible substantially to reduce labor and material expenditures and thus to reduce the presently high cost of construction.

Designing of substations of 110 kV and higher is a combined project, since the most diversified structures are involved:

outdoor distribution systems (ORU) with portals for leads, supports for equipment, transformer foundations and approaches, cable conduits and trays, etc;

substation control buildings (OPU) with protective relaying, automatic control and communications, indoor distribution system (ZRU) buildings, compressor rooms, etc;

approach and on-site roads, cable lines, water and sewer lines, oil drains and sumps, fences, exterior lighting and signaling equipment.

Substations of 500 kV and higher, require in addition construction of auxiliary buildings, transformer repair towers, rail sidings, and other facilities.

This is the reason for the great variety of different jobs involved in building substations: general construction, installation, finishing and other jobs characteristic of any industrial facility. The work volume involved in some jobs is very small, which additionally complicates substation planning, design and construction.

At the present time, for the purpose of standardizing design solutions, accelerating and improving the quality of planning and design, approximately 160 standard designs have been developed and are being utilized for all components of substations, primarily high and extremely high voltage, with elaborate layouts. They have been ratified by USSR Gosstroy, with agreement and coordination settled with structural components manufacturing plants, electric power network construction main administrations of the USSR Ministry of Power and Electrification, as well as with plants of the Ministry of the Electrical Equipment Industry and other agencies. All standard designs must be periodically revised in connection with change in the product list of the supplier plants as well as adoption of improved technical solutions. Due to the very limited funds allocated by USSR Gosstroy for standard design activities, in many cases revision and reworking of designs are not performed in a prompt manner, which in turn leads to elaboration of a number of custom designs. The result is increased labor expenditures, substation design and construction timetables.

Construction of substations is influenced by a number of factors, the most important of which are the following:

allocation of land not suited for agriculture, as well as for housing and industrial construction;

increase in volume of construction in sparsely-populated regions, including northern and inaccessible areas;

limited manpower resources.

In connection with this the main task is to increase labor productivity, to achieve all-out industrialization of construction activities, and transformation of a construction site into an erection site by means of extensive utilization of prefabricated structures and components [1].

We shall examine below the principal project stages which promote to a significant degree accomplishment of the assigned tasks.

Broadening of the area of application of fully prefabricated substations and distribution systems (KTPB and KRUB). Series-produced 110 kV substations put out by the Kuybyshev Elektroshchit Plant, employing simplified layouts without circuit breakers, developed by the Odessa Affiliate of the Orgenergostroy Institute jointly with the Energoset'proyekt Institute, are being more and more extensively utilized. In the last four years (1974-1977) the number of adopted KTPB has increased by more than 50%, comprising 66% of the total number of substations with layouts utilized in KTPB.

Plans call for developing and producing KTPB with a bridge layout and developed layout. An experimental 110 kV KTPB on a bridge layout with circuit breaker has already been adopted at the Rodnikovskaya substation. Series production on such KTPB was started up at the Kuybyshev Elektroshchit Plant in 1978. Extensive employment of these substations will ensure increased labor productivity; outlays on construction-erection activities and construction timetables will be cut in half, while consumption of metal and concrete will be reduced by one third to one half.

Also begun in 1978 was installation at 110 kV substations of series-produced complete 110 kV developed-layout factory-built distribution systems (KRUB).

At the present time the Energoset'proyekt Institute, its Northwestern department, jointly with the Kuybyshev Elektroshchit Plant and the Odessa Affiliate of Orgenergostroy, are working on first units of KTPB and KRUB of new types (construction of a 220/35/10 kV KTPB is almost completed at the Belaya Glina substation and a 220/110/10 kV KTPB at the Bezhetskaya substation); on reducing the quantity of electrical equipment (at the suggestion of the Northwestern department of Elektroset'proyekt the number of 6 (10) and 35 kV dischargers installed in KTPB has been reduced), as well as types of KTPB designs on modifications of the main layout; determination of overall future need for KTPB in different parts of the country, which will make it possible to substantiate the necessity of expanding production of KTPB at the Elektroshchit Plant.

In order to broaden the area of application of KTPB in the northern regions, the Northwestern department of Energoset'proyekt prepared a special preliminary design which was utilized by the Odessa Affiliate of Orgenergostroy in designing a northern version of KTPB. This version will be utilized in specific design applications at the end of 1979.

Planned for 1979-1980 are efforts to expand the list of manufactured units and panels for primary circuits and utilized equipment; development of 35 and 110 kV KTPB designs with prefabricated buses, northern-version equipment and small-size circuit breakers, as well as KTPB for areas with air pollution, etc.

Special attention is being focused on ensuring that this equipment is provided in complete sets.

We should note that successful accomplishment of these projects can be achieved only if there is achieved the planned expansion of production by the Elektroshchit Plant.

Fast-erection substations (BMP), 35-220 kV. In 1977 the Northwestern department of Energoset'proyekt prepared design documentation on a new design layout for 35-220 kV substations with unit and bridge layouts [2].

A new design solution specifies utilization of a terminal line support as an equipment support element, which makes it possible to eliminate lead portals as well as to reduce to a minimum zero cycle work volume.

Initial adoption experience indicates that employment of the new design (in comparison with existing standard solutions) will reduce construction site area by 62%, substation materials requirements by 65%, cable consumption by 40%, labor outlays by 34%, construction and erection volume by 47%, and building cost by 26%.

In 1979-1981 plans call for developing a series of 35-330 kV BMP employing unit and bridge layouts on the highest voltage side with double- and triple-wound transformers.

We should note that the area of employment of such substations is limited, since it is not possible to develop a substation on the highest voltage side.

Substation components of transportable units (UTB). When erecting substations in remote and difficult-access areas it is necessary to deliver components in large transportable units. This demand is met by prefabricated transportable unit components developed by the Elektrouralmontazh Trust and the Urals Department of the Energoset'proyekt Institute [3]. Depending on function, the UTB consist of one or several linking box units, in which the requisite equipment is installed.

The dimensions of the box units are dictated by transport vehicle size: length 12.1, width 3.25, and height 3.73 meters; weight 8,200 kg. Development of substation components employing UDB has made it possible to reduce labor expenditures by 50%, which is particularly important with construction of facilities in difficult-access areas.

Annual savings from comprehensive employment of UTB at 110 and 220 kV substations just in the power systems of the Urals has been determined at approximately 3 million rubles. This is achieved by reducing capital spending, decreasing the cost of construction and erection operations, and shortening the time required to build these substations.

At the present time UTB are being developed for OPU, compressor room, battery room, 6-10 kV ZRU, etc.

In the future there will be development of UTB with elegaz [SF_6] equipment for 110 and 220 kV.

The institute's departments are working on expanding the area of application of UTB in different parts of Siberia, the Urals, Kazakhstan, the Far East, etc.

Development and adoption of new design solutions with employment of prefabricated buildings -- BMZ. In 1976 Energoset'proyekt, working jointly with the enterprises of Energotekhprom and the Elektrostroypodstantsii Trust, developed and built the first buildings of BMZ sections at the 220 kV substations Yasenevskaya (two buildings) and Borisovskaya (four buildings) [4]. Experience in erecting these buildings confirmed the soundness of their employment in construction of 110-500 kV substations.

In 1977-1978 the Tula, Northwestern, Gor'kiy departments and Kiev OKP [expansion unknown] of the Energoset'proyekt Institute produced designs for OPU and ZRU buildings, pump and compressor rooms of BMZ sections for substations of 750 (Novo-Bryanskaya) and 220 kV (Bezhetskaya, Kineshma, and Pridonskaya). As a result of employment of BMZ sections, the construction timetable for each building at these substations was shortened by three months, with reduced labor outlays and improved building exterior appearance.

In 1978 the institute completed development of a standard preliminary design, which specifies that all substation buildings be erected of BMZ sections. At the same time development is in progress, jointly with Energotekhprom, on a two-story ZRU building with a large number of cables and OPU for 500 kV substations. The possibility of interlocking BMZ is being studied. The preliminary design specifies the area of application and requisite manufacturing volume of BMZ structures of different types (with 4 and 6 meter bays).

Designing substations with SF_6 equipment. The Energoset'proyekt Institute attaches great importance to extensive employment of complete distribution systems with SF_6 insulation (KRUE) at power facilities.

The technical requirements on 110 and 220 kV inside installation KRUE were elaborated by the institute in 1973.

In 1976 the institute published specifications for 110-1150 kV KRUE, which were ratified by the Scientific and Technical Council of the USSR Ministry of Power and Electrification and forwarded to the Ministry of the Electrical Equipment Industry. Preliminary specifications for 110 and 220 kV KRUE were examined and revised in 1978. Final agreement on preliminary specifications is being delayed due to the high limit price on a KRUE unit, which substantially exceeds the cost of a unit with traditional equipment.

At the present time the first Soviet-manufactured 110 kV KRUE units are being installed at the 220/110 kV deep-input Yelokhovskaya substation in Moscow. The institute has specified a number of other facilities at which this equipment is to be installed during the 10th Five-Year Plan. First experience in designing 110-500 kV ORU indicated that employment of SF_6 equipment, in comparison with analogous traditional equipment, will make it possible to reduce construction site area by 40-fold and more.

Installation of SF_6 equipment at enclosed substations will reduce construction site area and building volume severalfold.

Thanks to large-module layout and delivery of complete SF_6 equipment, labor requirements in construction of substations will be reduced by 20%, and erection time by 40-80%.

Development of standard substation designs with SF_6 distribution systems is being delayed due to an insufficiently rapid pace of startup of manufacture of the equipment at enterprises of the Ministry of the Electrical Equipment Industry.

ORU with rigid leads. Employment of rigid leads on ORU makes it possible to eliminate construction of portal structures, substantially to reduce facility site area and correspondingly to reduce the volume of construction work. For example, in utilizing a 110-220 kV ORU design with rigid leads in comparison with standard ORU with flexible leads, there is a reduction in facility site area, consumption of steel, reinforced concrete and labor outlays by 23, 6, 35 and 15% respectively.

The first substations with rigid leads (Mokhovyye Gory in Gorenergo and Serdobskaya in Penzaenergo) were designed by the institute's Gor'kiy department. The Mokhovyye Gory substation was built and put into operation in 1973. Metal structures for this substation were fabricated and erected by the Volgoelektroset'stroy Trust. 110 kV ORU for the Serdobskaya substation was fabricated by the Elektroshchit Plant. Rigid leads were subsequently employed in 110 and 220 kV ORU at a number of other substations [5].

At the present time the Northwestern department of Energoset'proyekt is completing preparation of working drawings for a standard 220 kV ORU design with rigid leads for simplified layouts with transformers of up to 125 MVA each.

Extensive adoption of substations with rigid leads is being delayed by the limited manufacture of aluminum tubing as well as a lack of requisite factory-made connecting hardware. The Elektroset'izolyatsiya Trust is presently working on terminal hardware for such leads at the institute's request. Tube attachment requires a terminal clamp design where minimal welding will be required in installation.

Factory series manufacture of rigid leads together with connecting hardware is to be set up at one of the plants of the Elektroset'izolyatsiya Trust.

Construction of substations on standard comprehensive designs. Thoroughly elaborated standard solutions utilized for 110 kV substations, individual substation structures, assemblies and distribution systems of all voltages with a standard layout network, as well as data on recurrence of employment of substations of various types have made it possible to transition to development of standard comprehensive substation designs [6].

Standard comprehensive designing of substations for the most commonly used layouts is promising, since this simplifies and reduces the cost of designing, and facilitates supplying facilities under construction with structures, equipment and materials.

A standard comprehensive design has been elaborated for two 110 kV substation modifications:

with two double- and triple-wound transformers (110/10 and 110/35/10 kV) of up to 16 MVA, which in the future can be replaced by two 25 MVA units;

with two 40 MVA transformers, which also can be replaced when necessary by two 63 MVA units.

In the design three different versions of electrical hookup arrangements for 110 kV ORU are being developed for each modification.

Alongside this, at the present time final work is being completed on working drawings of a standard comprehensive design of 220 kV substation with ORU on a simplified layout on the high voltage side.

Calculations indicate that adoption of efficient layouts for substations of these types makes it possible to reduce facility site area and materials requirements by approximately 10% in comparison with traditional designs.

For extensive adoption and further improvement of new design solutions for substations of 110 kV and higher examined in this article, it is necessary to determine reasonable areas of their employment substantiated by technical and economic calculations. In the near future the Energoset'proyekt Institute will complete this work, which will make it possible to refine the volumes of various advanced structures adopted in designing and building substations of 110 kV and higher.

Improvement of design solutions for substations of 110 kV and higher is being performed at the institute in close collaboration with construction trusts and plants of the USSR Ministry of Power and Electrification. Participation in joint conferences, business meetings with construction specialists, designer's supervision and other measures promote rapid adoption of efficient solutions into practical designing and construction of substations.

BIBLIOGRAPHY

1. Peterson, L. L., and Kurnosov, A. I. "Efficient Structures for Power Transmission Lines and Substations," ENERGETICHESKOYE STROITEL'STVO, No 5, 1977, pp 24-28.

2. Gorbov, G. L., and Piven', I. Sh. "Fast-Erection 32-220 kV Substations," ENERGETICHESKOYE STROITEL'STVO, No 4, 1978, pp 3-4.

3. Faynyud, G. M.; Erman, Z. B.; and Zaytsev, L. I. "Standardized Units for 110-500 kV Substation Buildings," ELEKTRICHESKIYE STANTSII, No 10, 1976, pp 38-42.

4. "Effectiveness of Employment of Prefabricated Buildings in Substation Construction." Sidorenko, L. P.; Kogan, Ya. I.; Elenbogen, G. N.; and Khokhlov, A. I. ENERGETICHESKOYE STROITEL'STVO, No 7, 1977, pp 17-25.

5. Brenner, A. I.; Burukhina, T. S.; Kogan, Ya. I.; Sidorenko, L. P.; and Khokholov, A. I. "Advanced Solutions in Construction of the Vozeyskaya 220 kV Substation," ENERGETICHESKOYE STROITEL'STVO, No 3, 1978, pp 28-32.

6. Grosman, G. P. "Building 110 kV Substations on Comprehensive Designs," ENERGETICHESKOYE STROITEL'STVO, No 4, 1978, pp 4-7.

3024
CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

UDC: 621.311.4.001.2

ADVANCED STRUCTURES FOR SUBSTATIONS DISCUSSED

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 4, Apr 79 pp 5-7

[Article by Engineer L. E. Levin: "Advanced Structures for Substations"]

[Text] Substation construction, a component part of electric power system construction, possesses a number of specific features. Construction of power transmission lines involves construction and erection operations of a comparatively limited variety (construction of foundations, assembly and erection of towers, stringing of wires). At the same time the construction site of large substations of 250 kV and higher, and even 110 kV substations, erected of structures supplied "in bulk," is practically an industrial site. A rather large variety of jobs being performed on the one hand and the comparatively small volume of some of these jobs on the other complicate resolving problems of organization of construction of substations and supplying the facility with material and manpower resources.

Therefore the problem of maximum simplification of substation construction, that is, increasing the degree of prefabrication and factory methods employed on individual components, is of vital importance.

Designs and techniques of building substations have been improving for a number of years. Structures of reinforced concrete poured on site, brickwork, and metal supports of the most diversified types for mounting ORU [outdoor distribution system] equipment have been replaced by structures of prefabricated reinforced concrete of the frame-panel type for construction of substation buildings (OPU [Substation Control Facilities], VRU [Indoor Distribution Systems], etc) and reinforced concrete supports or piles of uniform section for mounting a broad variety of equipment in ORU. Prefabricated reinforced concrete is also employed for fabricating lead portals, transformer foundations, cable lines and other substation components.

Subsequently, due to further standardization of space-layout solutions for substation buildings and structures, we have succeeded in substantially reducing the number of types of prefabricated reinforced concrete structures. The total number of type-sizes of prefabricated reinforced concrete structures was reduced by 20%, and the number of equipment fastening components -- by 50%. Calculated annual reduction of capital spending on substation construction totaled approximately 2 million rubles.

All this made it possible to prepare and in 1976 to put out a catalogue of product items for power system, including substation, construction, a catalogue which still applies.

However, the constantly increasing work volumes demand further improvement of process and design solutions utilized in building substations. Problems of maximum possible reduction of labor outlays at the construction site are acquiring particular importance.

The most laborious components of substations are the various buildings. Utilization of frame-panel structures, which are extensively employed today in industrial construction (including construction of buildings for thermal electric power stations), is not always optimal for the specific conditions of substation construction. When erecting OPU, ZRU or any other buildings for substations, one utilizes a rather large variety of product items (columns, beams, wall panels, ceiling-floor slabs, etc), assembly, erection and securing of which demand considerable labor. An increase in labor expenditures is also dictated by the construction of brick partitions, cable channels and other design components.

In constructing substations in remote and difficult-access areas, where construction industry capabilities are limited, additional difficulties arise, caused by the necessity of supplying a project with structures and product items from different plants.

In recent years design organization specialists, working together with the construction people, have come up with various engineering solutions aimed at simplifying construction of substation buildings. First of all we should note the designing of substation buildings with enclosure structures of shaped sheet steel. Of all the different design solution versions of this type, the most acceptable is the version which specifies utilization of "sandwich" panels, manufactured by the Kuybyshev Elektroshchit Plant. Employment of such panels has made it possible sharply to reduce the weight of building structures, which is particularly important in building substations in remote areas. Positive experience has already been acquired in the employment of "sandwich" panels in building substations in the Urals and Siberia [1].

The Energotekhprom enterprise, working together with the Elektrostroypodstantsii Trust and the Energoset'proyekt Institute, have developed a design specifying construction of substation buildings of fast-erection reinforced concrete sections (BMZ) [2]. In the short time which has passed since completion of construction on the first building at the Yasenevskaya substation in Moscow, approximately 35 BMZ section buildings have been designed, and more than 20 buildings have already been erected and put into operation. Amassed experience in designing and erecting buildings of BMZ sections has made it possible to proceed with elaboration of a standard design. Such a design already exists, containing a list of all buildings erected at substations, and specifying a list of reinforced concrete product items.

We should note that the first buildings were designed and built of 12 x 6 meter BMZ sections, which were available at that time. This led to an unwarranted increase in building height and consequently to excessive building cost. In connection with this, principal substation buildings (OPU of types I-IV, ZRU, etc) are to be erected of sections measuring 12 x 4 m. Such sections have already been developed at the Energotekhprom enterprise, and they are to go into production in 1980. The design process also revealed the necessity of designing and fabricating sections of other sizes, such as 6 x 4 m, for small buildings (compressor houses, water supply pump houses).

The substation design specifies elimination of brick walls, with replacement by prefabricated reinforced concrete. For this purpose it is recommended that one utilize lightweight vertical ribbed reinforced-cement partitions of type PTsP-R, series KP-201, developed by Kiev Promstroyproyekt. Employment of these in place of flat concrete makes it possible to reduce concrete volume. Taking into consideration experience in constructing buildings of BMZ sections, the design also specifies conduitless laying of cables.

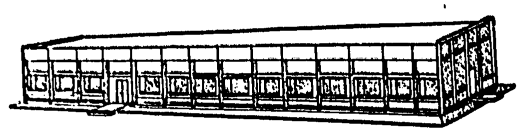
The following table specifies the principal technical-economic indices of OPU buildings erected of BMZ sections and of traditional structures.

Показатели 1	Тип здания ОПУ 2			
	I	II	III	IV
3 Объем сборного железобетона, м³	181,2/137,8	160,5/124,9	117,9/92,6	97,1/80,5
4 Объем бетона, м³	45,8/—	38,1/—	23,2/—	17,5/—
5 Стоимость строительно-монтажных работ, тыс. руб.	42,9/42	37,9/35,8	26,7/25,3	21,7/20,6
6 Трудозатраты, чел.-дни	840/370	753/350	500/225	424/190

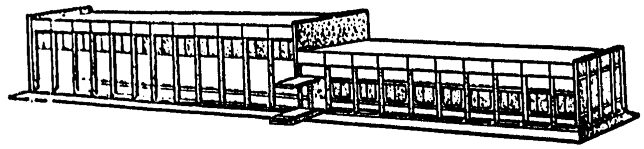
Key:
1. Indices
2. Type of OPU building
3. Volume of prefabricated reinforced concrete
4. Volume of concrete
5. Cost of construction and erection work, thousand rubles
6. Labor outlays, man-days

Note: The numerator contains indices for buildings of traditional structures, and the denominator -- for buildings of BMZ sections

Employment of BMZ sections in erecting substation buildings makes it possible to reduce labor outlays by 60% on the average, as well as to reduce the construction module, thanks to which in enlarging substations building length can be increased by 3 meters and not by 6, as is the case with the frame-panel version. We should also note that with utilization of BMZ sections (in comparison with the traditional frame-panel version), a building's architectural appearance is improved (see figure).

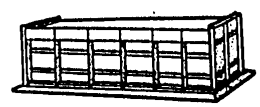


a)



b)

c)



Substation Buildings of BMZ Sections. a -- OPU of type I, of sections measuring 12 x 4 m; b—OPU of type VIII, of sections measuring 12 x 6 and 12 x 4 m; c -- compressor house of sections measuring 6 x 4 m.

For substations of 500 kV and up, the author feels that it is advisable to erect two-story buildings. The design developed for these buildings (with cable half-story) also specifies employment of BMZ sections, for which it will be necessary somewhat to modernize the standard sections specified for single-story buildings. The floor-ceiling slabs should measure 5.7 x 3 m and rest on BMZ section brackets and central columns.

Since modernization of sections and organization of manufacture of supplementary components require time (development, fabrication of equipment, preparation for production), at the present time a new design for a type VIII OPU building of prefabricated reinforced concrete has been developed. We should note that this design will apparently be utilized in this country's eastern areas, to which BMZ sections (due to the absence of fabricating plants in these areas) will be supplied in limited quantity.

The new type VIII OPU design differs significantly from the preceding one. The designed building is more compact: its plan dimensions are 18 x 36 m (as compared with the old design's 12 x 54 m). In place of the previously employed II-20 series, designed for multistory industrial buildings, the plan calls for employment of more economical series II-04 structures (communications version) which are being put into production at plants of the USSR

Ministry of Power and Electrification. Thanks to this, building height will be reduced by almost 2 meters, and building volume by more than 1,000 m^3. In addition, the design specifies utilization of prefabricated reinforced concrete partitions of vertical components developed by Teploelektroproyekt and employed in construction of the Zaporozhskaya GRES. As a result of adopting new technical solutions and an efficient layout, the cost of construction and erection will be reduced by 11% and labor outlays by 20%.

In order to achieve a further decrease in labor outlays, plans call for improving design solutions for laying cable on substation sites. In particular, it is proposed to replace the reinforced concrete cable trays presently employed for ground laying of cable with reinforced-cement trays. This will make it possible to increase tray length from 2 to 3 meters and to reduce the number of reinforced concrete tray rests by 30%. It is proposed that trays and conduits be covered by thin-walled ribbed slabs, which will make it possible to reduce by approximately one half the number of slabs utilized for these purposes.

It is recommended that semi-buried conduits of series II-01-04 elements employed for laying a large number of cables be designed in one piece (that is, a trough-shaped section, not of three separate components), which will also help reduce labor outlays on laying cable conduits.

There is one other possible version -- laying of cables in protective jackets, supported by suspension cables. Analysis of technical-economic indices confirms the economic effectiveness of adoption of such a technical solution in building large substations with extensive cable lines.

Certain work is also being done in the area of improving zero cycle structures. Of interest in this respect are bored and tamped-backfill foundations. Experimental-industrial utilization of such foundations for lead portals and power transformers at a number of substations has shown that their utilization sharply reduces volume of earthmoving, and consequently labor expenditures. For example, utilization of such foundations in the construction of a 110 kV substation (elaborated layout) resulted in reducing labor expenditures by 200 man-days. In areas remote from construction industry plants, employment of these foundations will produce additional savings by reducing transport costs of delivering reinforced concrete structures.

In conclusion we should note several problems resolution of which will promote further improvement of the construction part of substations.

1. One should reduce to the maximum degree the number of 110 kV substations erected of structures supplied in "bulk." Toward this end it is recommended that priority be given to development of KTPB [Fully Prefabricated Substations] for developed layouts, which in turn will make it possible to increase the extent of their adoption. At the same time measures should be taken aimed at increasing the volume of production of KTPB within the USSR Ministry of Power and Electrification system, since the presently existing level of production is clearly insufficient.

2. It is necessary to expand production volume on BMZ structures and to set up production not only in the European part of this country but also in the eastern areas. Special attention should be focused on expanding the variety of sections produced. It is advisable to set up production of sections measuring 12 x 4, 6 x 4, 9 x 4 m, etc. This will make it possible to construct almost all substation buildings of BMZ sections.

3. There is needed further development of construction industry base facilities in the eastern part of the country, and in particular expanded output of product items for substation construction. At the present time, due to inadequate development of base facilities in these areas, it is difficult to supply substations with building structures, and in many instances structures specified in the plans must be replaced by others, and this naturally leads to overexpenditure of materials and increased cost of construction.

BIBLIOGRAPHY

1. Filatov, A. M.; Yaroslavtseva, N. F.; and Volkov, A. N. "Experience in Designing Substation Buildings of Lightweight Structures," ENERGETICHESKOYE STROITEL'STVO, No 10, 1977, pp 61-63.

2. "Efficient Utilization of Buildings of a High Degree of Prefabrication in Erecting Substations," Sidorenko, L. P.; Kogan, Ya. I.; Elenbogen, G. N.; and Khokhlov, A. I., ENERGETICHESKOYE STROITEL'STVO, No 7, 1977, pp 17-25.

3024
CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

UDC: 621.311.4.001.2

NEW ENGINEERING SOLUTIONS FOR 500 AND 750 kV SUBSTATIONS PRESENTED

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 4, Apr 79 pp 7-9

[Article by Engineers G. K. Vishnyakov, L. V. Yevstigneyeva, and I. M. Smirnov: "Some New Technical Solutions for 500 and 750 kV Substations"]

[Text] A substation is one of the most labor-intensive facilities in electric power system construction, and it is therefore not surprising that considerable attention has recently been devoted to problems of improving substation construction.

The Overland Transmission Department (ODP) of the Energoset'proyekt Institute has developed the Mechta-500 and Mechta-750 500 and 750 kV substation designs. These designs are the results of a search for new ways to improve high-voltage substations with the objective of reducing the labor requirements in their construction as well as material outlays. The designs utilize latest advances in Soviet and foreign substation construction practices, and revise certain standards. For comparison of the technical and economic indices of the Mechta-500 and Mechta-750 substations, we examined the designs of the 500 kV Krasnoarmeyskaya substation and the 750 kV Yugo-Zapadnaya substation, which were prepared by ODP in 1976-1977.

We should note that the designers did not analyze technical solutions application of which would require either a radical change in the existing system of operation and control (for example, adoption of total automation and remote control of all operational and mode switchings), or utilization of equipment of new types which is in the initial stage of development (for example, circuit breakers operations with which will not lead to overvoltages, optoelectronic devices for holding currents and voltages in primary circuits in place of current and voltage transformers, etc).

Initiation of design was preceded by analysis of distribution of the estimated cost among individual 500 and 750 kV substation facilities, as well as among types of jobs in conformity with the consolidated estimates of preliminary design of the 500 kV Krasnoarmeyskaya and 750 kV Yugo-Zapadnaya substations. It was established that the cost of equipment for 750 kV substations comprises more than 56% of the substation's total cost. The most expensive equipment includes 750/500 kV autotransformers (14.4%), 750 kV ORU [Outdoor Distribution

Systems] (11.2%) and 500 kV ORU (9.9%). The construction portion of 750 and 500 kV ORU accounts for more than 5% of total substation cost, laying of a rail spur to the autotransformer site -- 2.9%, and construction of the substation control center (OPU) -- 2.7%.

The cost of construction on transformer-oil supply (TMKh) with combined building comprises 1.4%, while construction of fire protection facilities, sumps and oil drains comprises 0.8 and 0.3% respectively; the cost of cable lines is 3.4% of substation costs (1.9% for construction and 1.5% on installation).

The estimated cost for a 500 kV substation breaks down in the main the same as for a 750 kV substation: 50.1% of the total cost involves cost of equipment (18.7% for 500/220 kV autotransformers, 3.9% for 500 kV ORU, and 4.2% for 220 kV ORU); 7.7% for synchronous compensators; approximately 2% for construction on the TMKh facilities, and 2.8% on laying cable lines (we should note that the cost of the OPU building is greater than that of the construction portion of 500 and 220 kV ORU combined).

Analysis of distribution of estimated cost made it possible to determine the principal areas in which to seek efficient technical solutions. This does not signify, however, that one should abandon the search for the most economical solutions for those facilities the cost of which comprises an insignificant percentage of the total cost of building a substation.

Principal layouts of substation electrical connections. As we know, an efficiently selected layout ensures minimal capital expenditure while providing the required level of reliability.

In most cases these conditions are met by a standard set of layouts which include such arrangements as the square, buses-transformers, one and a half buses-transformers, and one and a half. The employment of combined layouts is advisable from the standpoint of reducing the quantity of utilized equipment. For example, recommended for four lines and two transformers is the layout buses-transformers with eight circuit breakers. Employment of a combined layout which contains one one and a half layout circuit and two circuits with two circuit breakers, will make it possible to reduce the number of circuit breakers to seven and will ensure the required level of reliability.

Distribution system structures. Distribution systems are the most costly and labor-intensive substation facilities. Their design determines for the most part the size of the site occupied by a substation. The designers analyzed various designs of the 500 and 750 kV ORU and layout arrangement for the substations as a whole:

standard;

three circuit breakers in series;

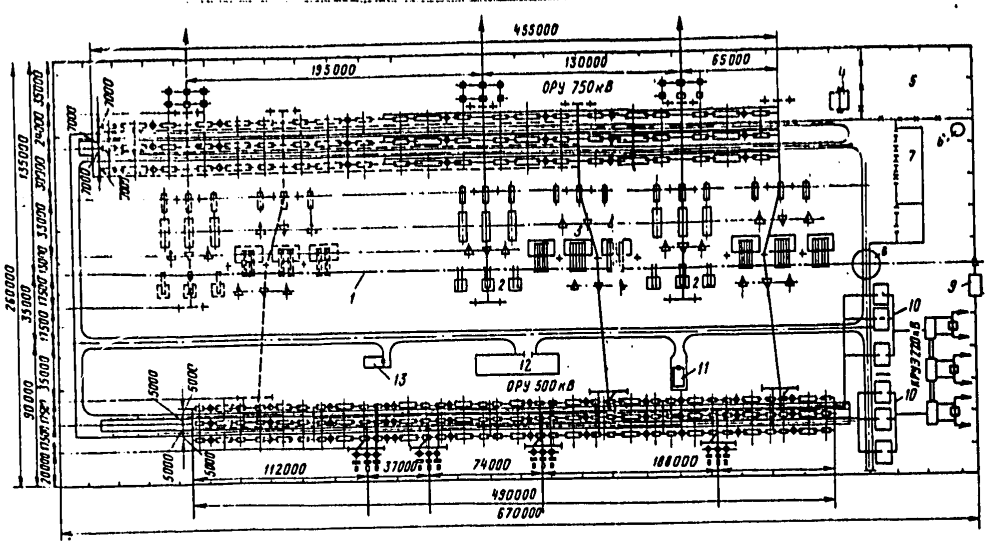
with overhead disconnectors;

with lengthwise equipment placement;

same, with employment of elegaz [SF_6] conductors;

same, with employment of structures of electrical insulation concrete.

Analysis indicated that widespread standard solutions are not optimal, since a maximum site area is required for the substation layout.



Layout of Mechta-750 Substation.

Key:

1. Rail spur
2. 750 kV reactor
3. 750/500 kV autotransformer
4. Compressor house
5. Treatment facility zone
6. Sump
7. Garage
8. Transformer turning device
9. Entrance
10. 500/220 kV autotransformer
11. Pump house
12. OPU building
13. Compressor house

ORU 500 and 750 kV layouts with lengthwise equipment placement proved to be the most acceptable in all principal indices. Further improvement of these designs involves utilization of SF_6 conductors as collecting bars. All principal distribution system equipment is conventional. Such a combined distribution system design makes it possible sharply to reduce the site area occupied by a substation, consumption of metal, reinforced concrete and cable. A drawback of this design is the high cost of SF_6 conductors. Its adoption into construction practice will become possible only after Soviet industry commences producing 500-750 kV SF_6 conductors.

The possibility of employing electrically insulating concrete is provided for the design of 500 kV ORU with a lengthwise equipment layout. At the Mechta-500 substation the 500 kV ORU bus leads are secured to separately standing stanchions (pipes), fabricated of electrically-insulating concrete. Employment of this material will make it possible to eliminate insulation (which provides considerable savings) as well as simplifying lead installation and operation.

ORU employ uprights fabricated in formwork for standardized centrifugally cast prestressed reinforced concrete pipe 560 mm in diameter. The adoption of uprights of electrical insulating concrete, as well as partial employment of rigid leads, has made it possible substantially to reduce metal consumption and somewhat to reduce ORU area. Further simplification of distribution system design is possible only after improving the electrical equipment (transiton to SF_6 equipment). The plans for Mechta substations specify the possibility of employing complete SF_6 distribution systems (KRUE), outdoor sited, 220 and 110 kV (see figure).

Installation of transformers, autotransformers and reactors. Series-produced transformer designs were employed in drafting plans for the Mechta substations.

Further simplification of installation of this equipment is possible only if the Ministry of the Electrical Equipment Industry develops improved transformer and reactor designs. These efforts should focus in the following areas:

development of 500-750 kV three-phase autotransformers rated to 1,000 MVA;

securement of reliable transformer operation throughout its entire service life (without inspections);

increase in tank strength;

manufacture of transformers with a high degree of prefabrication (elimination of assembly operations other than mounting and connecting leads without draining oil).

One should examine the possibility of building transformers with a 0.4 kV winding, which will make it possible to eliminate installation of transformers for substation operation needs.

Substation operational needs layouts. In the practice of designing 500-750 kV substations, layouts are employed which call for installation of from two to six transformers for substation operational needs, ranging in power rating from 630 to 1000 kV·A, feeding 380 volt panels. Transformers for substation operational needs are as a rule mounted close to these panels and thus are distant from the load center. In place of panels installed in buildings, it is advisable to employ combined transformer substations (KTP). This will make it possible to reduce building size and to bring transformers for substation operational needs close to load centers.

OPU and relay panels. OPU buildings and relay panels contain control, automatic control, signaling and relaying panels. At the present time the number of protection panels is rather large, and they require considerable space. For example, at the 750 kV Yugo-Zapadnaya substation, the OPU must contain 24 control panels and 23 automatic control and protection panels, while the 220 kV relay panel contains about 70.

By utilizing semiconductor components, the total number of panels can be reduced by 42.

A more promising solution, which makes it possible sharply to reduce building size, is delivery of factory-built relay stations. Relay stations should be installed in ORU, directly by primary equipment.

Cable conduits and cable equipment. At the present time power and control cables are laid in semi-buried conduits and ground trays, which are covered with prefabricated reinforced concrete slabs weighing up to 230 kg. Presently-existing cable conduits and trays have substantial materials and processing requirements. It would expedient to replace these designs with on-ground cable boxes of metal structures of the "Christmas tree" type, placed in the ground or in ground plates and covered by a lightweight fireproof asbestos cement or fiberglass tray.

Substation grounding. Present standards for electrical installations up to 500 kV specify only resistance to spreading (0.5 ohm), with laying of grounding network cross strips specified at an interval of 6 meters.

One possible way to reduce metal consumption on substation grounding, as well as increasing personnel protection against electrical shock, is transition to designing on the basis of "Provisional Contact Voltage Standards for Distribution Systems and Substations of 110 kV and Greater." In conformity with these standards, the size of the grounding network unit can be increased to 30 meters. On a site of approximately 30 hectares, an increase in the distance between cross strips even to 20 meters will make it possible to save approximately 30 tons of metal (with grounding steel diameter of 12 mm).

Rail spur. Transformer turning device. The designers provided for the possibility of employing when needed transformer transport tracks with a grade up to 2% in order to reduce the volume of grading work.*

The transformer turning unit is employed on the transformer transport tracks and makes it possible to turn transformers to any angle. It consists of a reinforced concrete base and a rotating frame. Circular metal guides are mounted in the base, on which ride the turning frame shoes; teflon sheets are secured to these shoes. Employment of this device makes it possible in a more flexible and diversified manner to handle problems of substation layout with the objective of maximum reduction of site size, reduction in the length of service lines (water, sewer lines, cable lines, communication lines, etc), as well as volume of construction work.

We should note that the solutions utilized in the Mechta substation designs make it possible to reduce site area by 63% for 500 kV and by 55% for 750 kV (in comparison with standard layouts). Employment of such designs is particularly advisable when cultivated farmland is being allocated for a substation site.

Primarily improvement of existing equipment will help solve the problem of combatting harmful noise. The 110 and 220 kV KRUE employed in the Mechta substation designs are most promising in this regard, since they operate practically noiselessly.

These substations are built in conformity with standard-specifying documents. The Mechta substations employ SF_6 conductors, which sharply decrease the biological effect of an electrical field. In addition, utilization of gravel or crushed rock for fill on a substation site (where high voltage equipment is installed) improves ORU operating conditions (step voltage is reduced).

Mechta substations leave the site environment little changed. They possess smaller linear dimensions, the tallest building is eliminated (TMKh), and the quantity of flexible leads and portals is reduced due to employment of SF_6 conductors. Utilization of structures of electrically-insulating concrete improves substation appearance. We should also note that, as is well known, the site environment is altered not by substations proper but rather by the overhead power transmission lines which lead to them. In connection with this it is advisable to take into consideration the following recommendations in designing overhead line approaches to substations:

---

* Goberman, Ye. A.; Strashnenko, B. F.; Lovkevich, K. I; Kogan, Ya. O; and Skorobogatov, G. F. "Employing Incline-Grade Transformer Transport Tracks at Substations," ENERGETICHESKOYE STROITEL'STVO, No 2, 1979, pp 9-11.

an effort should be made to employ towers of a single type;

to avoid overhead power line intersections in the vicinity of a substation;

to site terminal towers at an equal distance from portals;

to ensure if possible a parallel run of different overhead lines at a distance of 1.5-2 km from a substation.

As is indicated by an analysis of the technical and economic indices of Mechta substations and similar substations, employment of new technical solutions will make it possible to obtain the following results:

	Mechta-500	Mechta-750
Reduction in cost of construction and installation work, thousand rubles/%	850/19	1100/17
Savings in labor outlays, thousand man-days	14	18.5
Reduction in site area, hectares (-fold)	10(2.7)	20(2.2)

Consumption of reinforced concrete, steel and brick will be substantially reduced.

We should note that the total cost of Mechta substations is greater than that of similar substations due to the very high cost of SF_6 equipment (in calculations equipment cost was figured on the basis of preliminary figures from the Ministry of the Electrical Equipment Industry). In Mechta substation designs the cost of equipment comprises 70-75% of the total cost.

Thus construction of substations on the basis of the above-discussed designs is promising. One should note, however, that the proposed solutions represent only one of several possible directions to take in further improving the design of 500 and 750 kV substations.

3024
CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

UDC: 621.311.4.002.2

PROBLEMS OF IMPROVING SUBSTATION CONSTRUCTION DISCUSSED

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 4, Apr 79 pp 14-16

[Article by P. P. Falaleyev, First Deputy Minister of Power and Electrification USSR: "Principal Tasks and Paths of Improvement of Construction of Substations"]

> [Text] From the editors: the editors have asked P. P. Falaleyev, First Deputy Minister of Power and Electrification USSR, to discuss the essential points of questions brought up in a group of articles (see ENERGETICHESKOYE STROITEL'STVO, No 2-4, 1979).

A steady growth in electric power consumption in our nation's economy demands a priority growth rate in the power industry, particularly electric power networks providing transmission of electricity, and substations, which distribute electric power among customers. Thus substations are an important element of power systems.

As of the beginning of 1979 approximately 580 million kV·A of transformer power had been put on-line at substations of 35 kV and higher; with a total number of approximately 22,000 of these substations, 21,160 are 35-150 kV, 625 -- 220 kV, 140 -- 330 kV, 60 -- 500 kV, and seven substations -- 750 kV.

In the 10th Five-Year Plan each year approximately 30 million kV·A of transformer power is coming on-line each year, and 800-1,000 substations of 35 kV and higher are being built, the majority of which (approximately 96%) are 35-150 kV substations.

We should note that the volume of capital spending on construction of substations of 35 kV and up comprises approximately 45% of the total volume of capital investment in power system construction, while the volume of construction and installation work comprises 33%. At the same time the total number of construction workers employed in building substations comprises approximately 45-50% of the total electric power system construction work force. This is due to the fact that labor expenditures on building substations are approximately 50 to 100% greater than labor outlays on construction of power transmission lines.

Substation designs and construction possess a number of specific features. These include first and foremost existence in the design of a large number of structures of various function: outdoor and indoor distribution systems, a control panel facility, compressor house (with air-break switches), oil supply, water, sewer and fire extinguishing systems. As a result 15-20 separate facilities are built at average-size substations, and considerably more at big 500-750 kV substations.

A second feature is the large number of substations coming on-line in the plan-covered year. In 1978, for example, the plan specified construction of 73 substations of 220 kV and up, while the total number of substations of 35 kV and up to be constructed was 1,550. If we consider that they are built at a considerable distance from one another, there arise problems of preparation of each substation site and organization of construction and installation work at that site.

The job list in substation construction is practically the same as in erection of large industrial buildings and structures. The work volume involved in these jobs, however, is relatively small on substation projects. For example, in construction of an OPU [Substation Control Center] or ZRU [Indoor Distribution System] building it is necessary to perform all general construction jobs, plumbing and ventilating, roofing and finishing, installation of lighting fixtures, etc. Due to the small job work volume, workers are not always employed in line with their job qualifications, and sometimes not even in their area of specialization. In many instances this situation has a negative effect on quality of construction and utilization of manpower. The small volume of work involved on various jobs does not always make it possible extensively to utilize means of mechanization, and as a result some jobs at substations (plastering, puttying and spackling, painting, carrying concrete and mortar, etc) are performed manually, which naturally increases labor expenditures and lengthens construction time.

Due to the fact that substations under construction are scattered geographically and in many cases incorrect scheduling of work completion and initiation timetables, construction organizations are compelled to work simultaneously at many sites, which in turn leads to a shortage of construction equipment, trucks, as well as manpower. Completion of substations is as a rule scheduled for the latter half of the year. Thus performance of a large volume of work takes place toward the end of the year. This naturally has a negative effect on the quality of work performed in the fall-winter period. Project carryovers to the following year are scheduled in an insufficient amount, which fails to promote smooth, uniform operations of construction organizations throughout the year.

Construction organizations fail to develop their own construction base facilities for supplying construction jobs with small nonstandard items and custom fabrication, as a result of which there is an increased work loading on construction industry enterprises with products different from their product line.

In many cases clients are technically but not financially responsible for putting substations into operation, job timetables, quality of design and estimate documentation, prompt ordering and delivery of equipment, cable products and fittings.

The quality of plan documentation is substandard; problems in estimate documents are not promptly discovered by client and contractor. Practically no facility is provided by the client with the requisite electrical and other equipment on schedule. Clients fail to monitor suppliers and fail to impose appropriate penalties in case of failure to deliver. This leads to the necessity of creating temporary unreliable arrangements when putting facilities into operation.

Due to deficiencies in preparing startup diagrams and systems at substations, the volume of uncompleted production increases year by year, while a number of substations put on-line, including in Moscow, go for a long time without customers due to execution of ill-conceived plans.

It follows from the above that the principal task of further improvement of substation construction is maximum industrialization of the process of construction while ensuring a high quality of job performance.

Following are the principal ways of resolving this problem:

further improvement of design solutions by more extensive employment of standard structures;

elaboration and adoption of prefabricated substations delivered to the site fully assembled or in large modules (the prerequisites for this already exist);

development and utilization of industrial construction structures and prefabricated components in construction of substations;

adoption of a system of providing substation construction jobs with complete sets of equipment and supplies;

development and adoption of new types of electrical equipment;

provision on schedule of complete substation electrical equipment;

development and utilization of specialized comprehensive means of mechanization of construction and installation work at substations;

extensive adoption of the brigade contract in substation construction.

We should note that in recent years certain success has been achieved in substation construction. Thirty-five and 110 kV type KTPB prefabricated substations are becoming increasingly widespread; in remote parts of the country enlarged transportable units (UTB) for certain substation structures are being employed and have received high marks; so-called fast-erection substations (BMP) of 110 kV have been developed, which employ a power line terminal tower in place of portal structures; prefabricated fast-erection buildings (BMZ) of triple-layer lightweight reinforced concrete panels are utilized in erecting some substation structures; industrial substation fence structures have been developed and are being utilized; adoption of rigid ORU [Outdoor Distribution System] leads at 110 and 220 kV substations has been initiated, etc.

On the whole, however, substation construction does not fully meet today's demands.

Glavtekhupravleniye and Glavniiproyekt of the USSR Ministry of Power and Electrification must instruct the Soyuztekhenergo All-Union Association and design institutes to synthesize and analyze as quickly as possible experience in operation, design and construction of substations and prepare substantiated proposals for further improving substation designs. Special attention must be focused thereby on analysis of the technical and economic indices of new prefabricated substations.

Design organizations must step up work on simplification of buildings, structures and individual substation assemblies. A standard substation, a standard unit or at least a standard structure should be component parts of the plans of every substation under construction. Insufficient attention paid to standard design is due to a certain degree to limited funds allocated for standard and experimental design. It seems advisable to speed up coordination in USSR Gosplan of the matter of increasing financing of standard and experimental design with general appropriations allocated for experimental design work for capital construction.

At the present time a large number of 35 and 110 kV substations are still being erected "brick by brick" with employment of high labor-intensiveness structures; there is inadequate volume of fabrication of reinforced concrete product items for building substations (particularly in the eastern parts of the country); at the present time volume and variety of fabricated BMZ sections for building substations are extremely limited.

In spite of the fact that 35-220 kV substations built on simplified layouts comprise approximately 70% of all substations of this voltage, industrial KTPB on these layouts are being incorporated in an insufficient volume (40-50%). This is due to the slow development of KTPB for areas with elevated contamination of insulation, as well as for northern regions; it is also due to a limited selection of 6-10 kV units forming KTPB and failing to satisfy customers with installation of transformers of 10 MV·A and up. In order to achieve a sharp increase in volume of utilization of prefabricated substations, the Energoset'proyekt, Sel'energoproyekt and Orgenergostroy institutes, jointly with Glavenergostroymekhanizatsiya, Glavelektromontazh, and supplier plants must develop advanced designs both of complete substations up to 220 kV inclusive, totally fabricated at the factory, and 35-220 kV substations in complex layouts assembled of individual prefabricated units. At the same time it is necessary to expand production of KTPB for various climatic conditions. In coming years Glavenergostroymekhanizatsiya must expand production of complete substations; Glavenergostroyprom must increase BMZ output volume and ensure the fabrication of sections taking into account the variety required for erecting all substation buildings; Glavvostokelektroset'stroy must sharply increase volume of fabrication of substation structures.

At the present time labor expenditures and construction schedules for building 220 kV and particularly 500-750 kV substations are considerable. For industrialization of construction of these substations there should be more extensive utilization of designs ensuring a high degree of prefabrication and the possibility of mechanizing construction and installation work.

The greatest difficulties involved in building these substations are caused by the large site areas of both high and medium voltage distribution systems. In connection with this it is extremely important to develop and utilize efficient layouts for ORU. Pile or surface reinforced concrete elements and standardized portals should be extensively utilized as structures; standardized reinforced concrete elements and, where possible, BMZ sections, should be used for buildings. In connection with the great length of cable and other lines it is advisable to develop industrial designs for cable conduits, on-site roads, etc. In many cases it is advisable to employ rigid leads in order to reduce ORU space.

Transportable prefabricated units with built-in relaying and automatic control equipment for several connections, installed directly in 220 kV and up ORU, should be extensively employed at large 220 kV substations and up in order to reduce the size of the OPU building and expenditure of control cable. Beginning in 1979 the Sredazelektroapparat Production Association of the Ministry of the Electrical Equipment Industry will be developing and producing such units.

In building deep lead-in substations in large cities and at industrial enterprises, the problem of substantially reducing the site occupied by such substations and sharply reducing the volume of construction and installation work can be resolved by employing at these substations complete-set distribution systems with SF_6 insulation (KRUE), 110 and 220 kV. As is indicated by the experience of building the first enclosed deep lead-in substations in Moscow, this problem has not yet been resolved. It is necessary in the near future to develop several enclosed substation design variants employing KRUE in order to develop as rapidly as possible the most efficient structures for such substations.

We should note that, as is indicated by an analysis of available data on employment of KRUE at high and extremely high voltage substations abroad, considerable savings in labor, reduced volume of construction work and building materials will be achieved in building 330, 500 and 750 kV distribution systems. Employment of KRUE will be particularly efficient at 1,150 kV substations. Unfortunately the Ministry of the Electrical Equipment Industry is falling behind schedule in starting up production on a number of new pieces of equipment (advanced-design transformers, KRUE, small oil circuit breakers, pantograph-type and overhead circuit breakers, high-strength support insulation, etc).

The USSR Ministry of Power and Electrification should achieve acceleration of their development through the USSR State Committee for Science and Technology, and particularly development of production of 110 kV and up KRUE in conformity with previously-issued specifications.

One should also note thereby that equipment the manufacture of which has already been set up by the Ministry of the Electrical Equipment Industry is being turned out in insufficient quantity. A shortage of electrical equipment is leading to considerable complexity in the design of substations under construction and undergoing expansion and a worsening of their technical and economic indices.

At the same time prompt supply of the requisite (and particularly short-supply) equipment to all substation facilities under construction is the task of Glavenergokomplekt.

The problem of industrializing construction is most critical when building substations in undeveloped areas. In addition to adoption of 100% prefabricated substations, it is essential more extensively to utilize for some structures transportable modular units (UTB), developed and put into production by the Elektrouralmontazh Trust jointly with the Energoset'proyekt Institute. These modular units, consisting of insulated boxes with installed equipment, should find application in OPU buildings, compressor houses, 6-10 and 35 kV ZRU, battery rooms and other substation facilities. Following adoption of complete SF_6 setups, UTB can also be employed for 110 kV ZRU.

To improve the quality of construction work, it is essential to increase effectiveness of architect's and technical supervision, preventing deviations from the requirements of the plans, Construction standards and regulations, and other standards documents. Of considerable importance thereby is improvement in the quality of structures and product items turned out by our plants, and especially quality of finishing operations.

Main electrical system construction administrations and main operation administrations should use closer scrutiny in adopting substation designs, promptly making suggestions for their improvement and obtaining from design organizations elaboration of designs which are in conformity with today's technical demands.

Further reduction of labor outlays and increased efficiency of construction at substations is impossible without total mechanization. Construction organizations, however, are not fully supplied with the requisite equipment. A highly efficient vibration pile-driving unit which has been retired from production, for example, has not been replaced by a similar piece of equipment, while construction of pile foundations is the best technical solution, especially in water-saturated soil with poor load carrying capability. The problem of mechanizing low-volume plastering, painting, roofing, waterproofing, as well as earthmoving for laying the grounding network has not been resolved.

The main production-technical administration for construction, jointly with Orgenergostroy Institute and Glavenergostroymekhanizatsiya, should immediately examine the problem of manufacturing and delivering means of mechanization for substation construction, including pile-driving and drilling equipment, plastering and painting stations, attachments for mortar pumps, telescopic towers, as well as small-scale mechanization equipment and devices.

Special attention must be focused on problems of prompt supplying of facilities. In planning construction and installation work volumes, one should take into consideration the capabilities of supplier organizations. The main task of suppliers is 100% delivery of supplies strictly on schedule. This applies to deliveries both of building structures and materials, and process equipment.

Finally, existing regulations on fines and other measures of administrative penalty for failure to deliver the goods on schedule should become more effective.

The matter of determining the principal supplier plant for reinforced concrete structures has not yet been settled, and therefore some construction jobs are supplied by from 5 to 7 plants, of course without observance of complete-set deliveries, etc.

The Main Production-Technical Administration for Construction and Glavenergostroyprom should resolve this problem jointly with the electric power system main administrations.

In conclusion we should note that inadequate attention is also devoted to matters of organization of substation construction. In particular, such an advanced form of organization of construction as the brigade contract is not being vigorously adopted. The brigade contract should be extended to all stages of substation construction: design, design approval by the client and its forwarding to the general contractor, fabrication of structures and equipment at supplier plants, and work performed by subcontractor and equipment startup organizations (through contract). This will make it possible to increase the responsibility of all participating entities in a construction project for the final result.

The main electric power system construction administrations and Main Production-Technical Administration for Construction must systematically carry out measures in the area of synthesis of advanced know-how in organizing continuous substation construction, as well as drafting proposals for further adoption of the brigade contract in substation construction.

Discussion of problems of further increasing efficiency of substation construction ends with publication of the above materials. The editors.

3024
CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

UDC: 621.31.002.2:69.054

TEMPORARY BUILDINGS FOR CONSTRUCTION OF TETS DISCUSSED

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 4, Apr 79 pp 17-20

[Article by Engineer G. B. Granik: "Temporary Buildings and Structures for Construction of 400-700 MW Industrial-Heating TETs"]

[Text] The VNIPIenergoprom Institute has studied and synthesized experience in designing, building and operating construction base facilities for industrial-heating TETs of various sizes built in the last 4-5 years in various parts of the country (with the exception of the Far North). The institute studied in particular detail experience in construction and operation of construction base facilities for the Kuybyshev and Novo-Irkutsk TETs, and therefore we shall examine below the principal temporary buildings and structures at these TETs.

The study indicated the following.

1. The temporary building and structures inventory, their design and equipment were practically identical at these TETs.

2. Practically no permanent buildings are utilized during the period of construction (in some instances they are utilized during enlargement of electric power stations). This is due to the fact that in the preparatory period construction organizations do not plan the erection of unified-auxiliary buildings (OVK), some of which it would be expedient to utilize during construction. From a design and construction standpoint, OVK are not more complex than the temporary buildings which are erected.

3. Permanent railroad tracks and permanent utility lines (if available) are almost always utilized during construction. As regards permanent roads, although they are constructed at the beginning of the construction project, they remain practically unutilized due to what as a rule is a poor design solution. The plans specify constructing urban-type roads at downslope points with curbing and roadbed water drains. The lack of a storm drain system and final grading on the site results in muddy roads, which makes their utilization impossible. In the author's opinion rural-type roads should be designed, lying above grade and with roadside drainage ditches to control runoff.

Construction equipment repair shops, insulation installation, electrical installation and truck repair shops are not supplied with the equipment specified by the plans. Construction projects receive practically no funds for this equipment. The shops contain at best one or two lathes, a drill press and tool grinder. Shops either stand empty or are utilized for other purposes (for parking cars and trucks, etc).

Assembly and storage sites adjoining the temporary ends of main buildings are designated for storing and assembling structures and equipment for the main building and to some extent fuel feed facility structures. Structures for auxiliary facilities are usually hauled in and stored right next to these facilities. This practice is correct, since OVK and service building structures usually arrive at the construction site when assembly and storage sites and their spur tracks are not yet ready. The structures for these facilities are relatively lightweight and are delivered to the erection site by conventional truck transport. This eliminates additional transfer of loads. The following table contains figures on the principal temporary buildings and structures at the Kuybyshev and Novo-Irkutsk TETs.

Объекты или сооружения 1	2 Куйбышевская ТЭЦ			3 Ново-Иркутская ТЭЦ		
	Вид объекта или сооружения 4	Площадь застройки, м² 5	Сметная стоимость, тыс. руб. 6	Вид объекта или сооружения 4	Площадь застройки, м² 5	6 Сметная стоимость, тыс. руб.
Контора стройуправления 7	39 Трехэтажное каркасно-панельное здание	648	181	Двухэтажное 45 кирпичное здание	805	183,1
Столовая 8	Каркасно-панельное здание на 300 мест 40	864	249,7	Одноэтажное 46 здание из УТС-420-06 на 1?0 мест	1015	82,5
Бытовой корпус 9	Двухэтажное кирпичное здание на 500 чел. 41	504	88,3	Здание из УТС-420-06 47 на 450 чел.	904	101,7
Бетонорастворное хозяйство 10	42 Две установки БСУ	—	187,7	—	—	687,5
Блок мастерских № 1* 11	43 УТС-420-06	1656	177,5	УТС-420-00	1160	115,5
Блок мастерских № 2** 12	•	1224	123,1	•	1120	110,3
Мастерские: 13						
обмуровочные 14	•	432	58,3	—	—	—
арматурные 15	•	143	34,8	—	—	—
механические (для металлоконструкций) 16	—	—	—	УТС-420-06	302	33,6
теплоизоляционная 17	—	—	—	•	640	61,2
столярно-плотничная 18	—	—	—	Деревянное здание 48	613	64,1
Склады: 19						
материальный 20	УТС-420-06	792	50,6	—	—	—
оборудования 21	•	1296	82,9	УТС-420-00	1074	71
теплоизоляционных материалов 22	•	720	39	•	590	38,9
обмуровочных материалов 23	•	216	28,6	—	—	—
ГСМ 24	•	—	19,7	—	—	—
кислородных и пропанбутановых баллонов 25	—	—	—	УТС-420-06	149	18,5
для хранения лаков и красок 26	—	—	—	Кирпичное здание	243	28,6
Битумоварильные 27	—	—	—	— 49	222	18,6
Ацетиленовая станция 28	—	—	—	—	—	2,4
Пропанбутановая станция 29	—	—	—	—	—	0,16
Тепляк для обмуровочных работ 30	—	—	—	УТС-420-06	652	124,8
Укрупнительные складские площадки 31	—	34 792	402,6	—	55 000	195,7
Временная котельная 32	Котлованы 44	—	118,8	Передвижная 50	—	168
Электрокотельная 33	—	—	—	—	—	137,1
Насосная временного водоснабжения 34	—	—	—	—	47,5	19,6
Временные железнодорожные пути 35	—	—	224,4	—	—	349,2
Временные автодороги и площадки 36	—	—	348,9	—	—	441,4
Подстанция 110/6 кВ 37	—	—	—	—	—	249
38 Итого			2415,7			3238,36

Key to Table on preceding page:

1. Facilities or structures
2. Kuybyshev TETs
3. Novo-Irkutsk TETs
4. Type of facility or structure
5. Construction area, m^2
6. Estimated cost, thousand rubles
7. Office
8. Dining hall
9. Personal services building
10. Concrete and mortar supply
11. Shop unit 1
12. Shop unit 2
13. Shops
14. Brickwork
15. Reinforcement
16. Machine shop (Dal'stal'konstruktsii)
17. Insulation
18. Carpentry
19. Warehousing and storage
20. Supplies
21. Equipment
22. Insulation materials
23. Bricklaying supplies
24. Fuels and lubricants
25. Oxygen and propane-butane tanks
26. Paints and varnishes
27. Asphalt storage
28. Acetylene station
29. Propane-butane station
30. Heated enclosure for bricklaying
31. Assembly and storage sites
32. Temporary boiler house
33. Electric boiler house
34. Temporary water supply pump house
35. Temporary trackage
36. Temporary roads and cleared areas
37. 110/6 kV substation
38. Total
39. Three-story frame-panel building
40. Frame-panel building accommodating 300 persons
41. Two-story brick building accommodating 500 persons
42. Two BSU units
43. UTS
44. Foundation areas
45. Two-story brick building
46. One-story building of UTS-420-06 accommodating 150
47. Building of UTS-420-06 Accommodating 450
48. Wooden frame building
49. Brick building
50. Mobile

* Shop No 1 consists of the following: at the Kuybyshev TETs -- repair-machine shops, preventive maintenance units, garage; at the Novo-Irkutsk TETs -- chief mechanic's shop and supply storeroom.

** Shop No 2 consists of the following: at the Kuybyshev TETs -- insulation installation shops, testing and automatic control equipment, electrical installation ships, heating and air conditioning installation equipment supply; at the Novo-Irkutsk TETs -- insulation installation and electrical installation shops

---

Analysis of the technical and economic indices of a number of TETs, the preliminary designs of which were prepared in 1973, 1976, as well as the Kuybyshev and Novo-Irkutsk TETs, which were under construction, showed that with an increase in TETs size, the rate of growth of estimated cost and volume of construction and installation work is greater than the growth rate of maximum annual construction-installation work volume.

This is due to the fact that, regardless of the total output capacity of a TETS, work volume on the first production units is approximately the same, since growth in unit output capacity exerts practically no influence on them. One should bear in mind that the maximum annual work volume usually occurs during the year the first unit comes on line.

With a growth in the size of a TETs, work volume involved in erecting poured concrete and reinforced concrete structures remains practically unchanged, while the volume of erection of prefabricated reinforced concrete increases. This attests to an increase in the quantity of industrial structural design solutions incorporated in the plans.

The cost of temporary buildings and structures comprises 6-8% of the total cost of construction calculated in sections 1-7 of the consolidated estimate, which is significantly higher than that specified in Construction Standards and Regulations IV-7-76.

We list below the average figures on principal technical and economic indices of TETs which were designed in 1973-1976, which form the basis of the elaborated register of temporary buildings and structures for construction of industrial-heating TETs with 60, 110, 135 and 175 MW turbine units.

Estimated cost of construction	70-90 million rubles
Work volume:	
construction-installation	40-50 million rubles
construction	25-35 million rubles
insulation	9-11 million rubles
electrical installation	3-4 million rubles
concrete poured on-site	35-50 thousand m^3
erection of prefabricated concrete and reinforced concrete structures	40-50 thousand m^3
Maximum annual work volume:	
construction and installation	10-14 million rubles
concrete	20-25 thousand m^3
erection of concrete and reinforced concrete strucutres	15-20 thousand m^3
erection of metal structures	4-6 thousand tons
Total equipment weight:	
heating	20-25 thousand tons
electrical	3-4 thousand tons.

The following points were taken as guidelines in determining the inventory of temporary buildings and structures and in calculating their production capacity and floor area:

all structures, parts and component items are hauled to the site in finished form, that is, are not fabricated at the construction site (wall panels, modules and partitions for industrial construction, all types of carpentry items, including form panels, boiler-auxiliary equipment components, product items for bricklaying and insulation work, etc);

major overhauls and medium repairs on construction equipment, installation equipment and trucks are not performed at the construction site;

buildings are laid out to a maximum degree taking into account the requisite sequence in their construction and the possibility of cancelling construction of some buildings when the organization the manpower and resources of which are building the entire facility is the general contractor for the TETs construction project;

the level of utilization of permanent buildings and structures remains unchanged during the period of construction;

all principal temporary buildings are to be erected of series UTS-420-06 structures; employment of series UTS-420-04 is specified for some buildings, and the possibility of substituting other structures is specified.

A TETs construction base layout was drawn up in conformity with the list. The construction master plan was based on the design of a TETs burning solid fuel -- a 500 MW TETs-ZITT (four turbine units of 80, 110, 135 and 175 MW, and 6-7 boiler units of 420 t/h each).

In conformity with thermal electric power station design standards, the plan provided for the possibility of future expansion of the TETs (installation of two units with an aggregate output of 310-350 MW). Thus the ultimate output of the TETs is figured at 800-850 MW.

In the master plan the construction base facility is situated where TETs expansion will occur; all stationary temporary buildings and structures are located outside the expansion site. As we know, in the overwhelming majority of instances the length of TETs construction sites is limited by adjoining shops of industrial enterprises or urban construction. Site width is dictated by the process layout of permanent TETs shops, and comprises 400-600 meters.

Thus the length of a construction base for an industrial-heating TETs should be as little as possible, while its width can be equal to that of the main construction site of the TETs.

In connection with this, two assembly-storage zones for process equipment and structures (300 meters long each) are located in front of the main building, the building structures area is located in front of the turbine house, and the process equipment area is located in front of the boiler house. The railroad track leading to the boiler house, along which large boiler units are transported, should be straight.

All buildings and structures of the construction base facility (other than the construction administration office and dining hall) are situated between the assembly-storage areas and rail spur entering the industrial site. This one-sided construction base layout is economically the most expedient (see figure).

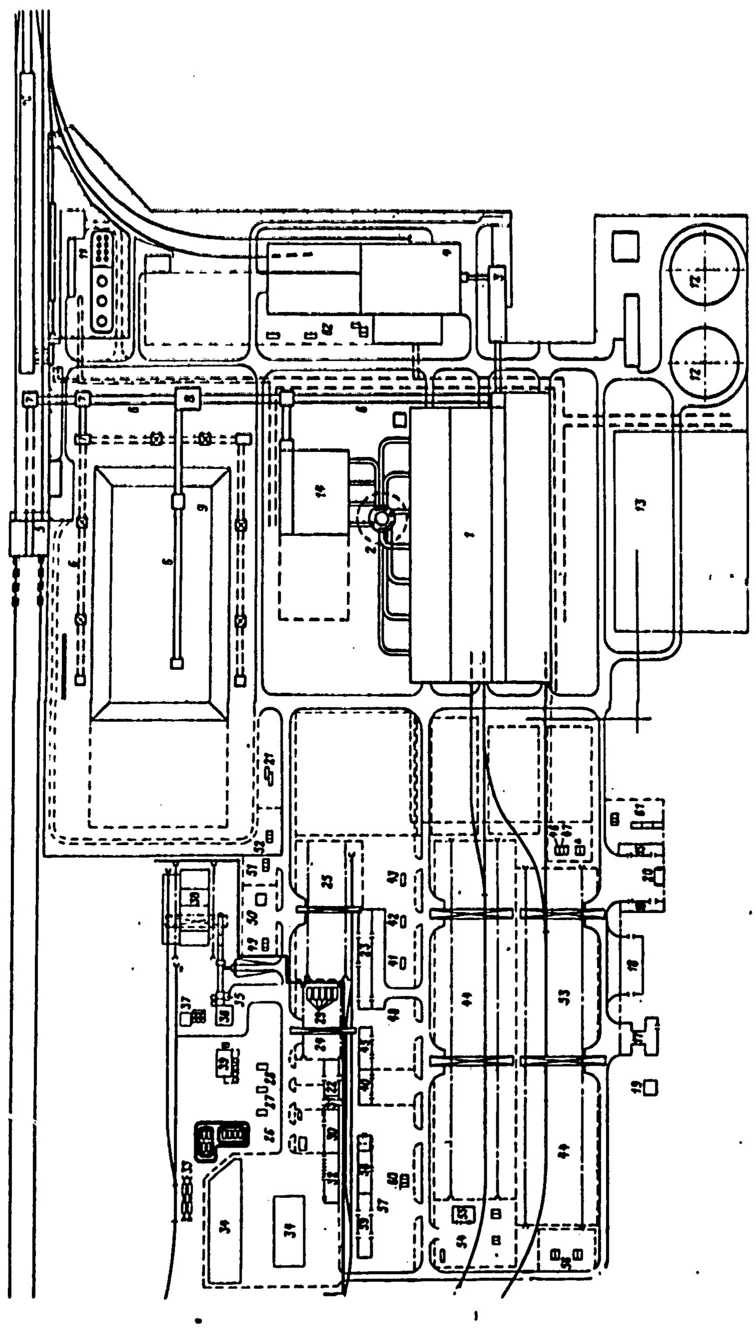


Diagram of Construction Master Plan of a 400-700 MW Industrial-Heating TETs

Key to Diagram on preceding page:

1. Main building
2. Smokestack
3. Service building
4. Unified-auxiliary building
5. Unloading facility
6. Fuel supply tunnels
7. Charging points
8. Crushing building
9. Coal storage
10. Bulldozer garage
11. Oil and lubricants supply
12. Cooling towers
13. Outdoor distribution system
14. Water-heating boiler house (permanent structures)
15. Construction office
16. Subcontractor organizations office
17. Dining hall
18. Service building
19. Vegetable storage
20. Medical aid station
21. Mobile dining hall
22. Central supply
23. Equipment storage
24. Outdoor supply storage
25. Outdoor equipment storage
26. Carbide storehouse
27. Paints and solvents storehouse
28. Lubricants storehouse
29. Supply shelters
30. Chief mechanic's shop
31. Reinforcement shop
32. Automotive repair shop
33. Mobile boiler house
34. Parking lot
35. Concrete batching
36. Mortar mixing
37. Cement supply
38. Aggregate supply
39. Compressor house
40. Insulation shop
41. Compressed gas tank storage
42. Oxygen dispensing
43. Propane-butane dispensing
44. Equipment assembly-storage site
45. Electrical installation shop
46. Setup personnel
47. Equipment assembly inspection
48. Cable yard
49. General construction section
50. Construction-erection section
51. Carpentry-formwork shop
52. Finish work shop
53. Construction structures assembly-storage site
54. Energostroymekhanizatsiya area
55. Machine shop
56. Gidrospetsstroy area
57. Insulation area
58. Insulation shop
59. Stores shed
60. Industrial ventilation area
61. Small-scale mechanization area
62. Anticorrosion treatment area (temporary buildings and structures)

Utilization of the construction base site area can be developed zone by zone, beginning with the rail spur. Structures needed at the very beginning of construction are erected close to it: motor transport facilities, concrete-mortar supply and unit No 1 with motor vehicle repair shop, preventive maintenance units, chief mechanic's shop, and central supply. We should note that if the TETs general contractor is a construction organization which is building the entire industrial enterprise, all specified priority buildings and structures at the TETs construction base facility are not erected, since the general contractor has its own central base and has the requisite resources at its disposal. The layout of the remainder of the TETs construction base remains unchanged.

The layout of roads and rail lines provides for maximum utilization of permanent roads and tracks.

The indices of two construction base facilities were compared in order to determine the technical-economic effect from adoption of the elaborated list: one in operations during construction of the Novo-Irkutsk TETs, and one planned in conformity with the list (in both instances total estimated cost of buildings and structures was taken into account, while rate of turnover and depreciation outlays were not).

Since the list of temporary buildings and structures was drawn up applicable to the first territorial zone in conformity with standards for specific capital spending on TES construction, a correcting factor of 1.08 was applied in calculating cost of a construction base elaborated in conformity with the list.

The comparison indicated that the site area of the Novo-Irkutsk TETs construction base is 9.7 hectares larger, or 38%, than that of the planned construction base. The total cost of the latter is 500,000 rubles less, or 15% less, than the total cost of the Novo-Irkutsk TETs construction base.

3024
CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

UDC: 621.311.21:621.221.3

CONSTRUCTION OF PUMPED-STORAGE POWER GENERATING PLANTS DISCUSSED

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 4, Apr 79 pp 28-31

[Article by V. Ya. Shaytanov: "Some Problems of Organization of Construction of Pumped-Storage Power Generating Plancs"]

[Text] Since 1975 our country has been building large pumped-storage power generating plants. In connection with the fact that the greatest peak power demand occurs in the power systems in the European part of this country, construction of the first GAES [Pumped-Storage Power Generating Plant] -- the Zagorsk and Kayshyadorskaya -- began in these areas.

Sites of GAES presently under construction or planned for future construction are characterized by moderately hilly topography without extremely steep slopes, which excludes the possibility of heads exceeding 100-120 m at GAES. In connection with this fact, practically all the first pumped-storage power generating plants are fairly similar in parameters (head -- 100-120 m; turbine unit power -- 200 MW; total installed generating capacity -- 1200-1600 MW), design and layout of principal structures, construction job breakdown and volume (Table 1).

Table 1.

ГАЭС 1	2 Установленная мощность, МВт	3 Расчетный напор, м	4 Стоимость строительно-монтажных работ, млн. руб.			8 Объемы работ		
			5 по объектам производственного назначения	6 по основным сооружениям	7 по временным зданиям и сооружениям	9 Выемка (профильная/общая), млн. м³	10 Насыпь (профильная/общая), млн. м³	11 Бетон и железобетон, тыс. м³
Загорская 12	1200	100	141	91	14	18/25	19/25	672
Кайшядорская 13	1600	100	171	104	20	16/24	17/24	796
Ленинградская 14	1360	111	166	97	15	5/7,5	14/21	690
Днестровская 15	2160	139	275	183	31	32/48	17/26	1220
Тереблинская 16	1350	...	184	105	15	11/17	0,4/0,6	422
Теребля-Рикская 17	2025	...	280	159	24	9/13	3/5	932

Key to Table 1 on preceding page:

1. GAES
2. Installed capacity, MW
3. Design head, m
4. Cost of construction
5. On production facilities
6. On principal structures
7. On temporary buildings and structures
8. Job volume
9. Excavation (shaping/total), million m^3
10. Fill (shaping/total), million m^3
11. Concrete and reinforced concrete, thousand m^3
12. Zagorsk
13. Kayshyadorskaya
14. Leningrad
15. Dnestr
16. Tereblitskaya
17. Tereblya Rikskaya

GAES location areas are also approximately the same: they are characterized by a fair density of population and development, a fairly high level of industrial-economic development, well-developed road and rail networks, and the existence of construction industry bases and a construction organization engaged in building power facilities.

Designs of principal GAES components which are similar in parameters enable one to examine the possibilities of setting up to a certain degree standardized procedures of erecting the principal structures for this series of GAES, a standard construction base, and a standard construction organization arrangement. However, in spite of what would seem to be fairly favorable conditions for creating new forms of organization of construction and a sharp decrease in the labor-intensiveness of construction, as regards organization of construction the initiated construction projects do not essentially differ from hydroelectric power projects of recent years, which are characterized by an extended period of construction and a low level of organization of the preparatory period, and a low level of industrialization of construction of production base facilities and worker housing. This in turn results in high labor expenditures, a large construction labor force, and consequently large volumes of housing and cultural-services construction.

As an illustration we can cite the example of organization of construction, which was initiated in 1975, on the Zagorsk GAES, located 100 km from Moscow in a fairly densely-populated area with a good transportation network. Construction on this GAES is being handled by the All-Union Gidroenergokanalstroy Trust of the USSR Minister of Power and Electrification, which builds water engineering structures for power generation and economic uses in the central region of the European part of this country. When work began on the GAES, the trust's output capacity was 20 million rubles of construction work per year. The trust operates several small production bases and possesses a fleet of heavy construction equipment and trucks located in various parts of Moskovskaya and Kalininskaya oblasts. Structurally the trust consists of mobile mechanized columns, separate administrations and sections.

Diagram of Zagorsk GAES Construction Site.

Key:
1. GAES building
2. Penstock
3. Upper pool
4. Lower pool
5. Motor transport
6. Mechanization base
7. Gravel grading facility
8. Concrete supply
9. Facilities of specialized construction organizations
10. Permanent housing
11. Temporary housing

The plans called for setting up at the construction site of the Zagorsk GAES a temporary construction base, built chiefly of stock prefab structures, as well as temporary and permanent housing. The plan called for building in the temporary housing area two-story container-type prefab buildings, improved design series SKD. For performing initial work on the construction site, the plan called for setting up an advance crew operation equipped with stock production enterprises, also consisting of container-type buildings.

This was to make it possible, with minimal labor expenditures (essentially "right off the truck"), to build on the construction site within a span of a few months a construction base and housing, which in turn would make it possible to bring the requisite construction work force to the jobsite.

With construction organized in this manner, the plan called for building at the construction site in the first two to two and a half years the requisite volume of permanent housing, to provide the construction organization with requisite construction manpower, and to eliminate labor force turnover by providing workers with permanent housing. During this same time the plan called for completing construction on principal production base facilities, establishment of a construction organization and initiation of work on the principal GAES structures.

Volume of construction in the preparatory period was specified at 25-30 million rubles. The volume of excavation and blasting to be performed in the preparatory period was to total approximately 1 million m^3, concrete and reinforced concrete work -- approximately 3,000 m^3. During this period the plan called for building approximately 20 km of roads and 7 km of rail lines, as well as completing for tenancy approximately 30% of the permanent housing. In addition, the plan called for completing construction on principal production base facilities: a concrete supply facility with a monthly output of 40,000 m^3 of commercial concrete, a gravel grading facility with an annual output capacity of 600,000 m^3 of finished product, a prefabricated reinforced concrete yard with a monthly production capacity of 13,000 m^3 of prefabricated reinforced concrete products, a reinforcement facility with an annual output capacity of 12,000 tons of reinforcing structures, a formwork shop, a 350-truck motor pool, a mechanization facility with repair and machine shops, various facilities for the Gidromekhanizatsiya and Gidrospetsstroy trusts and installation organizations of Giromontazh and Spetsgidroenergomontazh. All construction facilities were designed in prefab or modular buildings. The total construction base site area is 60 hectares (see figure).

Project development was to proceed as follows. In 1975, the first year of construction, the plan called for building the first unit of a temporary housing community accommodating 400 persons, advance crew operations and a trackside off-loading facility, with construction of primary approach roads and power lines. Total volume of construction work was specified at 12 million rubles, or 8.6% of the project total. In 1976 the plan called for completing construction on temporary housing for 1,000 persons, plus access roads, continuation of construction on facilities of the main production base and permanent housing for construction workers, with work to begin on the upper reservoir. Volume of construction work in this period was to total 21 million rubles, or approximately 15% of the project total. In 1977 the plan called for fully completing work in the preparatory period, continuing construction of permanent housing, and beginning work on the main GAES structures. Volume of construction for that year was 33 million rubles, or 23.4% of the project total. According to this project timetable, the first power generating units were to go into operation no later than 1980.

In actuality construction proceeded at a different pace. In connection with the fact that container-type stock production buildings were not allocated in 1975 for the advance crew operation, it was necessary to replace them with buildings of other series, more laborious to erect and more costly. This led to an increase in the estimated cost of the advance crew operation (from

120 to 370,000 rubles) and duration of construction. In addition it became necessary to rework the plans.

The situation was no better as regards construction of temporary housing. In place of the plan-specified two-story improved-design type SKD container buildings, single-story type PDU prefab buildings and two-story UGPD-2e buildings were delivered to the site. These were buildings of obsolete design, they were delivered to the construction site incomplete, and their condition was such that they required major repairs.

Delay in construction of the main housing made it necessary to build temporary housing for 2000 persons. All these things combined made it necessary to come up with a new housing plan, which in turn resulted in increased cost.

Delivery volume on stock buildings allocated for housing construction met requirements by only 20-25%, which held down the construction work force growth rate.

Under these conditions one could hardly count on the plan-specified increase in construction work force size, construction capacity of the organization and successful accomplishment of the job timetable. This is also confirmed by the results of studies performed by the Orgenergostroy Institute. In the course of investigation it was established that an increase of 1% in labor force turnover in a construction organization leads to a 0.5% decrease in labor productivity and a 0.2% decrease in completion of construction volume. With a work force turnover of greater than 40% a construction organization as a rule fails to meet the construction target, that is, operates at a loss.

Actual financing and completion of construction work volume was as follows. A total of 5 million rubles was allocated for the first year of construction, while only 2.6 million rubles were spent; in 1976 4.9 million of the allocated 7.6 million rubles were spent, and in 1977 -- 8 million of the 9.4 million rubles allocated. Thus in 3 years of construction slightly more than 15 million rubles were spent on construction, or approximately 10% of the project total.

The example of organization of construction of the Zagorsk GAES is no exception. Construction is developing in a similar manner on the Kayshyadorskaya GAES. The general conditions of the site areas of the Kayshyadorskaya and Zagorskaya GAES are similar in many respects. The construction site of the Kayshyadorskaya GAES is located in an economically developed area in the Baltic. Roads, high-voltage power transmission and communication lines pass in the immediate vicinity of the construction site. Construction of the GAES was assigned to an established construction work force which had just completed construction of the Lithuanian GAES, the construction base of which can be utilized as a base for starting up construction on the GAES. The power industry worker town of Elektrenay has been built adjoining a GRES, and plans call for further expansion of this town to house construction workers on the Kayshyadorskaya GAES.

The nature of organization of construction of the Kayshyadorskaya GAES is approximately the same as that of the Zagorsk. A similar advance crew operation is set up at the construction site to organize preparatory work. Then the principal production base facilities are to be constructed. In connection with the fact that the principal work volume on GAES water engineering structures and the procedures of their erection are similar to those adopted at the Zagorsk GAES, the composition and production capacity of construction facilities are fairly close.

One feature of organization of the construction site at the Kayshyadorskaya GAES consists in its division into two sections. Production enterprises which are involved with erecting the principal GAES structures are located on the site directly adjacent to the principal structures. These include the concrete and gravel grading facilities, the reinforcing shop, parking area and preventive maintenance inspection facility for heavy trucks, the mechanization base section, and several other facilities. All other enterprises, as well as facilities connected with rail operations (supply and equipment storage, the Gidromontazh erection supply facility, etc) are located at the site of the former construction base of the Lithuanian GRES 30 km from the GAES.

The character of development of construction on the Kayshyadorskaya GAES maintains all the shortcomings characteristic of organization of construction of the Zagorsk GAES: a shortage of housing slows the rate of construction work force growth, which in turn prevents the go-ahead with housing construction; the disorganized nature of delivery of fast-erection prefab buildings for production enterprises (and particularly for advance crew work on the construction site) slows construction of the main construction facility and housing. This engenders construction worker labor turnover, a loss operation for the general contractor organization, slow rate of construction development, and in the final analysis delay in completing power generating facilities.

In connection with the fact that the need for GAES will continue rising in the European part of our country, it is necessary to develop more efficient methods of construction, which ensure a reduction in construction time and labor requirements for building these power stations. We can recommend the following as principal ways of resolving this problem:

improvement in the system of organization of the preparatory period;

increase in industrialization of construction of principal GAES structures with the essential condition that requisite funds and resources are allocated for construction.

These problems must be resolved first and foremost within the USSR Ministry of Power and Electrification system because, as is indicated by the practical experience of hydropower construction, one cannot count on utilizing existing construction industry facilities even in building GAES in economically developed areas. First of all, in connection with steadily growing volumes of capital construction, construction industry facilities located in the GAES construction area do not have available production capacity at their disposal; second, local industry enterprises are designed for turning out series-production and standard product items for industrial and civil construction, whereby possibilities of obtaining even these items are limited as a rule, and increasing their production involves additional capital spending, which frequently exceeds the original capital investment. Thirdly, in many instances rayon maintenance facilities are unable to service and repair the heavy construction equipment employed in water engineering construction.

In connection with this, improvement of organization of the preparatory period should proceed in the direction of improving organization of preparatory work and organized establishment at the construction site of a construction organization advance facility and temporary housing based on stock container-type prefab structures.

To achieve this, a specialized organization should be established within the USSR Ministry of Power and Electrification system -- a production association for construction of stock prefab production enterprises and temporary housing. The association should carry out within the power construction system a uniform technical policy in the area of design and fabrication of stock production enterprises in buildings of mobile, container and prefab types, as well as temporary housing and cultural-services buildings.

Association facilities should be based on two or three large plants fabricating mobile container and prefab production buildings and buildings for temporary housing, process equipment assembly facilities, as well as the requisite furniture and other furnishings for worker housing; a planning-design and scientific research center, charged with developing designs for new production, housing and cultural-services buildings and structures. The association should have its own specialized transport vehicles and, in conformity with orders placed by construction organizations, deliver building structural components (including process equipment for production enterprises and housing) from the plants to power project construction sites. Specialized association brigades should handle assembly of delivered buildings and structures, install and test process equipment, and turn it over to the client 100% ready to go. The client (general contractor construction organization) should perform zero-cycle work with its own manpower and resources or call in subcontractors.

This solution will make it possible sharply to reduce labor outlays and construction time both of facilities in the preparatory period and a construction project as a whole, with improvement in quality of the work performed and a substantial increase in efficiency of hydroelectric plant construction.

Improvement in the level of industrialization of construction of principal GAES structures will be promoted by standardization of principal components of water engineering structures -- penstocks, water intake, and above-ground construction of the GAES building.

3024
CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

UDC: 621.311.21-146

HYDROELECTRIC CONSTRUCTION ON KOLA PENINSULA REVIEWED

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 4, Apr 79 pp 32-33

[Article by Engineers V. G. Ivanov and N. P. Shargorodskiy: "Construction of Series of Hydroelectric Power Stations on the Kola Peninsula"]

[Text] Specific features of construction of hydroelectric power stations on the Kola Peninsula include harsh climatic conditions of the Arctic, sparsely-populated construction areas, lack of roads and rail lines, comparatively small work volumes on hydroelectric power facilities and, as a consequence, frequent construction organization work force and equipment movements within the oblast distances of 500 to 1,000 km.

The period from 1962 to 1977 encompasses the following principal stages of Sevgidrostroy activities: completion of construction of the series of Kovdinskiye GES, construction of the following series -- the Serebryanskiye GES, followed by initiation of construction on the Teriberskiye GES.

Following completion of the Kumskaya GES (the last GES of the Kovdinskiy series), Sevgidrostroy was to proceed with construction of the next series -- the Serebryanskiy, the first power station of which -- Serebryanskaya GES-1 -- exceeds the Kumskaya 3.5-fold in power generating capacity.

It was necessary efficiently to rebase the construction work force, equipment and supplies 1,000 kilometers, from the southern to the northern part of the Kola Peninsula, encountering new climatic and environmental conditions, while meeting the project timetable and accomplishing the specified volume of construction work (SMR).

In August 1964, having built a 115 km access road to the hydropower site in less than 2 years, the lead detachment of construction workers reached the Voron'ya River, in the vicinity of the construction site for Serebryanskaya GES-1.

It was possible to ensure a growth in SMR volume in 1964 over 1962 (the year the Kumskaya GES went into operation) and a rapid pace of access road construction during the difficult period of rebasing the construction organization only thanks to the existence in the community of Prichal'naya of the industrial and housing facilities of the Verkhne-Tulomskaya GES, facilities which were transferred over to Sevgidrostroy: this enabled the construction workers to get settled in the new area and to concentrate manpower resources on expanding housing and industrial facilities in the communities of Murmashi and Prichal'noye.

Thus a gradual and "painless" (for workers and organizations) transition was made to construction of the next string of GES.

Having renovated by 1965 the transshipment, industrial and housing facilities in the communities of Prichal'noye and Murmashi, the construction workers were able to proceed with construction on the principal industrial and housing facilities of Serebryanskaya GES-1, which was completed by 1968.

Of great importance for moving the project as rapidly as possible was the possibility of setting up line settlements of type PDU and panel-construction buildings.

These prefab buildings proved effective in the tundra (they meet both service and installation requirements). Their main advantage over frame-panel, berm and other well-known types of buildings is the possibility of local heating which, as we know, reduces to a minimum building assembly time and labor expenditures on building erection.

Thanks to employment of type PDU structures, it was possible quickly to build a comparatively good-quality housing settlement and industrial base, which in turn made it possible not only to maintain the work force at its original strength but also during the period 1963-1967 (that is, in a period of 2 years in the sparsely-populated tundra) to increase the work force by 1,000 and to proceed with work on the main structures of Serebryanskaya GES-1.

By 1968 Sevgidrostroy was working in full swing on the main GES-1 structures and had established housing and industrial bases. Construction project management was transferred from the community of Murmashi to the main work site area. In 1968 the labor force of workers, engineers and technicians on the construction project was joined by skilled and experienced hydroelectric power specialists (most of whom came from other of the ministry's hydropower projects -- Plyavin'skaya, Bratsk, Vilyuyskaya). Growth in the size of the work force had an immediate effect on the volume of SMR, which increased from 17 million rubles in 1968 to 23 million in 1969 (labor productivity also correspondingly increased).

Construction on the Serebryanskaya GES-1 entered a decisive phase when Sevgidrostroy adopted an important decision -- to begin preparatory work on construction of Serebryanskaya GES-2. In 1968 a specially established subunit was continuing construction of a road to GES-2, while in 1969-1970 it was working continuously on construction of an industrial base and temporary housing of type PDU structures. It was only for this reason that by the beginning of 1971, that is, when work was cut back on GES-1, it became possible to proceed, without slowing the pace and reducing the volume of SMR, with construction on the principal structures of GES-2, which was located a distance of 40 km from GES-1.

By this time Sevgidrostroy possessed a modern production base, a sufficient number of skilled cadres accustomed to the harsh climate, as well as powerful heavy equipment (EKG-4.6 excavators, BelAZ-540 dump trucks, etc) and well-preserved stock structures (housing and industrial).

By mid-1971 practically the entire construction work force of GES-1 was working on GES-2, doing concrete work on structures for getting the project moving, and by the end of the year on other facilities as well. As we know, by the end of 1972 three GES-2 units were already in operation, and the GES building had been put up in 8 months.

Following startup of Serebryanskaya GES-2, however, Sevgidrostroy had not yet been assigned a work task on the following hydroelectric power stations.

In February 1971 a general memorandum on utilization of the rivers of the Kola Peninsula was prepared by the Leningrad Department of Gidroproyekt and was ratified in July of that same year by the scientific and technical council of the USSR Ministry of Power and Electrification, specifying that Sevgidrostroy would construct an additional five water engineering systems (series of hydroelectric power stations) on the Kola Peninsula.

The construction sites of the Teriberskiye GES are situated 70-80 km from the Serebryanskiye, and 130 km from the transshipment facility in the community of Prichal'noye. Therefore construction of the Teriberskiye GES is to be handled by the so-called "watch" method, which consists in the following. The industrial and housing facilities of the construction work force is located a considerable distance from the project site, in more populated areas. The construction workers and their families live in nicely-developed communities near major administrative centers, while workers of the principal subunits directly involved in erecting the principal GES structures and engaged in operating essential ancillary enterprises (such as a concrete plant, truck terminal and equipment yard, compressor stations, etc) are transported to the principal site area. Workers are transported by bus from the base communities, work on the job during the week, live in a mobile camp-type settlement, and return home on the weekend. Concentrated in the vicinity of the housing base are transshipment and maintenance facilities, a prefabricated reinforced concrete yard, as well as metal, reinforcement and carpentry shop.

The adopted method of construction makes it possible to save considerable funds by avoiding construction in the principal project area of permanent housing, social and cultural-services enterprises as well as a developed industrial base. One important advantage of the "watch" method is the fact that the families of construction workers are able to live in full-service modern communities near large administrative and cultural centers, which has an appreciable influence on reducing labor turnover.

In building by the "watch" method a series of hydroelectric power stations located at relatively short distances (up to 200 km) from the construction worker central residential base, the stability of the construction organization proper is increased, and requisite conditions are created for its further development.

Under conditions of construction of the Teriberskiye GES, delay of several years in beginning construction and insufficient project financing made it impossible to utilize the existing facilities of the Serebryanskiye GES, while the former industrial base of the Verkhne-Tulomskaya GES in the community of Prichal'noye, built approximately 20 years ago, had become rather dilapidated and obsolete.

In connection with this, the most rational solution for construction of the Teriberskiye GES is renovation and expansion of the industrial and housing facilities in the communities of Murmashi and Prichal'noye, situated near a rail line, not far from an airport and the city of Murmansk. Therefore the construction administration has been located in this area since 1976, and modern apartment houses with all conveniences are being erected in the construction worker community; designers have been assigned the task of preparing a plan for renovation of facilities in the community of Prichal'noye.

As we know, essential for successful incorporation of the "watch" method of construction is the existence of a smoothly-functioning system of transporting workers and a sufficient number of modern vehicles. Sevgidrostroy has not yet resolved this problem.

Another obstacle in the path of adoption of the "watch" method consists in the following. To compensate for outlays connected with the mobile character of the job and separation from one's family, a worker is paid a wage supplement in the amount of 40% of the basic wage if he is a member of a mobile mechanized column (PMK). Sevgidrostroy has organized such a PMK for construction of the Teriberskiye GES, which creates the legal possibility for workers, engineers and technicians to be sent to live for an extended period of time away from their home and family at a project under construction. This is very important with the "watch" method and is out of the question for the conventional construction administration, since possibilities of sending workers away to jobsites are restricted by present labor laws. With the establishment of PMK, however, employees of certain central services, such as a laboratory (technical inspection), geodetic, power and other specialized services, as we know cannot receive compensation for the mobile character of their job; including them in a PMK overloads its structure and unbalances the system of management, monitoring and support of a given subunit on the part of the construction administration.

Conclusions

1. Construction of a series of hydroelectric power stations which are approximately identical in generating capacity, physical work volume and layout creates favorable conditions for construction organization specialization, good adaptation to local (even extreme) working conditions, and consequently for achieving a rapid pace of construction and labor productivity indices.

2. An essential condition in building a series of hydroelectric power stations is prompt priority performance of preparatory work to prepare the

construction site of the hydroelectric power stations which will be built after the current project is completed. This is possible only with the existence of a precise future work plan and maintenance of a design backlog.

3. Construction of a string of hydroelectric power stations by one construction organization within the boundaries of a limited area (within a radius of 200-400 km or 4-6 hours travel) is best conducted by the "watch" method, with establishment of a central production and housing base near large administrative, industrial and cultural centers of the given region. This helps avoid labor turnover, increase labor productivity and improve quality of ancillary work, as well as achieving savings in expenditures by eliminating the construction of separate facilities for each GES under construction and relocation of these facilities.

3024
CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

UDC: 620.186.5.001.5

SEREBRYANSKIYE GES ON-SITE DAM STUDIES

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 4, Apr 79 pp 34-35

[Article by Engineers V. S. Kuznetsov, N. P. Shargorodskiy, and N. V. Tolokno: "On-Site Studies of Serebryanskiye GES Dams"]

[Text] The two-stage Serebryanskiye GES string was built on the Voron'ya River, which flows into the Barents Sea, between 1967 and 1972. These GES are situated beyond the Arctic Circle (north of the 69th parallel) in a harsh-climate region. The mean annual temperature is -2°C; the temperature extreme reaches 80°C (from -48°C in winter to +32°C in summer). There is snow on the ground more than 7 months of the year; there is no permafrost.

Maximum river flow during spring floods is 1860 m^3/sec. The power generating plants of this string employ a head of 144 meters: 80 meters at GES-1, and 64 meters at GES-2. Geologically the river basin is situated on the Baltic crystalline shield, which in this area consists of metamorphic and igneous rocks, chiefly slightly-jointed strong granites covered with glacial deposits (moraine, sand, gravel, etc).

Dam study at Serebryanskaya GES-1. The rock and earth fill dam of Serebryanskaya GES-1 is 76 meters high and 1,800 meters in length along the crest of the embankment. The dam's antifiltration component is a symmetrical core of sandy loam moraine soil of glacial origin. The core slopes at a gradient of 1:0.5, with width at contact with base 0.8H.

The moraine soil is very inhomogeneous in composition, with an average coefficient of nonuniformity of 40. The soil contains the following: clay (5%), sand (48%), gravel and pebbles (30%), boulders (9%), and silt particles (8%). Due to its high degree of nonuniformity, the moraine soil is compact in composition and has a low water permeability . The upstream dam face is of rock fill. Between the core and rock fill there are sand-gravel transition zones 6-12 meters thick, performing the role of filters. The total volume of fill on this dam was 5.8 million m^3, including 2.15 on the core, 1.1 on the transition zones, and 2.55 million m^3 on the face. The dam was the principal structure determining the work volume, timetable and economic indices of hydroelectric power station construction.

We should note the considerable labor requirements of the job of building the dam core under harsh winter conditions. A new technique of laying moraine soil into the core at deep sub-freezing temperatures was developed and successfully employed for the first time in the Soviet Union on this project. The technique was based on dumping soil into water [1]. This technique made it possible to work year-round and ensured a high intensity of work with good quality. As a result GES construction was shortened by 2 years.

In connection with the features of dam construction technology, it was necessary to perform an aggregate of on-site studies to substantiate the required quality of the structure, and consequently the possibility of a winter technique of dam core construction. For this purpose studies were made during dam construction and operation on the characteristics of the moraine soil and processes of development of pore pressure in the core, settling, forming of cracks, as well as filtration conditions of the structure [1, 2].

Considerable importance was attached to study of change in the antifiltration properties of moraine soil in the winter-fill locations during a protracted time under water, that is, under conditions corresponding to winter work. It was established in the course of these studies that soil under water was subjected to hydraulic stratification. Soil enriched with particles of clay, silt and fine sand would concentrate in the central zone of the core. This material has a filtration factor of A x 10^{-6} cm/s and an internal friction angle of 30°. In peripheral zones of the core the water permeability of the soil was greater than in the center (A x 10^{-2} cm/s). With subsequent filling with moraine, however, the peripheral core zones became enriched with fine particles, and their water resistance increased.

The results of tests on 3000 soil samples taken from the core during construction indicated that soil dumped into the fill sites acquired high density and water resistance. Average values of the volumetric mass of the soil frame in the core, corresponding to coverages of 75 and 50%, comprised 2.03 and 2.1 t/m^3 respectively, while those of the volumetric mass of the silt or aleurite frame (less than 2 mm) were 1.73 and 1.82 t/m^3. The core filtration factor values obtained in experiments performed under field and laboratory conditions averaged 2 x 10^{-4} cm/s. Soil density, its granulometric composition and water permeability throughout the entire volume of the core proved to be practically uniform (difference in values did not exceed 7%). The quality of those core zones filled in winter proved to be just as good as the quality of zones filled in summer.

Excessive pore pressure in the core during site soil filling comprised not more than 10-15% of the load from the soil mass. The process of soil consolidation took place during a period of 3-6 days, which provided grounds for not limiting intensity of core growth in height, which reached 6-9 m/month. Relative settling of the dam core comprised 1%, and of the rock facing -- 6-8%. As a result of a significant difference in settling between core and facings, there occurred a "slipping" of the latter relative to the core along filter zones, which was attested by the appearance of lengthwise cracks in the dam. Formation of these cracks, as was assumed, did not cause any difficulties in operation of the structure. There were no transverse cracks in the core.

Observations of dam filtration indicated that the structure is highly water-impermeable. An increase in filtration flow during reservoir filling took place strictly in conformity with increase in the head. Total filtration flow through the core (with a water pressure front of 1,820 m) was less than 80 l/s, that is, was below the calculated value.

Reliable operation of the Serebryanskaya GES-1 dam for 7 years now constitutes convincing proof of the high quality of dam design and the efficiency of the construction techniques employed.

Study of the Serebryanskaya GES-2 dam. In building earth-fill dams in the Far North, special attention is focused on the question of placing in these dams antifiltration elements of nonsoil materials. The antifiltration element in the Serebryanskaya GES-2 dam is a steel core in the form of sheet piling in a trough-shape profile [3]. Dam height is 64 meters, length 1,800 and width across the crest 10 meters; dam slopes are 1:2. The dam fill consists of high water-permeable sand-gravel soil. Selection of dam design was predetermined both by the lack of impermeable soils in the vicinity of the dam site and the availability of an unlimited supply of dry sand-gravel soil, and the fact that a design employing a steel sheet piling core made it possible to build a dam at any time of the year and was more economical than other designs.

The material at the base of the dam is as follows: in the river bed and left bank -- high-strength granite rock; on the left-bank terrace -- sand-gravel soils characterized by a filtration factor of 10-70 m/day and internal friction angle of 39-40°.

During dam construction considerable attention was devoted to installation of monitoring equipment. This equipment (soil dynamometers, piezodynamometers, tensometers, piezometers, etc) was placed at three points. A total number of approximately 400 devices were positioned. In addition, a program of comprehensive full-scale studies of static performance of the structure was specified, which called for determining the following:

antifiltration efficiency, stressed state and horizontal displacements of the steel sheet piling;

stressed state and deformations of the body of the dam;

filtration conditions of the structure.

It was established in the course of these on-site studies that the steel core performs fairly effectively from an antifiltration respect: head losses on the core comprised 90%, and specific filtration flow -- 0.1 cm^2/s. As a result of improving land by silt deposition in gaps in the "locks" with fine soil particles and increase in lateral soil and water pressure from the upstream side on the rubber seal, water impermeability of the core increased with time.

The results of tensometric measurements indicated that in a core resting on a rock foundation there exist only compressive vertical stresses occurring under the effect of soil friction forces from the dam body against the core surface during settling of the dam. Vertically along the core stresses change according to the triangular law; maximum stresses occur at the base of the core. It was established that if the surface of the dam base does not have steep gradients, there are no horizontal stresses in the locking connections of the sheet piling elements; with gradients, these stresses are small. This is due to the fact that the sheet piling has a curvilinear profile and easily absorbs horizontal deformations. The results obtained from on-site observations convincingly attested to the fact that breaching of the core is impossible.

In the process of studying soil pressure on the core (capable of displacing) in a horizontal direction it was established that its value matches fairly well the value calculated on the basis of Coulomb's theory (the difference comprised 6%). The soil lateral pressure curves differed substantially, however, from triangular in shape: there was observed a substantial (by 30-40%) decrease in pressure close to the base. The coefficient of transfer of active load through the core from the upper pool to the downstream dam body was 0.89.

Horizontal displacement of the core bearing section toward the tailwater with a filled reservoir totaled 185 mm, or 0.7% of dam height; the top of the steel core displaced 50 mm toward the downstream side.

On the whole the results of the on-site studies demonstrated that the state of the Serebryanskaya GES-2 dam is totally reliable.

BIBLIOGRAPHY

1. Kuznetsov, V. S. "Some Results of On-Site Observations of the Serebryanskaya GES-1 Dam," GIDROTEKHNICHESKOYE STROITEL'STVO, No 4, 1974, pp 25-29.

2. Kuznetsov, V. S., and Liberman, A. I. "Studies of Moraine Soil in the Core of the Serebryanskaya Dam," GIDROTEKHNICHESKOYE STROITEL'STVO, No 10, 1973, pp 8-11.

3. Ivanov, V. G.; Kuznetsov, V. S.; and Fomichev, V. F. "Construction of and Earthen Dam With Metal Core in the Arctic," GIDROTEKHNICHESKOYE STROITEL'STVO, No 12, 1975, pp 6-11.

3024
CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

UDC: 624.138.24

INJECTION SCREEN IN HIGH-PERMEABILITY SOILS

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 4, Apr 79 pp 35-38

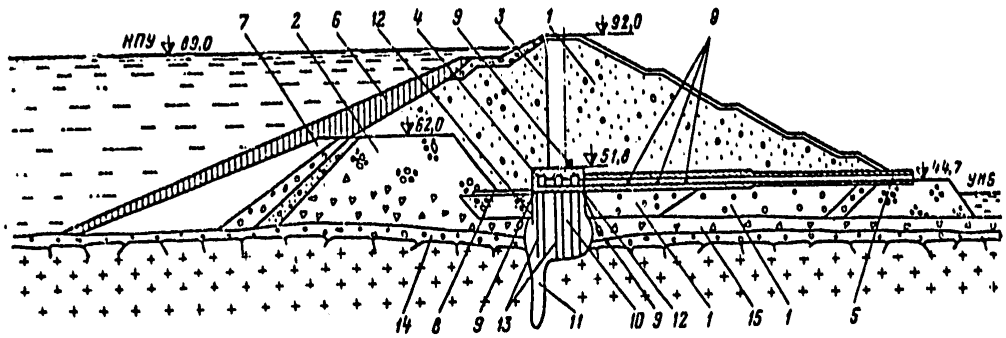
[Article by Engineers P. U. Ponimatkin, and V. B. Kheyfets: "Building an Injection Screen in High-Permeability Soils"]

[Text] In Soviet and foreign practice, the construction of injection screens in dams and dam foundations would usually be performed under conditions of relatively low permeability of the injected soils: as a rule the average soil filtration factor would not exceed 1,000 m/day. The first injection screen in layers of alluvium and rock rubble was incorporated in the foundation of the riverbed portion of the Serebryanskaya GES-2 dam; the average filtration factor of this material was several tens of thousands of meters per day.

According to the original plan, in the riverbed portion of the sand and gravel fill dam with a 65 meter high sheet piling core, core linking with the rock base was to be performed on a drained site, protected by cofferdams [1, 2]. However, due to the fact that the riverbed contained alluvial deposits and a layer of rock debris of high permeability, which had formed in the process of blasting and excavation of rock when laying a pipe to pass construction-site discharge, as well as when constructing a rock banquette for the upstream cofferdam, attempts to pump water from the excavated site proved fruitless (for example, with water being pumped from the site at a rate of 2,400 m^3/h, the water level dropped only 0.5 m).

Calculations taking into account figures on pumping of water from the excavation site indicated that the mean filtration factor of the layers of alluvium and rock debris was 25-40 thousand m/day. As a consequence of a lack of sediment discharge in the river, colmation of the permeable layers with sediment was not taking place.

It was decided to stop pumping water from the excavated site, to fill it to the 44.0 meter mark with sand-gravel material with a filtration factor of approximately 100 m/day, and to construct an injection screen below this mark in place of a sheet piling core connecting to the bedrock (see figure). In order to be able to construct the injection screen, a three-chamber reinforced concrete gallery was constructed at the 44.0 meter elevation mark simultaneously with filling the body of the dam (the internal cross section of each chamber is 3.5 x 4 m); the gallery was connected to the surface by a transport tunnel with inside dimensions of 1.5 x 2 m. In order to reduce mortar leakage loss during injection, sheet piling was driven on both sides of the gallery within the fill zone.



Serebryanskaya GES-2 Fluvial Dam

Key:

1. Sand-gravel fill
2. Banquette
3. Sheet piling core
4. Three-chamber injection gallery
5. Transport tunnel
6. Temporary apron
7. Apron of upstream cofferdam
8. 60 cm diameter drain pipe
9. Piezometers
10. Injection screen
11. Cementation screen in bedrock, 40 meters deep
12. Sheet piling wall
13. Injection holes
14. Layer of alluvium
15. Rock rubble layer

Prior to beginning of construction of the screen, the level of filtration water flow in front of and under the poterne was at practically the same elevation mark as the water level beyond the downstream cofferdam (approximately 41-42 m): due to a high average soil permeability under the tunnel, filtration water flow from the upstream cofferdam (upper ridge of the dam) passed under the tunnel with practically no pressure drop. However, in the process of constructing the screen, as a result of a decrease in the permeability of the injected ground, the water level ahead of the gallery should rise, which would complicate creation of the screen due to erosion of the pumped-in injection material by filtration flow. Therefore in order to pass the filtration flow from the upstream ridge to the downstream side and to reduce pressure on the screen to 1-3 m, it was proposed to lay steel drain pipes under the gallery.

Three steel drain pipes 60 cm in diameter with shutoff valves were placed under the gallery at an elevation of +3.5 m. Actually one pipe operated. The inlet part of this pipe, located at a distance of 20 meters from the upstream edge of the gallery, was filled in with a reverse filter; beyond the gallery the pipe was laid in the downstream side of the embankment and was run to the tailwater. Shutoff valve control was located in the lower chamber of the gallery.

An injection screen 18 meters wide, a maximum of 19 meters deep and 22 meters long was to be constructed with utilization of six rows of holes (with 2 meter spacing in each row); the two outside rows were injected with dense mortar without employment of sealing collar strings, while the holes in the remaining rows were equipped with such columns. At the most important and critical stage in constructing the screen -- drilling and injecting the holes of the exterior rows -- the largest cavities in the rock rubble and alluvium layers were grouted.

In order to speed up the job, the holes of the exterior rows (to a depth of 4-10 m) were drilled with casing pipe by cable-tool drilling rigs until gallery construction began; during gallery construction the casing pipe was brought into the gallery. Completion of drilling on the exterior rows from the gallery was performed in two sequences by ZIF-300M and ZIF-650 core drilling rigs (diameter of drilling element 110-150 mm) with milling and core (with steel cutter) bits with water flushing.

The length of the drilling zone was 0.7-3 meters. A thick cement-clay mortar with a volumetric weight of 1.52 g/cm^3 and 11-13 cm AZNII cone spread were pumped into the rock rubble and alluvium layers. 300 kg of grade 400 Portland cement, 500 kg of Kil'dinskoye clay and 720 liters of water were expended per cubic meter of mortar.

Pressure during injection did not exceed 1 MPa, with standard mortar expenditure of 4-6 m^3 per meter of borehole. In the case of absorption of mortar without pressure (from the load imposed by the weight of the column of mortar in the borehole), sand was added into the mouth of the borehole simultaneously with pouring of the mortar, at a rate of 20-40 kg/min. A thinner cement-clay mortar with a cement content of 125 kg/m^3 and 20-23 cm spread was pumped into the upper zone of the exterior rows within the sand-gravel fill.

After completion of injection, a small quantity of thick purely cement mortar was pumped into the zone, with the addition of sodium silicate solution for rapid setting and binding of the borehole walls. This made it possible, after a minimum hold, to begin drilling and injection in the lower zone.

Injection into the zones located within the casing pipe was performed in an upward direction following completion of injection of all zones in the given borehole below the casing shoe. The length of the zone was 0.7-1 m. Prior to injection the casing within the zone would be broken up by blasting.

Permeability of the ground at the base of the gallery diminished as injection was performed through the holes of the exterior rows, as a result of which the water level upstream of the gallery rose (with practically no change in water level upstream of the cofferdam). At the end of the summer part of the filtration water flow from the upstream side of the dam began running through the drain pipe placed under the gallery.

In the process of constructing the screen, as a result of drilling and injection into the boreholes of the first sequence of exterior rows it was determined that the thickness of the layer of high-permeability soil was greater than specified in the plans. In connection with this there was an increase in volume of drilling operations which, due to the narrow work front in the gallery, it was impossible fully to complete before the reservoir began to fill. Therefore it was decided to perform in the time remaining before reservoir filling a maximum volume of work on the exterior-row boreholes (distance between holes in some areas was reduced to 1 m) and to complete injection on two rows of sealing-collar holes. The rest of the work on constructing the screen was to be performed during reservoir filling under the protection of a temporary clay shield. Water filtering through the temporary shield and upstream side of the dam was to be passed through the drain pipe.

To test the effectiveness of performed (but not fully completed) injection in the exterior screen rows, one month before filling the reservoir the drain pipe valve was closed for 24 hours. The water levels on the upstream cofferdam, upstream of the gallery and on the downstream side of the dam were at 52.0, 46.0, and 41.5 meters respectively. After opening the valve, the water level upstream of the gallery dropped 2.5 meters, and flow through the drain pipe ran 190 l/s.

The average screen filtration factor upon completion of the main volume of injection work on the exterior rows was 500-600 m/day. The decrease in the soil filtration factor indicates the effectiveness (even with partial completion) of the exterior rows of injection holes; however, the relatively high residual soil permeability attested to the fact that large ungrouted cavities remained in the layers of rock debris and alluvium.

Before reservoir filling began, the pipe was opened to allow construction flow to pass through. Filling of the reservoir took place with simultaneous placement of a temporary clay shield. In a month's time water in the reservoir had risen to 81.0-82.0 meters and was maintained at this level until screen construction was completed. Part of the water filtering through the temporary shield passed through the screen, while part passed through the drain pipe, as a result of which the water level upstream of the gallery during the winter the reservoir was filling up was maintained within acceptable limits for performing injection operations (at 44.0-45.0 m). However, as a consequence of a drop in the water level on the downstream side by 4-5 m (in connection with decreased water discharge on the downstream side after the pipe was closed to allow passage of construction discharge), the pressure differential on the uncompleted screen increased from 0-2.5 to 7-8 m. The large pressure differential and the low temperature of the filtering water (approximately 1-2°C) made further work on the screen difficult: in spite of employment of setting acceleration agents, a large part of the injected mortar was carried by the filtration flow beyond the screen.

In connection with this, the authors of the article sugg^ested pumping sand without hardening material into some of the boreholes of the lower and penultimate rows in sections characterized by a high de_t ee of mortar absorption. Injection work was to be completed after large passages were clogged.

In order to reduce the pressure differential on the screen, a cofferdam was built on the downstream side, as a result of which the water level beyond the dam rose to 42 meters.

Pumping of sand into the screen was complicated in connnection with the fact that in the summer, as a result of wave action, part of the temporary clay shield on the dam was eroded away. As a consequence of this the water level upstream of the gallery rose by 5-10 m (to 50.6-55.0 m), back pressure formed under the gallery, which complicated performance of drilling and injection operations, and the pressure differential on the screen increased. As a result a large portion of the pumped-in sand was carried beyond the screen boundaries.

In order to lower the water level upstream of the gallery, it was decided to reinforce the dam's temporary shield by dumping moraine soil into the water. In the second half of the following year of construction after execution of this measure, the water level upstream of the gallery dropped by 6-10 meters (to 44.0-45.0 m).

Sand was pumped from the crest of the dam into the screen at intervals during the course of 2 years, in those periods when backpressure under the gallery was relatively small and during drilling operations there did not occur substantial carrying of screen material into the gallery through the boreholes.

A trough with screen was constructed on the dam crest for pumping sand; water at a rate of up to 40 m^3/h and sand were fed simultaneously into the trough. The water-sand pulp forming in the trough, of a composition of 1:5-1:10, was fed through a 150 mm diameter pipe down an inspection shaft into the gallery, and entered the borehole through a flexible hose connected to a conductor pipe.

The length of the sand-washed zone was 0.5-2 m (a longer zone could not be bored due to loss of flushing fluid and borehole wall collapse). When no more sand would enter, the zone would be drilled, and as a rule sand would again be pumped in. Some zones were sand-pumped several times, since in many instances refusals to absorb more sand were false and occurred as a consequence of the borehole shaft becoming clogged with coarse sand.

After completion of sand pumping, cement mortar with a hardening acceleration agent was pumped into the zone under a pressure of 0.5-1 MPa, and then the hole was deepened by the length of the next zone.

Cement or cement-clay mortar under a pressure of 0.5-1 MPa was injected into boreholes and zones which did not absorb sand.

Sand absorption occurred primarily in the middle and lower zones of five left-bank boreholes of the lower and penultimate rows.

A total of approximately $1,000^3$ of sand (for the most part fine-grained) was pumped into the screen, with a size modulus of 1.71 (complete residue comprised 13.8% on a screen with 1.25 mm mesh).

After completion of sand pumping and lowering (as a result of reinforcing the shield with moraine soil) the water level upstream of the gallery to 44.0-45.0 m, screen construction was completed with injection of three rows of boreholes with sealing collar strings.

During drilling zones were encountered where considerable loss of flushing fluid occurred. These zones were subjected to conventional cementation under a pressure of 0.5-1 MPa, after which drilling was resumed.

Collar strings were installed and injection performed according to the standard procedures employed on many jobs.

Pressure during injection was 2.5-3 MPa. Upon casing rupture pressure reached 5 MPa. Mortar pumping amounts were as follows: for the two end rows -- 1.2 m^3 per collar, and for the middle row -- 0.5 m^3.

Cement-clay mortar of the following composition was pumped into the end rows (per m^3): cement -- 125 kg; Kil'dinskoye clay -- 226 kg; water -- 880 l; mortar weight by volume -- 1.23 g/cm^3; AZNII cone spread -- 21.5 cm; compressive strength at age of 7 days -- 0.28 MPa.

A clay-silicate mixture with a volumetric weight of 1.5 g/cm^3 was pumped into the middle row. Each cubic meter contained 750 kg of Biklyanskoye bentonite and 45 kg of sodium silicate.

The screen required a total consumption of 4,900 tons of cement, 1,700 tons of clay, 300 tons of bentonite, 50 tons of sodium silicate, and 1,200 m^3 of sand.

The total cost of construction of the injection screen, gallery and sheet piling was 1,600,000 rubles, while the cost of filling and reinforcement of the temporary shield was 1,510,000 rubles.

After work on the screen was completed, the drain pipe valve was closed and the pipe was grouted with cement mortar. The water level in the reservoir was raised to the projected level (89.0 m).

In August 1976, with water level on the upstream side at 89.0 and on the downstream side at 38.6 m, water levels on the upstream and downstream side of the screen (in a piezometer with sensor mounted at 30-35 m) were 87 and 46.7 m respectively. Horizontal piezometers sunk in the transport tunnel proved to be dry. Consequently the screen eliminates approximately 80% of the pressure head on the dam. Total water losses in the riverbed portion of the dam through the sheet piling core located above the gallery, the injection screen and rock foundation comprised 150 l/s.

We should note that ground water above the gallery, directly downstream of the sheet piling core, was at 56.3 m, that is, somewhat higher than the water level marks in the piezometer located on the downstream side of the screen. This indicates the occurrence of filtration above the gallery (through the sheet piling core and rock).

In conclusion we should emphasize that this was the world's first injection screen in high-permeability soil (filtration factor 25-40 thousand m/day). The experience gained from this job indicated that a screen can be constructed under such conditions only when reducing to a minimum pressure differentials on the screen (2-3 m).

BIBLIOGRAPHY

1. Vasil'yev, A. F.; Gavrilets, M. A.; and Tolokno, N. V. "Serebryanskiye GES String on the Voron'ya River," GIDROTEKHNICHESKOYE STROITEL'STVO, No 10, 1973.

2. Vasil'yev, A. F. "GES String on the Voron'ya River," GIDROTEKHNICHESKOYE STROITEL'STVO, No 10, 1977.

3024
CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

UDC: 621.31.002.2:65.011.46

ZAPOROZHSKAYA GRES CONSTRUCTION DESCRIBED

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 4, Apr 79 pp 38-40

[Article by Engineers A. G. Golotsvan, O. V. Reznikov, A. A. Safronyuk, and A. Yu. Shekhtman: "Experience on Construction of the Zaporozhskaya GRES"]

[Text] As we know, the seventh (last) generating unit at the Zaporozhskaya GRES came on-line in 1977, giving the facility an overall generating capacity of 3,600 MW (4 x 300 MW -- first group; 3 x 800 MW -- second group).

Construction on the Zaporozhskaya GRES began in August 1969. Plans called for construction to run a total of 125 months (a 6 month frame for completing 300 MW units and 12 months for 800 MW, combined work on the first and second group -- three months, and completion of station construction -- in December 1979). Following are the actual power generating unit completion dates:

Generating Unit Number	1	2	3	4	5	6	7
Month and Year Completed	Dec 1972 (on schedule	Dec 1972 (six months ahead of schedule)	Dec 1972 (12 months ahead of schedule)	March 1973 (15 months ahead)	Dec 1975 (15 months ahead)	September 1976 (18 months ahead)	September 1977 (18 months ahead)

Following are the principal features in designing the first group of units:

departure from the normal unit-by-unit issuing of principal design documentation (issuing of documentation for all four units at the same time);

elaboration of new work organization and production arrangements;

elaboration of a new job performance process taking into account the possibilities of employing a high-speed assembly line method of construction.

In conformity with the design, a number of totally new technical and design solutions were applied in building the first group of generating units, which made it possible to achieve savings in materials and reduce specific labor outlays per kilowatt of installed generating capacity. For example, the following were achieved in conformity with the new design:

elimination of employment of poured-on-site reinforced concrete and brickwork in the main building above 2.7 meters;

decrease in consumption of metal and cement;*

elimination of employment of gantry cranes in open installation of electrostatic precipitators and flue gas extractors.

30% weight reduction of boiler equipment;

elimination of foundations on boiler afterbodies and construction of a poured slab with cables laid in tubular conduits rather than cable tunnels;

construction of lightweight foundations under the main building and new-design foundations under boilers (in the form of separate poured reinforced concrete continuous footings) and under boiler columns (in the form of prefabricated reinforced concrete blocks);

elimination of erection of a 12-story annex at the permanent end of the boiler house;

reduction in length of the main building by efficient equipment layout;

reduction of total length of trackwork at the GRES by 1.25 km, and in-plant trackage -- by 0.8 km;

decrease of on-site road area by 27,300 m^2 and 12% decrease in construction site area.

Due to employment of advanced technical solutions in the design, a number of structural components weigh considerably less, which helps boost the degree of industrialization of construction.

Improvement of design solutions made it possible to save 45,120 tons of cement, 10,760 tons of rolled metals, 9,375 tons of reinforcing steel, 5,100 tons of brick and 86,000 square meters of waterproofing seal.

Issuing of plan documentation for all four units made it possible for the Odessa Affiliate of the Orgenergostroy Institute -- author of the construction organization and process plans -- to speed up examination of the KhOTEP [expansion unknown] design and promptly to make changes and additions.

---

* Here and henceforth indices are compared with those of the Ladyzhinskaya GRES.

For example, all brick and gypsum concrete partitions were replaced by prefabricated reinforced concrete and finished, as a result of which construction labor outlays were reduced by 2,070 man-days.

The work plan suggested coating the sides of the water delivery canal "dry," not "under water" from barges, as was specified by the KhOTEP plan. Work volume was significantly reduced by altering the thickness of the crushed rock and rubble fill.

Показатели 1	Первая очередь 2		Вторая очередь 3		По всей ГРЭС 4	
	по нормам 5	фактически 6	по нормам 5	фактически 6	по нормам 5	фактически 6
Продолжительность строительства, мес. 7	69	44	69	66	126	107
Мощность вводимая, МВт 8	1200	1200	2400	2100	3600	3600
Капитальные вложения, млн. руб. 9	228,2	228,2	176,8	242,2	405	465
Объем СМР, млн. руб. 10	109,6	109,1	112	126,6	221,6	236,7
Трудозатраты, чел.-дни: 11						
общие 12	2 931 241	2 783 413	4 709 883	4 601 230	7 641 124	7 386 649
на 1 кВт мощности 13	2,442	2,319	1,962	1,918	2,122	2,052
Численность работающих, чел. 14	2492	2478	3142	2280	2814	2370
Средний заработок, руб. 15	8554	10 913	8912	11 103	8733	11 008
Прибыль (балансовая), тыс. руб. 16	11 825	14 313,1	21 930,6	25 254,4	33 765,6	40 247,5
Экономический эффект, млн. руб. 17	—	14,71	—	22,34	—	37,05

Key:
1. Indices
2. First group
3. Second group
4. GRES as a whole
5. Standard figures
6. Actual figures
7. Duration of construction, months
8. Generating capacity on-line, MW
9. Capital spending, million rubles
10. Construction volume, million rubles
11. Labor expenditures, man-days
12. Total
13. Per kw of generating capacity
14. Size of work force
15. Average earnings, rubles
16. Profit (balance sheet), thousand rubles
17. Savings, million rubles

The basic principles of high-speed construction, as well as the organizational and process conditions of construction of the Zaporozhskaya GRES were specified by the Odessa affiliate of the Orgenergostroy Institute and the Khar'kov affiliate of the Energomontazhproyekt Institute. The work was performed in a direction specified by the USSR Ministry of Power and Electrification -- to build the GRES in a considerably shorter time than specified by standard figures and to ensure a sharp decrease in labor outlays and high degree of economic effectiveness of construction.

These basic principles include the following:

concentration of finances and resources;

careful, thorough engineer-technical preparation for construction;

employment of the conveyor belt-separate method in construction of the principal first unit facilities;

establishment of independent specialized construction conveyor lines in erecting structures and installing process equipment, adoption of lengthwise production flows in installing principal process equipment, etc.

The technical-economic indices of construction of the Zaporozhskaya GRES are contained in the table.

Taking into account the experience of designing and high-speed construction of the first units of the Zaporozhskaya and Uglegorskaya GES by KhOTEP, the following were specified in designing the second unit: maximum prefabrication of structures, organization of specialized production flows in erection of structures and installation of process equipment, concentration of funds and resources, separate performance of construction and installation work.

All technical solutions pertaining to the main equipment of each power generating unit and common station elements are standardized. The principal standardized component is the power generating unit, which contains an LMZ [Leningrad Metal Plant] K-800-240-3 close-coupled turbine and a 2,650 t/h TKZ [Taganrog Boiler Plant] TGMP-204 single-stage straight-through gas-fuel oil boiler with pressure charging.

A tiered arrangement of the turbine installation with lengthwise condenser and placement of circulating water lines in the main body below the turbine house basement level made it possible to reduce the latter's span length.

The generator stator was to be installed with the aid of a special 350 ton gantry, which made it possible to reduce the lifting capacity of the overhead traveling cranes to 125 tons and to reduce the height of the turbine house.

The arrangement of the boiler section of the 800 MW gas-fuel oil unit was worked out taking into account the new gastight boiler design, working on pressure charging, and the method of its suspension mounting to boiler house structures.

A building measuring 45 x 48 m, 79.3 m high to the bottom of the roof trusses, is erected for each boiler. The boiler is hung on three center girders positioned symmetrically to the axis of the boiler with 12 meter spacing. In each insular boiler house the plan specifies installation of two 100/10 ton overhead traveling cranes with a lift of 74 m, one of which remains after completion of construction for operational utilization.

The foundations of the main building and auxiliary structures are poured on site and are of simple geometric shape; employment of stock metal formwork cuts in half the cost of these structures in comparison with prefabricated, with equal labor outlays.

Condensation floor uprights were placed in specially drilled holes in reinforced concrete slabs, which made it possible to avoid construction of socket-type foundations.

The frame of the main building of the second unit was designed by KhOTEP with beam structures proven in construction of Kiev TETs-5 and the Stavropol' GRES. They can be used as columns, and in combination with metal components -- for erecting various built-up load-bearing structures of building frames. Employment of beam structures (in place of metal columns) for erection of the main building with three 800 MW units provides a savings of 5,000 tons of steel, and the cost of construction is reduced by 1.3 million rubles.

Facilities for housing electrical equipment in the deaerator department constitute unit-containers in a metal frame. Thanks to this, erection of electrical equipment, monitoring-measuring instruments and automatic control devices was performed in the large assembly area.

We should note that in the process of erecting the main building, the following design solution deficiencies were discovered, which must be taken into account in designing large GRES;

the insular siting of the boiler houses results in additional outlays for laying crane tracks along the building ends, requires that tower cranes be driven onto these tracks, as well as additional crane erection and takedown when moving from installation of one boiler to the next;

design of the main building frame without temporary brace trusses and ties fails to provide building stability with the axial method of erection;

assembly design and insufficient allowances at center girder rest points complicates column adjustment and centering;

the interior partitions in the deaerator house are not standardized in type-sizes and materials; in addition, they are poorly designed for erection and are quite heavy;

a complicated arrangement of mechanisms for opening skylight and transoms requires considerable expenditures on their installation;

securing of ceiling spans in the deaerator house at a height of 11.4 m is performed with preliminary installation of unit-containers, as a result of which the pace of erection of the building frame depends on the status of delivery of electrical equipment.

In building underground facilities of the main building of the second unit of the Zaporozhskaya GRES, fabrication of poured structures was performed in four lengthwise production flows with adoption of advanced metal formwork of the block-form type. Only two sets of this formwork were required for 87 foundations of eight type-sizes.

The arrangement for mechanizing construction of the underground portion of the building was elaborated taking into account available equipment. The plan specified 11 principal erection and nine transport flows in construction of this building.

Partial changes were incorporated into the work process in erecting the frame of the boiler house of unit 7.

The covering of the boiler house was erected without attached frame branches of rows D and C on axis 29 (they were utilized for erecting a temporary turbine house end wall on axis 22). Subsequently the boiler house traveling crane was employed for erecting these components. The newly-elaborated work plan specified alteration of the temporary support attachment points (braces ensuring frame rigidity and making it possible to take down parts of the wind truss on row D with its subsequent replacement).

Work in the boiler house was performed with two BK-1000 cranes instead of the three specified by the work plan.

At the beginning of construction of the second unit of the Zaporozhskaya GRES, erection of the block frame of unit 5 was begun with a delay of six months due to late and incomplete delivery of blocks and metal structures. Subsequently an automated control system was installed at the Zaporozhskaya GRES, which provided the following:

centralized deliveries of materials;

record keeping on concrete-mortar plant and ancillary facilities output;

record keeping on movement of materials and structures;

monitoring of achievement of resource limits;

forming of physical volumes and estimated cost by types of jobs and facilities;

calendar planning of construction and installation work;

calculation of requirements in basic materials on the basis of physical volumes;

record keeping on estimated cost of construction and installation work;

preparation of limit cards for each facility;

management data support (ASIOR);

record keeping on personnel availability and movement, etc.

Thus improvement of the Zaporozhskaya GRES construction management system was effected on the basis of automation of management functions with utilization of a Minsk-32 computer.

The construction work plan from the beginning of construction was accomplished by 106.4%, including 100.3% on construction of the second unit.

For the power plant as a whole the decrease in labor outlays comprised 254,475 man-days, including 106,647 on the second unit.

Output growth on the completed facilities of 800 MW units 5-7, in comparison with calculated figures, comprised 27.4, 25.7, and 20.6% respectively, while the specific number of workers per million rubles of construction was 93 (with a calculated 119), 88 (110) and 86 (104).

The average annual number of workers in construction in comparison with the calculated figure was reduced by 439 persons with a labor productivity growth of 45.2% by 1978 (the plan called for 30.26% by initiation of construction).

The Odessa affiliate of the Orgenergostroy Institute rendered continuous methodological and practical assistance to the construction crews in elaboration of measures providing labor productivity growth, verification of execution of measures, and factor-by-factor analysis of labor productivity growth and conditional decrease in work force size.

Thanks to improvement in organization, process and management of construction, savings totaled 37.05 million rubles. Actual labor outlays per million rubles of construction totaled 31,339 man-days with a calculated 34,497 man-days, and per kilowatt of installed generating capcity -- 2.05 and 2.12 man-days respectively.

Analysis of experience of construction of the Zaporozhskaya GRES indicated that it can be recommended for further adoption on other construction projects.

There have presently been noted the following principal progressive directions of improvement of construction of big thermal electric power stations;

further standardization of design solutions, and a transition to assembly-line construction of large power generating plants;

improvement in layout of the main building (in particular, by eliminating insular siting of boiler houses);

improvement and adoption of new, advanced structures and materials;

series construction of power generating plants;

establishment of large construction associations for the assembly-line erection of large power facilities and securement of a smooth process of completion of generating facilities and reduction of duration of construction by concentrating material and labor resources;

establishment of on-site computer centers at large construction projects;

extensive adoption of the brigade contract method and extensive development of socialist competition to achieve high labor indices.

3024
CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

EKIBASTUZ GRES-1 DESCRIBED

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 4, Apr 79 pp 64-66

[Article by Engineer A. A. Zlotin: "Ekibastuz GRES-1"]

[Text] More than 50 years have gone by since the following statement appeared in Lenin's GOELRO plan: "The Ekibastuz mines near Pavlodar are our most important sources of coal." At that time there were several mines, plants and railroad shops operating in Ekibastuz.

The future of Ekibastuz, as planners envision it today, includes surface coal mines capable of producing 170 million tons of coal each year, thermal electric power stations with a total generating capacity of 20 million kilowatts, producing approximately 220 million kilowatt hours of electricity each year, and a modern city of power industry and mine workers with a population of 200,000. Ekibastuz will produce one tenth of the total electricity presently generated in this country.

The Ekibastuz fuel and power complex has no parallel in today's world power industry in respect to grandiose character of structures erected in a comparatively small area, as well as level of technical solutions and economic effect. Suffice it to say that the pride of the Americans -- the famous Tennessee Valley complex -- consists of 31 power generating plants with a total generating capacity of 13 million kilowatts.

Five huge GRES will generate electric power. Construction of the first of these has already begun. The power plant main building is a triple-span structure 540 meters in length, 132 meters in width and 75 meters in height.

Much of what is presently being done in Ekibastuz is being accomplished for the first time: the first 330 meter chimney is being built, and a unified production-supply facility is being established for construction of the power generating plant complex.

There will be a one-of-a-kind 1500 kV DC power transmission line. The gigantic electrical bridge which will link Ekibastuz with the central part of our country will cross the steppes of Kazakhstan, stride over the Ural mountains, and run across the vast spaces of central Russia. This line will have a total length of 2,415 km. More than 5,000 towers 32.5 meters in height will be constructed along the route of this future power transmission line. Terminal inverter substations will be constructed in areas adjacent to the cities of Ekibastuz and Tambov.

The year 1979 is an important one for the builders of the Ekibastuz GRES. This year the first two 500,000 kW generator units will come on-line.

The construction job is presently pulsating with a powerful labor rhythm. This is understandable, for the facility will soon be starting up.

Gennadiy Mikhaylovich Aksenov, chief of Glavenergostroy and member of the board of the USSR Ministry of Power and Electrification, comments on the forthcoming events as follows: "The first power generating unit at Ekibastus GRES-1 is scheduled to go into operation in September 1979. By that time construction crews will have performed more than 115.7 million rubles worth of construction on the facilities of the Ekibastuz power complex; more than 70,000 m^3 of prefabricated and 65,000 m^3 of poured reinforced concrete should be laid this year alone, plus erection of 25,000 tons of metal structures. Over a 15-year period construction workers will complete approximately 8 billion rubles of capital investment. Such a huge scale is a result of the party's comprehensively-conceived long-range economic strategy. A strategy grounded on the latest scientific and technological advances, multiplied by the enthusiasm of Soviet citizens. As we know, complexes of this magnitude have never before been built either in this country or elsewhere, and therefore we were compelled to start literally from zero. For example, it was necessary to determine the principles on which the entire complex should be built. How should power station construction be handled? Where should worker communities be located? It was necessary to resolve many technical and organizational problems. The complexity of this job is indicated by the fact that the design and plans for the complex were prepared by the Novosibirsk Department of the Teploeletroproyekt Institute jointly with dozens of design and scientific research organizations. As a result of this work, the decision was made to build this power generating plant complex by the rapid assembly-line method, with organization of an extended work flow and a six-month interval in putting generating units on-line. Delivery of equipment, structures and building materials to all construction sites is to be in complete packages, from a common area supply base. A special assembly shop is being constructed at this facility. This solution is an innovation in power plant construction. A plant designed to assemble and finish erection components is rising up literally on the Kazakhstan steppe. This facility makes it possible significantly to reduce the cost of construction and erection, to improve their organization and process, to reduce the size of the construction work force, and to ensure an optimal work-loading of construction and erection equipment and truck transport. In addition, under conditions of the harsh local climate, performance of structural assembly operations in an enclosed facility will promote improvement of quality and performance."

Considering the future prospects for development of the area of the Ekibastuz fuel and energy complex, the decision was made not to build housing adjacent to the GRES. The workers employed at the future Ekibastuz GRES will reside in a large modern city, in apartments with all the conveniences; they will be able to attend plays and concerts and to enroll in evening school.

With each passing day the panorama of the construction site assumes increasingly more definitive features. It has already acquired the features of space and height which are so transforming the featureless steppe. In discussing the silhouette of this construction project one cannot help but mention such a unique item as the chimney stack. Unfortunately its construction is being delayed. There are also problems with construction of facilities which are vitally important for power station operation: fuel handling plant, chemical water treatment, and utility lines. In this connection we should like to note the unsatisfactory performance of a number of supplier organizations which are failing to meet structure delivery schedules. This particularly applies to plants situated in Naberezhnyye Chelny, which for several years now have been regularly failing to meet delivery schedules. It would behoove the work forces of these enterprises to recall the history of construction of their own city: the entire country helped build the Kama Automotive Plant and to erect housing.

Nevertheless, in spite of objective and subjective difficulties, the construction work force is doing everything possible successfully to achieve generating unit startup on schedule. Here are a few figures. In 1977 27.2 million rubles of capital investment was spent on construction on the Ekibastuz GRES, and the figure was 45.04 million in 1978; it is anticipated that this figure will increase to 70 million rubles for 1979.

"Such a high-paced rhythm is promoted by precision organization of socialist competition," G. M. Aksenov noted in conclusion. Following the example of V. A. Sizintsev's brigade, a movement under the slogan "Work without laggers" is picking up momentum on the construction project. Excellent production success is being achieved by the brigades of P. V. Zaytsev, who holds the Order of Lenin and Order of the October Revolution, K. I. Aralbayev, and others. The construction workers have established solid contacts with many cooperating organizations. The 'Worker Relay' is becoming stronger and stronger with each passing day -- in January 1979 an agreement was signed calling for production cooperation with 39 machine building and instrument engineering enterprises."

...Soon the electric star of Ekibastuz will light up above the boundless steppes of Kazakhstan!

3024
CSO: 1822

END