8 OCTOBER 1980 (FOUO 19/80) 1 OF 1

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USSR Report

ENERGY

(FOUO 19/80)

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CONTENTS

ELECTRIC POWER

General Plan for Nuclear Power Plants With Water-Cooled Reactors
(I. S. Shcherbatenko; ENERGETICHESKOYE STROITEL'STVO, Aug 80) 1

Installing the Kurskaya AES - Bryansk 750-kV Overhead Power Line
(E. A. Ovcharov, S. B. Kacher; ENERGETICHESKOYE STROITEL'STVO, Aug 80) 7

Construction of 750-kV Overhead Powerline Substation Described
(V. S. Mel'nik; ENERGETICHESKOYE STROITEL'STVO, Aug 80) 14

V-Shaped Spacer Support for 750-kV Overhead Powerlines
(B. P. Novgorodtsev, S.A. Shtin; ENERGETICHESKOYE STROITEL'STVO, Aug 80) 20

Building 750-kV Overhead Powerlines in Mountain Areas
(V. I. Andriyenko; ENERGETICHESKOYE STROITEL'STVO, Aug 80) 24

Yuzhno-Ukrainskaya AES Energy Complex
(A. Zlotin; ENERGETICHESKOYE STROITEL'STVO, Aug 80).. 29

Operating Conditions for Pressurized Water, Nuclear Power Reactors
(Fedor Yakovlevich Ovchinnikov, et al; EKSPLUATATSIONNYYE REZHIMY VODO-VODYANYKH ENERGETICHESKIKH YADERNYKH REACTOROV, 1979).......... 31

ELECTRIC POWER

UDC 621.31.002.2:622.014

GENERAL PLAN FOR NUCLEAR POWER PLANTS WITH WATER-COOLED REACTORS

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 8, Aug 80 pp 30-32

[Article by Engineer I. S. Shcherbatenko]

[Text] The development of nuclear power engineering demands continued improvement in nuclear power plant technical resolutions from the viewpoint not only of their technology, but also of other factors, and in particular, a more optimum building and installation layout, a reduction in the amount of land withdrawn from other uses to build power plants, and so forth.

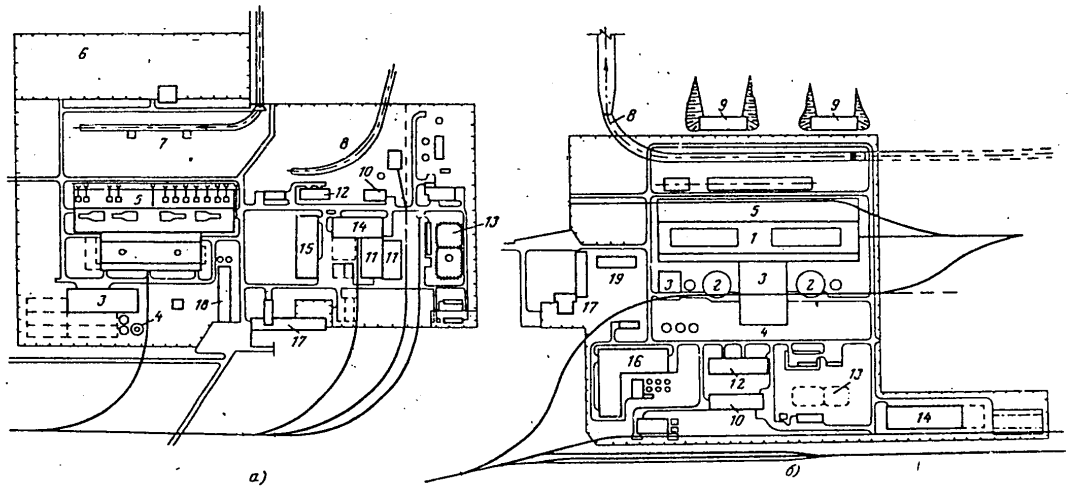
Special note should be made of the fact that stricter demands are made of AES [nuclear power plant] construction sites than of TES [thermal electric power plant] sites. Meeting these demands limits possible AES construction sites. In this connection, selection of a specific AES site is preceded by much work on revealing areas suitable for its installation (technical-economic reports and substantiation, site cadasters, and so forth). However, in spite of the fact that the layout of AES and TES general plans is similar to an extent, when developing an AES general plan, we must meet a number of special demands related to zoning individual facilities, creating safety systems, ensuring autonomy of operation of individual power units, reliability, and others. Moreover, the same demands are made on AES layouts as are made on TES layouts: interlocking which ensures a reduction both in the number of separate buildings and facilities at the site and in the length of utility lines and roads, as well as unitizing, standardizing and typifying layout resolutions.

The first series-produced condensation-type nuclear electric power plants built in our country generally used VVER-440 reactors (Figure 1, a [following page]).

The layout of the general plan for such electric power plants includes the following features:

the site is arbitrarily divided into two zones, one for the buildings and facilities in which radioactive aerosols can be released and another for administrative and living facilities, subsidiary-auxiliary buildings and facilities;

Figure 1. Di: ram of the General Plan for an AES Using VVER Reactors



Key:

a) VVER-440 (2x440 MW)
b) VVER-1000 (2x1000 MW)
1. Machinery room and deaerator stacks
2. Reactor department
3. Special vessel
4. Vent pipe
5. Open transformer installation
6. 110- and 220-kV outdoor distribution system
7. Head race
8. Overflow race
9. Technical water supply pump station units
10. Start-up boiler room
11. KhVO [not further identified]
12. Diesel generator room
13. Fuel oil system
14. TsMS [not further identified]
15. Central repair shop
16. OVK [not further identified]
17. Administration building
18. Living quarters
19. Living quarters utilities section

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the reactor department is in the same building as the primary facility;

the site includes quite a few separate buildings and installations.

At present, a number of AES's are being built with VVER-1000 reactors (Figure 1, b).

There are essentially no fundamental differences in the general plan layouts of such AES's and AES's with VVER-440 reactors. However, thanks to the interlocking of the subsidiary-auxiliary buildings and installations and the higher unit capacity of the power units, the ratio of capacity to AES industrial site area increases from 30-60 MW/ha to 90 MW/ha.

One shortcoming of the layout is the location of the special vessel between the reactor departments, which makes subsequent expansion of the AES difficult.

Given a building width of 160 m and the placement of cranes outside it, construction and installation is very difficult, especially when installing the linings and special vessels, and the more so in the case of consolidated units.

Nuclear power plant planning and construction experience shows that it is most appropriate to install AES's as monoblocks, with maximum standardization of the monoblocks.

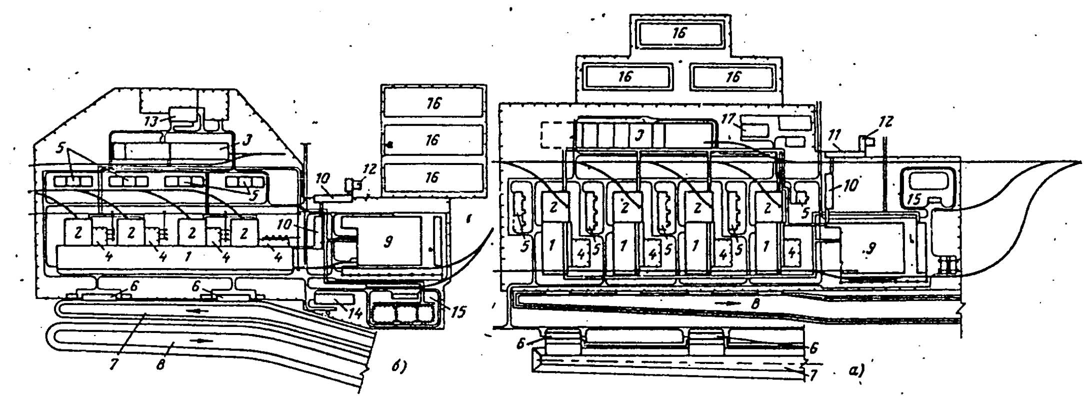
Based on the monoblock principle, using unitization and standardization in planning resolutions, the layout of an AES general plan might anticipate either separate monoblock locations, with the turbines and reactor located alongside, or turbines located in-line, in the same machinery room.

The general plan (Figure 2, a) for an AES built on the monoblock principle proposes locating each 1000-MW power unit in a separate structure which includes a reactor department, machinery room, deaeration stacks and add-on electrical engineering installations. In order to supply the equipment and load in fuel, the plan anticipates railroad sidings into the reactor departments; transformers are installed out from the long side of the machinery room (this arrangement permits separating them from the hydrotechnical installations).

Diesel-generator rooms can be situated either in the gap between the reactor departments or between the reactor departments and the special vessels, and the administrative and living quarters and combined auxiliary structure can be situated on the first power unit side. Flexible electrical outlets can be routed to the side of the special vessel (passing through it) or to the overflow- and head-race side.

The general plan (Figure 2, b) for an AES with in-line turbines in a common machinery room differs from the plan with a transverse arrangement only in that the transformers are installed in the gaps between the reactor departments and the flexible electrical outlets are routed to the special vessel

Figure 2. General Plans for a 4000-MW (4x1000-MW) AES With Transverse (a) and In-Line (b) Turbines



Key:

1. Machinery room and deaerator stacks
2. Reactor department
3. Special vessel
4. Open transformer installation
5. Diesel generator room
6. Technical water supply pump station units
7. Open head race
8. Overflow race
9. OVK
10. Laboratory and living quarters
11. Administration
12. Dining hall
13. Processing building
14. Start-up boiler room
15. Combined oil system
16. Sprinkler system
17. Storage for slightly radioactive waste

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side. The respective locations of the other buildings and installations do not change. In-line placement of the turbines in a single machinery room enables us to reduce the amount of crane equipment, to plan maintenance areas more efficiently, and to simplify equipment servicing. At the same time, in such a layout the equipment construction and installation is made more complicated, both in the machinery room and in the reactor department. Moreover, to build the first power unit, the below-grade work has to be done for the entire machinery room, which significantly increase the amount of work which must be done for the start-up complex of the first power unit, complicates the routes for rolling transformers into the machinery room, and reduces the operating safety of the AES.

A monoblock layout makes it possible to move crane equipment for construction and installation along the entire power block, to significantly reduce the size of the start-up complex of the first power unit, and to work on other power units in parallel. Shortcomings of this variant include a slight increase in the size of the enclosed industrial site and a slight increase in the length of on-site railroad tracks and roads.

Some indicators for the AES general plan layout variants being examined are given below:

Site, in hectares	
enclosed industrial site	47/43.5
housing development	19.8/17
Housing development density factor, in percent	41.4/39.1
Industrial site ratio per 1000 MW, in hectares	11.9/10.9
On-site railroad track length, in kilometers	11.1/10.8
On-site roads and yards, in square meters	50,020/50,130

(Note: Numerator gives indicators for a monoblock arrangement, denominator gives layout in a common machinery room)

Analysis of indicators in the general plan variants shows that these plans have no significant differences either in terms of enclosed industrial site or in terms of length of roads and utilities. However, noting the fact that the AES general plan with in-line turbines in a common machinery room has a number of shortcomings in terms of organizing construction and installation, the general plan using monoblocks is the preferred layout.

With a view towards further developing monoblock unitization and typization and towards reducing the size of the industrial site and the length of the roads and utilities, the block pump station can be interlocked with the machinery room. This arrangement enables us to reduce the number of large-diameter outside stand pipes and the number of separate buildings, as well as to ensure even greater autonomy of the power block.

Characteristics of a monoblock AES of 1000 MW are given below:

Capacity, in MW	2000(4000)*
Enclosed industrial site, in ha	26.5 (47)
Housing development site, in ha	10.3 (19.8)
Housing development density factor, in percent	39 (41.5)

On-site railroad track length, in km	5 (5.7)
Area covered by internal roads, in 1000 m^2	60 (51)
Industrial site area per 1000 MW, in ha	13.2 (11.9)

----

*Indicators for the general plan of a 4000-MW AES are given in parentheses.

Future nuclear power development will facilitate the creation of more optimum layouts with consideration of the requirements of technology, safety, reliability, industrial architecture and the withdrawal or a minimum of land suitable for agriculture for AES's through the interlocking of buildings, centralization of maintenance services and reduction of auxiliary services.

11052
CSO: 1822

ELECTRIC POWER

UDC 621.3.051.2

INSTALLING THE KURSKAYA AES - BRYANSK 750-KV OVERHEAD POWER LINE

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 8, Aug 80 pp 47-50

[Article by Engineers E. A. Ovcharov and S. B. Kacher]

[Text] This collection of articles concludes with publication of materials generalizing experience in planning and installing 750-kV electric power lines.

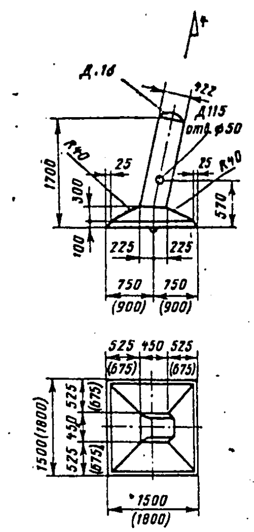
The 207-km 750-kV overhead power line from the Kurskaya AES to Bryansk was built to send power from the Kurskaya AES and is also a link in South - Center - Southwest electric power transmission.

The terrain traversed by the route is on the whole a slightly undulating plain broken up by the broad valleys of several rivers. In several sections, there is a broad network of gullies, ravines and small stream valleys. For 123 km, the route passes through plowed fields, 50 km goes through forest, and approximately four kilometers goes through long-cultivated pasture. The route intersects 19 year-around water courses, the most important of which are the Seym, Svana, Navlya and Desna rivers and large number of lines of communication, including railroads, highways, 220-kV or smaller overhead power lines, communications, and so forth. The power line basically runs through III (149 km) and II (58 km) ice-glaze regions.

Unitized, mushroom-shaped prefabricated reinforced concrete pedestals and anchor slabs are used for the mast foundations. New FK2-07 and FKZ-07 foundation designs (Figure 1) based on the unitized FK2-05 and FKZ-05 designs but with smaller dimensions are used to support the spacer and spacer-angle supports. However, the brace angle is 1:4, that is, the same as for spacer and spacer-angle supports on braces.

As is known, a pedestal with an inclined support coaxial to a support boom works almost solely on axial stress (compression or pull). The horizontal stresses on such pedestals are 3-4 times less than the loads acting on pedestals with a vertical strut, so cross-bar connectors can be eliminated by using foundations with an inclined strut.

Figure 1. Foundations for Spacer and Spacer-Angle Supports



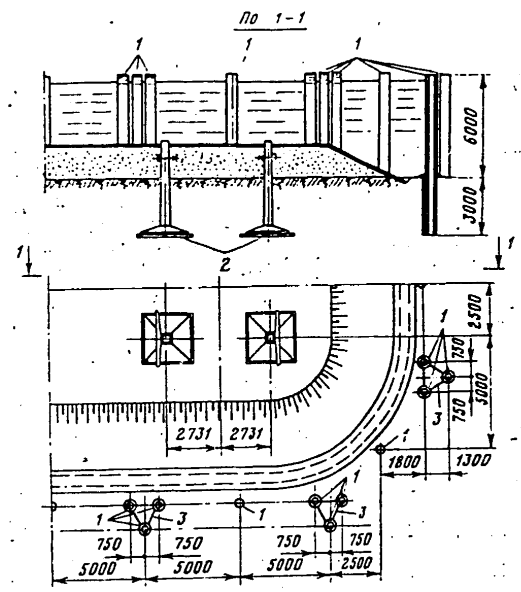
The supports are set in prefabricated reinforced concrete pedestals in submerged river bottom land. According to the plan, in this instance the foundations must be protected against icicles and other floating objects which might be in the bottom lands during high water by using a dam attached by 1x1 concrete slabs 0.16 to 0.2 m thick. The plan is to install concrete catch basins 0.4x0.5 m across and 1 m long around the dam. Altogether, we would have to lay about 10,000 slabs, using about 1,500 m^3 of concrete, and install 330 m^3 of concrete catch basins in order to attach 12 PS and PS+5 "flood" support dams. The earthmoving work would be about 43,000 m^3.

The Tsentrstroyelektroperedachi trust has proposed a replacement for the planned "flood" support to protect it from ice using STs-5 support segments (Figure 2). The amount of earthmoving work drops to 39,670 m^3 and the amount of concrete and gravel used drops by 1,660 and 1,868 m^3, respectively.

The overhead line uses metal galvanized, rolled bolt struts. For all elements under heavy load, low-alloy 14G2 steel is used, and VSt3 carbon steel is used for low-load and inactive elements.

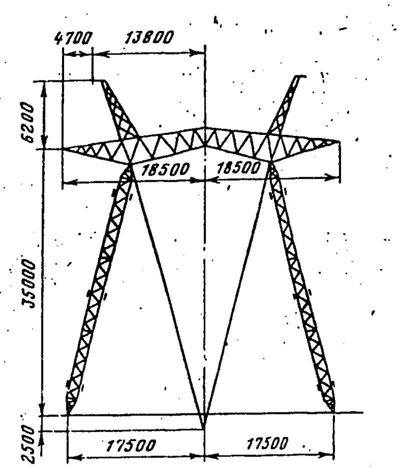
Experience in planning, building and operating 750-kV overhead power lines from Konakovo to Moscow, Dnepr to Donbass and Konakovo to Leningrad showed that supports on struts are the most economical design in terms of both cost and expenditure of materials. Thanks to the use of a pivoting attachment of the supports to the foundation and the struts to the anchor slabs, such supports are less sensitive to imprecise installation and foundation shifting under operating loads than are free-standing rigid ones. Therefore, the

Figure 2. Fragment of the PS and PS+5 Support Ice-Protection System Used in River Bottoms



Key:
1. STs-5 support section
2. Support foundations
3. Support section connectors

Figure 3. Overall View of PU750-1 Mast



spacers and spacer-angles mainly used on this line were straddle supports on P750-1 and PU750-1 struts (Figure 3) in which the brace angle is 1:4, not the 1:10 in previous plans. The geometric sizes of both types of supports are identical. However, the shapes of the spacer-angle supports are larger than the spacers, and the four paired struts have a diameter of 21 mm (17 mm for the spacers). The P750-1 support is calculated for a small deflection angle -- up to 2°30'.

On sections of the route where it was inappropriate to use supports on struts (backwater sections), free-standing straddle-type PS and PS+5 supports with crosspieces 35 and 40 m above the ground, respectively, were installed. The PS supports weigh about 20 tons. These supports are similar to those used on the 750-kV overhead power lines from the Kurskaya AES to Metallurgicheskaya Substation.

Three-strut spacer-angle PU750-3 supports (developed by the Ukrainian Department of the Energoset'proyekt Institute) were used where the route turned 10-20°. U750 anchor-angle supports were used with turn angles up to 60°. When necessary, they were supplied with braces of varying heights (5, 10 and 15 m). The design of these supports is not new. They are similar to designs used on the 750-kV overhead power lines from Vinnitsa to Al'bertirsha, Chernobyl'skaya AES to Western Ukraine Substation and Kurskaya AES to Metallurgicheskaya Substation. The supports consist of three free-standing struts, with a conductor of just one phase attached to each. The middle strut is lightweight, since it is to carry only the conductors (no cable), so it has no cable support.

Each angle support also has an additional strut for bracing the outer phase loops, and the transpositional support has two struts (one from each side). According to the design, these additional struts are to be metal and to be installed on four F2-2 foundations. However, the Tsentrostroyelektroperedachi trust proposed replacing each of the additional metal struts with two reinforced concrete SK-4A struts. As a result, we saved 67,700 tons of metal components, 32,200 $m^3$of prefabricated reinforced concrete and reduced labor expenditures 1.5- to two-fold. The total economic impact was 18,800 rubles.

Brand AS240/56 conductor (five to a phase) was installed on the line. The phase loop by-pass is made with guy lines. The guy line of one outer and middle phase is secured to the neighboring support strut and that of the other outside phase to an additional strut.

The conductor and cable support guy lines are double-chain, the conductor tension lines are five-chain, and the cable tension guy lines are two-chain. Glass PS120-A, PS160-B and PS60-D insulators were used.

Two transpositions were made on Ut750+5 angle supports on the overhead power line. Five-ray 5RTN-4-300 spacers were used for the conductors, the number in the span depending on its length. Opaque, hinged RGShIP-3-400 insulating spacers (500 mm long) were installed between the bundled cables. The lightning-protection cables were provided with GVN-3-17 vibration dampers.

When installing the 750-kV overhead line from Kurskaya AES to Bryansk it was necessary to solve a number of design and technological problems. We were faced with using new P750-1 spacer support designs and new PU750-1 and PU750-3 spacer-angle support designs. Work could only be done in the wintertime on very swampy sections of the route with peat deposits 1-5 meters thick.

Along with additional difficulties caused by installing foundations in the wintertime and compressed work schedules, construction-installation organization was complicated by the fact that the Volga production enterprises combine failed to deliver metal supports on schedule and in complete sets.

The overhead line was built by specialized brigades drawn up by type of work: cutting openings and laying log roads, excavation and earthmoving, installing foundations, assembling and installing supports, installing conductors and cables. Eleven production sectors were organized on the line construction. All the more important problems were solved by a construction staff located in Lokot'.

In connection with the fact that newly designed supports and foundations were used on this overhead line, the trust technical service developed a special handbook reflecting the basic planning data on the designs of the supports, foundations, conductors, cable, fittings and insulators; it provided instructions on construction-installation work technology and gave appropriate tolerances and norms. The handbook was intended for use by foremen, work superintendants and other engineering-technical workers of the trust and the mechanized column.

Thanks to precise work organization (foremost in installing the foundations), the below-grade work was completed quickly, in five months, in the wintertime in the swampiest, hardest to reach places. The ground in the basins was worked as follows. First, the frozen layer was removed using cutter bars. Then we used excavators with 0.3 to 0.5-m^3 scoops, and large amounts of dirt had to be brought in to bottomland sections of the route to fill in foundation pits and dikes. The foundations were set in place by TK-53 and T-75 tractor cranes. They were delivered on a winter road.

It should be said that quite a bit of time was spent on assembling the complicated sectional foundations, which were supplied to be bolted or welded, and not complete, as anticipated by the plan. The foundations were not test-assembled at the factory either, and some arrived at the overhead line route with defects. Moreover, the development of the bolted version did not take into account the necessity of using a [gostirovannyy] wrench to fasten the bolt heads.

In order to speed up the work, bolted spacer support section preassembly yards were set up at the station centers of nearly all construction sectors (some supports other than the spacer-angles and anchors were assembled in staked-out areas). Final support assembly was done in staked-out areas. At a majority of the production sectors, supports were assembled and adjusted using means of small-scale mechanization (impact wrenches, scaffolding, jigs and so on).

The spacer supports were raised by turning them with a 26-meter drop boom, traction and auxiliary mechanisms. A brigade of 10-12 people installed two supports per shift. The methods of assembling and installing the anchor-angle supports used for the overhead line did not differ fundamentally from those developed previously for other lines in the same voltage class.

The conductors and cables were installed following flow charts and plans developed by the chief technologist's department at the Tsentrostroyelektroperedachi Trust. The installation technology was initially worked out by trust and mechanized column workers for small five- to eight-kilometer spans. After that, the brigades began working on the main sections.

Unwinding the conductors and cables was complicated by the fact that this overhead line intersected many existing electric power lines, which had to be switched off for long periods. At those times, the trust's mechanized columns used power cable fuses switched into the existing overhead lines (which were temporarily switched off), making it possible to install the conductor without shutting off electric power to consumers.

The Kurskaya AES - Bryansk is the first 750-kV overhead power line to use spacer-angle supports, which ensure route turn angles of up to 20°, and special conductor clamps. It was revealed while installing the conductors that they could not be installed either one at a time or five at a time, since the clamp turned when taking bearings and the conductor formed a "stocking" when it touched the side of the balance post, that is, the aluminum strands of the conductor split. Because of this, we used a sequential installation method: we first installed the two upper conductors through a balance roller secured to a tractor, and then we installed the three lower conductors, secured to a second tractor (two conductors through a balance roller and one on the tractor winch). In the authors' opinion, the Elektroset'izolyatsiya Trust must do more work on the clamp design before a support of this type can be used in construction.

Previously, the lack of rigs which could telescope to 36 meters delayed the installation of conductors and cables on 750-kV overhead power lines. Difficulties also arose in installing AS70/72 split lightning-protection cable, especially when installing insulation spacers. Because of the lack of proper hoisting equipment, we had to manufacture special trolleys with a large number of rollers (up to eight per side). The roller channels were carefully machined, and in some instances we installed rubber padding so that the aluminum layer of the cables would not be broken as the trolley with the mounter moved. Two installers installed the insulation spacers (one above and one below).

On the whole, the work organization adopted and the innovations introduced ensured high installation labor productivity. One brigade installed an average of 8-12 km of conductor and cable in one month; output per worker was 20,000 to 21,000 rubles.

In conclusion, we need to note that the new P750-1 spacer support designs can be made standard and are promising for use on 750-kV overhead power lines.

It is inappropriate to use the PU-750 spacer-angle supports, since these designs are technologically unsound in assembly and installation and cause considerable set-assembly difficulties.

Supplier plants should take special note of the quality of the components they are producing. Thus, the Volga production enterprises combine supplied defective sheets, irregularly shaped bolts and substandard hardware for the important P750-1 and PU-750 support subassemblies. Moreover, all the parts were poorly marked. All this delayed support assembly and construction of the overhead line as a whole.

As before, the problem of mechanizing overhead power line construction remains unsolved. Trust mechanized columns are poorly provided with special construction equipment and various means of small-scale mechanization. Elimination of these obstacles to improving the quality and tempo of electric power supply network construction is now one of the most important tasks.

11052
CSO: 1822

ELECTRIC POWER

UDC 621.315.17

CONSTRUCTION OF 750-KV OVERHEAD POWERLINE SUBSTATION DESCRIBED

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 8, Aug 80 pp 50-52

[Article by Engineer V. S. Mel'nik]

[Text] The 100-km section of the 750-kV overhead power line from Chernobyl'-skaya AES to Zapadno-Ukrainskaya [Western Ukraine] Substation (from support No 649 to support No 876) passes through two oblasts (Zhitomirskaya and Khmel'nitskaya). The terrain in this area is relatively calm. The bulk of the route, 76 km, passes through plowed land, about 15 km passes through pasture, and approximately five kilometers passes through marshy meadows (swamps, in places) and forest. The high-voltage electric power transmission line crosses Sluch' River, more than 30 existing electric power transmission lines with voltages from 10 to 330 kV, and numerous utility lines, railroads and roads.

The ground is basically sandy, muddy or peaty (up to 1 m thick), with subjacent loams. On many sections of the route, the groundwater level is quite high, but it basically contains no sulphates aggressive to concrete. In the aggressive groundwater zone, a protective layer of BN-IV bitumen was applied to the surface of the reinforced concrete elements of the structures.

The number of supports of various types the plan envisioned installing on this section of the route are as follows:

Metal spacer supports on PO-35 spans	195
Free-standing supports 5 m off the ground, PS+5	2
Three-strut metal anchor-angle supports	
AU-20	15
AU-25 with a 5-meter stand	6
AU-30 with a 10-meter stand	3
AU-30T (for conductor transposition) with a 10-meter stand	1

Construction of the overhead line was entrusted to mechanized column No 31 of the Yuzhelektroset'stroy Trust. The construction and production organization plans were developed by normative research station No 4 of the Yuzhelektroset'stroy Trust and included the organizational structure of the work superintendent's sector, work schedules, specifications for components, materials and equipment, and calculated labor expenditures by type of work. The technological portion of the work plan gave calculations on the forces acting on the supports and conductors during installation, offered cable installation diagrams, blueprints of attachments and rigging used for all the different types of work. The blueprints for each type of job provided tables indicating the needed vehicles and machinery, rigging and attachments. The documentation described in detail the work methods and sequence in which the work was to be done.

The sector base site was chosen for the following considerations: minimum distance from the route of the overhead line, availability of a site suitable for the base and for access to it, availability of worker housing, electricity, water and telephone communications.

It was decided to set up the sector production base in Slavut, Khmel'nitskaya Oblast. The base contained administrative and living facilities, including a Red Corner van and mobile dining room, a mobile tool and spare parts storeroom, an assembly-disassembly shop for fittings, insulators, hardware and building materials, a consolidated-assembly site, a metal structures storage facility, and so on.

The incoming freight was received at Baran'ye and Novograd-Volynskiy stations on the Southwestern Railroad. All the basic components and materials were unloaded at rented unloading yards.

MK-31 [mechanized column No 31] did the preparatory work on the work superintendent's sector itself, did some clearing of the route and some installation of spur tracks to the supports and along the route. The remaining preparatory work (timber cutting and rerouting the 0.4-6-10 overhead power line being intersected) was done by subcontractor organizations.

The preparation took three months. It should be noted that the main work (setting the foundations, for example) was begun one month after the preparatory work began, that is, without waiting for the latter to be completely finished, which naturally speeded up the main work.

The following specialized work superintendent's sectors were created to install the overhead line: freight receiving and assembling spacer supports in yards, earthmoving work and setting foundations, setting up supports and installing conductors.

Each specialized work superintendent's sector was relocated only after it had received at least 75 percent of the needed components. Subunits arriving at a new place were provided with tools, small rigging and attachments. Machinery and vehicles were relocated at the same time. Tractors, excavators, vans, bulky rigging and attachments were shipped by rail, and small equipment and rigging was shipped by motor vehicle.

The reinforced concrete foundations received from the supplier plant were carefully checked. Particular attention was paid to their integrity and conformity to blueprints. Foundations deemed suitable were hauled to the route by KamAZ vehicles (with trailers) and KrAZ-600 vehicles and were unloaded in the immediate vicinity of where they would be installed.

The foundations were set in place using a T-75 tractor crane. The basin footings under the anchor slabs were leveled to the planned slope using templates. The basins were filled in in layers 20-25 cm thick, with careful tamping immediately after the foundations were set and trued. The primary machinery used for the below-grade work were an E-302 excavator, a D-271 bulldozer, a Zif-55 compressor and two S-245 pumps.

A brigade of 19 people (including three machine operators) equipped with two Zif-55 compressors, a TK-53 crane, eight impact wrenches and other tools did the consolidated support-assembly in the yards. The brigade's work area was set up ahead of time: jigs were set up and the yard had a reinforced concrete-slab road.

The pallets were unloaded alongside the appropriate jigs, enabling us to avoid unnecessary moving of the metal components. The hardware was put in the center of the jig, where a worker fit bolts with the appropriate nuts and washers. After that, the hardware ready for installation was carried to the assembly area. All the parts were distributed to the places designated for each position by a plate with lettering on it, so any needed part could be found. The assembled sections were moved to a finished products storage area, immediately stacked and put on pallets of several sections each for transport to the route. The pallets were assembled in this sequence: two lower and two upper sections, two crosspiece halves and two cable struts, and four middle sections.

One vehicle had to make five runs to deliver spacer supports to the place of installation. The trunk sections were transported in ZIL-157's and ZIL-131's with log trailers; sections with crosspieces and cable struts were transported on a platform KrAZ (the cable strut being laid on top of the canted portion of the crosspiece and tied to it). Unloading at the route was done by a crane assigned to the brigade involved in the installation.

This system of work organization ensured high labor productivity, protection of the materials, components and hardware, precise specialization of assemblers, and economy of working time. Moreover, stationary assembly ensured high-quality work and constant quality control was easily effected at the assembly site, as well as at the finished output storage area, before the output was sent out the the route.

The anchor-angle and free-standing supports (AU-20, AU-25, AU-30, PS and PS+5) were assembled right on the overhead line route using the usual technology and in accordance with SNiP [construction norms and regulations] III-V.5-62 and technological rules. The spacer supports were assembled and installed in staked-out areas by two-link brigades: one preassembled the supports and the other installed them. Doing the work with one brigade enabled us to maneuver people and equipment easily.

We first installed the hinges to the foundation and the lower support section. We then assembled the trunks and connected the crosspieces and the cable struts. Equipment and the installer link were hauled to the assembly site to unwind and lubricate the stays and spread out and connect the rigging. By the time the assembly was finished, the installation boom had been raised and the equipment put in its place. The brigade leader checked the positioning of the support, and then the equipment bracing was pulled tight.

Some of the workers moved on to the assembly site for the next support to true the support with guy lines and secure the cable clamps. After the support was trued and secured, the equipment, hinges, boom and rigging were moved to the next staked-out area.

This technology has a number of advantages: the assembled support need not be installed on a hinge, labor productivity is high, people and equipment are easily maneuvered, and work quality improves significantly.

The overhead line plan anticipates installing AS500/64 conductors four to a phase and two lightning-protection AS-70/72 cables.

The conductors were unrolled with stationary unrollers. The conductors of the outer phases and one cable were unrolled at the same time using a 4MIR equalizer with an additional hole drilled through it. On sections of the route impassable to the tractors, the conductors and cables were unrolled by an L8 tractor windlass (the cable was first unrolled by hand from the windlass to the conductor). The molding was done by PO-100M presses.

The conductors were raised to the PO-35 and PS spacer supports by an LN8 windlass using an MI-257 equalizer. This was the procedure used to install the phases: outer - middle - outer. The lightning-protection cable was raised onto the supports together with the conductor support guy wire off of rollers. The conductor anchoring, leveling and fastening were done in pairs, first the two upper and then the two lower conductors of the phase. After the conductors were lowered to the ground, they were transferred to the supporting terminals from the unrollers (the phase transfer procedure was the same as for installation). The lightning-protection cable was let down onto the crosspiece during the transfer.

Four-beam spacers were installed on the overhead line. The spacers were mounted on the spans from mounting trollies, but the first spacer from the supporting terminal was installed from the ground when the conductors were transferred.

During installation, the ends of the flexible loops were tightened with a rope block and tackle and temporarily secured with PA-5-1 jaw clamps. Then the supporting terminal was installed in the middle of the loop bracket down, and a corresponding mark was made on the mounting cable going from the tractor windlass. The cable from the windlass was connected to the supporting terminal through a mounting block secured to the strut. The loop was brought to the planned position (to where the mark on the cable coincided with where the guy line was to be attached to the strut) by tightening the cable. After the distance between the loop and the support and after making any adjustments needed, the loop was welded.

The following work was done in the concluding stage:

- laying and connecting grounds;
- final leveling of staked-out areas and installing drains;
- sealing up slight chips in the foundations;
- tightening and adjusting guy lines;
- installing equipment safety placards;
- cleaning up construction debris;
- cultivating the land.

Total construction time was 11 months on this section of the 750-kV overhead power line route from Chernobyl'skaya AES to Zapadno-Ukrainskaya Substation with this work organization system (including the preparation period). However, that time could have been significantly reduced had the projects been supplied promptly with high-quality sets of components (foundations and supports, insulators and line fittings) and materials (conductor, cable). So the start of installing the conductors and cables was held up for 1.2 months due to considerable delays in receiving sets of line fittings.

As is known, the quality of the components supplied, and particularly of the prefabricated reinforced concrete items (F3-OMA, F4-OMA and NF-1 footings) is of considerable importance, and they sometimes do not meet our requirements.

As concerns deliveries of metal components, the basic shortcoming still is getting complete sets, that is, the absence of individual parts of angle and sheet iron in certain packets. And the quality of the estimate planning documentation is also inadequate.

Planning organizations are constantly striving to reduce the cost of overhead power line construction, but they are little concerned with making working conditions easier in remote, difficult areas. The plans and estimates do not anticipate (or do so to an inadequate extent) the construction of temporary roads and spur tracks to the supports and the route. Effective measures are not planned to protect foundation pit walls from collapse when the ground is worked on flooded and swampy sections. The plans calculate that work in such places will necessarily be done only in the dry summer months. However, this is impossible in practice. As a result, work rhythm is interrupted and the supports must be set and the conductors installed under extremely difficult conditions.

Mechanized columns spend considerable funds on overcoming these difficulties not anticipated in the plans and estimates and are not compensated in any way whatscever. In the end, this leads to increased construction costs and to failure to meet assignments in terms of profit.

Thus, in order to improve working conditions, increase labor productivity and reduce construction time, we should improve the provision of projects with complete sets of components, materials and equipment and must improve their quality; planning materials must take into account the complexities of the construction (in particular, plans and estimates must anticipate additional work volumes and funds for installing overhead power lines in areas of difficult access); the mechanized columns' need for highly productive vehicles and machinery which can handle rougher terrain should be better met: 15-ton or larger tire-mounted crane trucks, tractor cranes, largc bulldozers, PO-100 and PO-200 pressure-molding units.

11052
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V-SHAPED SPACER SUPPORT FOR 750-KV OVERHEAD POWERLINES

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 8, Aug 80 pp 52-53

[Article by Engineers B. P. Novgorodtsev and S. A. Shtin]

[Text] A great deal of 750-kV electric power transmission line construction is being done in our country. Heretofore, individual supports were developed for nearly every overhead power line in this voltage class. This resulted from many reasons, and in particular from the climatic features of the regions through which the overhead power line routes passed, from differences in the brands of conductors used, and so forth. However, further 750-kV electric power transmission line development demands that not individual, but standard designs be worked out. In this connection, it is interesting to examine and compare the types of supports used previously on individual 750-kV overhead power lines, inasmuch as this approach considerably facilitates adopting the most correct resolutions.

Portal spacer supports on guy lines were used on 750-kV overhead power lines built in the Ukraine, as for example the one from the Donbass to Dnepr to Vinnitsa to Zapadno-Ukrainskaya Substation to the border; V-shaped supports with multiple guy lines were used on the similar Konakovo to Leningrad overhead power line. V-shaped supports with multiple guy lines were also worked out for the 750-kV overhead power line from the Leningrad AES to Leningradskaya Substation.

The total phase conductor cross-section was 1400 mm^2 for the electric power transmission line from Leningrad AES to Leningradskaya Substation. That was achieved by combining different sections and numbers of single conductors. At the technical planning stage, six versions of phase design were examined in terms of capital investment and calculated expenditures to build the line. The 5xAS300/39 phase turned out to be the most preferable in terms of these two indicators. It was also appropriate to use this version because it would permit using the same line fittings and anchor-angle supports previously developed for the Konakovo to Leningrad 750-kV overhead power line.

The possibility of using spacer reinforced concrete and steel supports was also analyzed at the technical planning stage.

They examined reinforced concrete supports with 800-mm struts, but the maximum possible length of such struts would be 26.4 meters. As a result, the supports would be comparatively short, as would be the spans between them. In other words, these supports would be uneconomical. The possibility of installing supports consisting of two 20-meter struts joined together was revealed considerably later, because that version had not been developed fully.

They examined four types of steel supports: portal on guy lines, V-shaped with the conductors placed horizontally, V-shaped with the middle phase elevated, and "Chayka"-type single-span on guy lines with the conductors in a triangular pattern.

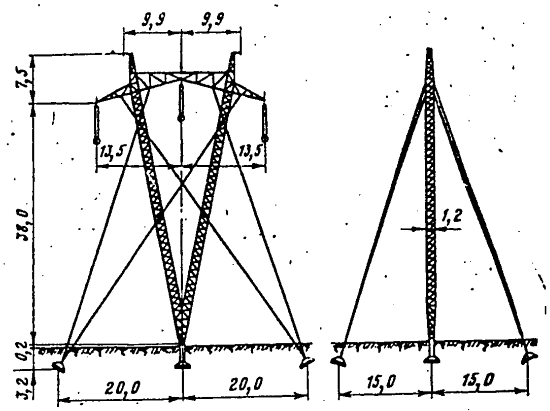
The "Chayka" support design was convenient because a minimum distance between phases could be adopted, but it had substantial shortcomings. First, it would be quite hard to install the support due to the heaviness of the upper portion; second, installing the conductors of the middle phase was very complicated, as they had to be tightened through a "window." Therefore, these supports were not used on this overhead line, in spite of the fact that they used the least metal.

The basic criterion used in choosing the optimum type of supports was that of most economical span. It is known that that criterion is somewhat lower for portal supports than for V-shaped. Portal supports with crosspieces 32 and 38 meters above ground were examined, as were V-shaped supports with crosspieces 32, 38, 42 and 46 meters above ground.

The technical plan for the portal-type of support outlined an economical span length of 440 meters, which corresponded to a crosspiece height of 32 meters. Given this height and a phase of 5xAS300/39, one portal support would weigh 11 tons, with a steel expenditure of 27 tons per kilometer of line (not including an anchor type of support. Subsequent refinements established that if the slope of the struts were increased and the portal set at a height of 35 meters, we could obtain a more economical resolution and reduce steel expenditure to 26.2 t/km, or by approximately three percent, as compared with the portal examined in the technical plan, with a crosspiece height of 32 meters.

For a V-shaped support with multiple guy lines and the conductors placed horizontally, the most economical span is achieved with the crosspieces set at 38 meters; the span would be 538 meters. In this case, the V-shaped support would weigh 11.9 tons and steel expenditure would be 24.5 t/km.

They also examined a V-shaped support with multiple guy lines in which the middle phase would be 3.3 meters higher than the outer phases (see figure, following page). With consideration of the electrical field voltage on the surface of the conductors and radio interference, the horizontal distance between phases in this design could be reduced to 13.3 meters. However, if we meet the required distances from the body of the support to the guy lines, it would have to be 13.5 meters. The support would weigh 11.5 tons, that is, V-Shaped Spacer Support for 750-kV Overhead Power Lines



0.4 tons less than the weight of the V-shaped support with the conductors placed horizontally. Metal expenditure drops to 23.5 tons per kilometer.

It should be noted that the most unfavorable ratio of wind and weight spans was adopted in working out the upper portion of the support.

This V-shaped support was approved and recommended for use on the Leningrad AES to Leningradskaya Substation line, inasmuch as using this design achieved the necessary savings of metal and reduced the distance between the outer phases and the width of the opening. Incidentally, the latter circumstance was of very important significance, since more than 110 km of the overhead power line route passed through forests.

All the comparisons were made for support designs using VSt3 steel. When the blueprints were being developed for the support's trunk booms and crosspieces, 14G2 steel was chosen, which permitted reducing the support further, from 11.5 to 10.56 tons (14G2 steel expenditure was 4.14 tons, in two shapes, 90x6 and 80x6).

In structural terms, the support is a flat, triangular frame with elements of equal rigidity resting on foundation hinges and maintained in a vertical position by a system of four multiple guy lines. The support hinge is of the same design as that used on the 750-kV Konakovo to Leningrad line. One merit of this design is that it ensures automatic centering of the forces and their equal distribution on the booms of the lower section of the support trunk.

As distinct from the supports on the 750-kV Konakovo to Leningrad overhead power line, which were made with a horizontal crosspiece, the center portion of the crosspiece for the new support is of varying rigidity, diminishing towards the middle in conformity with the curve of the forces. As has already been indicated, this design permitted reducing metal expenditure not only by reducing the geometric length of the crosspiece, but also through a more efficient distribution of forces in the elements.

At the suggestion of specialists from the Donetsk High-Voltage Supports Plant, the design of the subassemblies fastening the guy lines to the support was simplified, resulting in the elimination of labor-consuming beam welding. Several other changes were also made in the design to increase its technological effectiveness.

The foundations under the spacer supports were hybrids, as on the Konakovo to Leningrad line, but 1.5 meters deeper. Rectangular unitized anchor slabs were designed for the guy lines. The slab design took into account changes made in their manufacture for the 750-kV Konakovo to Leningrad line. Foundations 2.5 meters deeper were anticipated for supports set in swamps. (The use of pile supports turned out to be impossible due to the closeness of bedrock to the surface on a considerable portion of the route and the presence of large rock fragments in very dense ground on the remaining portion of the route.)

We can thus conclude that the design resolution examined in this article is the latest stage en route to creating standard supports for 750-kV overhead power lines (relative to saving materials in manufacturing the supports).

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BUILDING 750-KV OVERHEAD POWERLINES IN MOUNTAIN AREAS

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 8, Aug 80 pp 54-55

[Article by Engineer V. I. Andriyenko]

[Text] One of the technically most interesting 750-kV overhead power lines, that from Vinnitsa (USSR) to Al'bertirsha (Hungary), was built and put into operation in 1978. The plan, design and construction were developed at the Ukrainian Department of the Energoset'proyekt Institute.

The section from Zapadno-Ukrainskaya Substation to the border, 211 km long, with 120 km passing through the Carpathian Mountains, deserves particular attention. In the mountainous section of the route, the overhead power line runs basically at elevations of 500.0 to 700.0 meters, at 900.0 to 1015.0 meters through the passes. There are 72 turns in this section of the route, due to the conditions found in the mountains: they had to go around regions with steep slopes (more than 30°), eroded slopes, talus and slides, and keep away from mountain stream beds and ravines. The Carpathian valleys and passes most convenient for routing the overhead lines were basically occupied by existing communications (railroads, petroleum and gas pipelines, and electric power lines).

The ground where the overhead line went was complex in structure, and the mountain route was divided into two regions based on their characteristics. The first, with a total length of 100 km, covered the folded region of the Carpathians, where the ground was primarily sedimentary rock in the form of sands, aleurites and argillites. The second, with a total length of 20 km, was characterized by volcanic rock (andesites, andesite-basalts, tuff, and others).

The overhead power line route passed through a seismic zone of 6-7 points. In terms of climate, its mountain section belongs to the IV region and to a special ice-glaze region at 800-1100 meters), with wind speeds of 760 N/m^2 (35 m/sec).

Prefabricated reinforced concrete footings were used for the overhead line support foundations. In sections with aggressive groundwater, prefabricated reinforced concrete components were protected by a coating of hot asphalt.

The plan anticipated installing bolted metal galvanized supports.

For the mountainous section of the line, as distinct from the plains section, the height to the spacer support crosspiece was 32, rather than 35, meters. Portal spacer supports on guy lines with one shortened strut were used in places with slight inclines (up to 10°). For sections where it was impossible to set supports in a large base, a PRS-type spacer support with two independent struts was used.

The center phase on this support was suspended by a V-shaped guy line. Anchor-angle supports were made in the form of three struts, with phases secured separately and the lightning-protection cable and the phase located in a single vertical plane. The height of the support at the point where the phase was secured was 20 to 30 meters.

The phase design used four AS400/93 conductors. Glass plate insulators were used for the guy lines, as they are more reliable than porcelain ones and do not require insulation monitoring during operation. The supporting guy lines were combined in pairs. In addition to the vertical ones, V-shaped supporting guy lines were used to secure the middle phase on the spacer supports, with separate struts without a center crosspiece. In connection with the great distance between struts of the PRS support (20 meters), the branches of the V-shaped guy line were considerably lengthened using spacer links. In order to ensure the needed mechanical strength, the tension guy lines of the anchor-angle supports were four-strand, with each conductor attached separately to the support. The loops on the anchor-angle three-strut supports were by-passed using guy lines, as well as horizontal arched loops hung to the support cable strut on an L-shaped supporting guy line.

Construction of the 750-kV Vinnitsa - Al'bertisha overhead power line from Zapadno-Ukrainskaya Substation to the border was entrusted to two general contracting trusts, the Yugzapelektroset'stroy and the Yuzhelektroset'stroy. Three mechanized columns (Nos 34, 35 and 62) from the Yugzapelektroset'stroy participated in building the overhead line. Each mechanized column did the entire construction-installation work cycle for the section assigned it. Mechanized column No 92 of the Energostroymontazhsvyaz' Trust was called in as a subcontractor to reroute existing lines of communication and to set up communications for the 750-kV overhead line on mechanized column No 34's section.

It should be noted that work organization in the mountain section was associated with great difficulties due to the lack of roads and spur tracks, the steep inclines, swampy sections, and a far-flung network of gullies and ravines. Considerable work had to be done to cut and clear timber, reroute electric power lines and lines of communication being intersected, and install crossings over electrified railroads.

Experience in building large, main electric power lines in regions of difficult access has shown the appropriateness of creating temporary housing settlements with a production base for the work superintendent's sector. In installing the 750-kV overhead power line in the Carpathians, this resolution has fully justified itself. Three work superintendent's sectors were created (one from each mechanized column), each of which was responsible for 25-35 km of the route. The base sites were chosen with consideration of maximum closeness to the overhead line route, availability of spur tracks, a source of water near the base, and the opportunity of installing telephone communications.

The housing settlement contained 10-20 living vans, a dining hall and a Red Corner. From 50 to 150 power construction workers lived in the settlement at different construction periods. The base also had a sector chief's office (senior work producer), a material-technical storage area, a mobile temporary workshop, a temporary warehouse for storing line fittings, a spare parts storage area, temporary machinery and vehicle preventive and routine maintenance facilities.

Each living van was provided with electricity and radio, the sector chief's office had a telephone, and the Red Corner had a television. The production base was generally located somewhat apart from the settlement.

A subunit of the Yugzapelektroset'stroy Trust had to build 163 staked-out areas in mountainous terrain, do a large amount of installation of reinforced concrete components (4100 m^3) and a large amount of earthmoving work (350,000 cubic meters). A large amount of earthmoving work also had to be done to level slopes and install access roads.

Below-grade work was done by mechanized column specialized brigades equipped with the necessary machinery and attachments.

Galvanized, bolted metal supports were used for the mountainous section of the overhead power line. It was necessary to assemble and install 4154 tons of metal support components.

As is known, the amount of manual labor increases sharply when connections are bolted. With a view towards improving the assembly of steel spacer supports and reducing labor expenditures, subunits of the Yugzapelektroset'-stroy delivered supports to staked-out areas in individual sections assembled at special yards for construction of the 750-kV overhead power line.

Impact and electric power wrenches were used for final spacer and anchor-angle support assembly in staked-off areas.

Assembly of the metal supports included: consolidated assembly of spacer supports on guy lines in transportable sections at temporary mechanized yards; final assembly-joining of consolidated spacer support sections; assembly of PRS-type anchor-angle and spacer supports right in staked-off areas; assembly of certain spacer supports on guy lines where delivery of the sections was difficult due to the terrain.

Yards created with consideration of local conditions and opportunities for providing them with complete sets of equipment, attachments and means of mechanization were used for consolidated assembly of spacer support sections. Thus, mechanized column No 34 used 200-m^2 semienclosed yards for consolidated assembly. Reinforced concrete centrifuged support struts served as the yard enclosure. The metal support sections were assembled on scaffolding set up on two trollies mounted on a narrow-gage track. The yard was equipped with four two-ton hoists, a compressor and transformers for the impact and electric power wrenches. The parts and assembled support sections were stored in the open.

The use of yards for consolidated spacer support assembly permitted a 3-4 percent increase in labor productivity.

The supports were installed using a drop boom. Given average route complexity, a brigade of 10 people equipped with the necessary machinery and transport raised one support per shift, one support per 2-3 shifts under particularly difficult conditions.

The anchor-angle supports were installed using a mounting boom 22-24 meters long. The support was raised using two T-100M tractors. After the support was raised to an angle of 75°, one tractor went quickly to a new spot and it began the braking (if it could not move over, a third tractor was used).

After the construction work was completed on the anchor sections, brigades of electricians began preparing and installing conductors and cables. Multiple-phase 4xAS400/95 conductors and AS-95/141 lightning-protection cables were installed in accordance with flow charts and diagrams developed by the Ukrainian Department of the Energoset'proyekt Institute. Extensive use was made of the experience of specialized brigades which installed conductors on the 750-kV overhead power line from the Donbass to Dnepr to Vinnitsa to L'vov in this installation work. The conductors and cables were unrolled from stationary unrolling devices on which drums with conductor and cable were installed. One pass of a tractor generally unrolled four phase conductors and two separate cables simultaneously.

The unrolling, connecting, leveling and transferring of the conductors and cables was done using the same machinery and attachments used when installing conductors in the level section. The spacers were installed both from cradle-bicycles designed and manufactured in the trust and from the ground, when transferring conductors and letting them down to the ground. The installation technology for the insulator tension guy lines and the rigid horizontal loops was worked out during the construction.

Experience in building 750-kV overhead power lines under mountain conditions has shown that the greatest difficulties in installing the line are associated with delivering the various kinds of freight to the staked-out areas. For example, it often turned out to be harder to deliver rigging attachments, installation booms and other attachments from staked-out area to staked-out area than to install the supports themselves.

Mechanized columns of the Yugzapelektroset'stroy Trust transported various structural elements of the foundations, metal supports and other freight from the foothills to the staked-out areas using special trollies they developed themselves. This made it considerably easier to deliver freight to the work site. However, such means of transport need further improvement. In order to resolve this task at the proper level, we will need the joint efforts of appropriate organizations of the USSR Ministry of Power and Electrification.

And the builders have certain claims against the planners. Thus, installation of the foundations was delayed due to the fact that trust production sectors did not have data on the geological structure of each section in which the supports were to be raised. As a consequence, rocky ground was often discovered where it was not expected when the foundation pits were being dug. The upshot was that normal production had to be interrupted and much additional time had to be spent setting up work with explosives. Difficulties also arose in installing center-phase conductors on PRS supports.

Elimination of all these shortcomings will doubtless facilitate improving the efficiency of overhead power line construction in this voltage class under mountainous conditions.

11052
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ELECTRIC POWER

YUZHNO-UKRAINSKAYA AES ENERGY COMPLEX

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 8, Aug 80 p 78

[Article by A. Zlotin]

[Text] The Yuzhno-Ukrainskiy [South Ukraine] energy complex is something fundamentally new in domestic and foreign power engineering.

As is known, the problem of improving the maneuverability of energy installations remains urgent. The necessity arises of storing energy during periods of low load on the energy system and of releasing it during peak load periods. At present, the most widespread method of storing and producing peak-load electric power is the GAES [pumped-storage electric power plant].

It is for precisely that reason that the Yuzhno-Ukrainskiy energy complex includes, in addition to a four million kilowatt nuclear power plant, two GAES's: the 1.8 million kilowatt Konstantinovskaya GES-GAES and the 384,000 kilowatt Tashlykskaya GAES. (It should be noted that three 368,000-kW direct units will be installed in addition to the six 130,500-kW reversing units at the Konstantinovskaya GES-GAES.)

Three reservoirs with capacities of 400 million, 100 million and 80 million cubic meters have already been created. At night, when surplus electric power is being generated, water will be pumped into the reservoirs, and in the evening, when electric power is in short supply, this water will be passed through the two pumped-storage electric power plants. Thus, the capacity of the energy complex will increase by more than two million kilowatts during the evening hours.

And one other detail. After construction of the AES is complete, it will be possible to irrigate 100,000 hectares of the arid Prichernomorskaya Steppe. But that will come later.

All those now working on construction of the Yuzhno-Ukrainskaya AES understand that they are faced with the complex task of completing the construction and putting the first power unit into operation.

The capacity of the power unit is one million kilowatts. One outstanding feature of this new "millioner" is its unique one million kilowatt turbine, which was created at the lead enterprise of the Khar'kov Production Association imeni S. M. Kirov.

This turbine unit has five vanes, including three weighing 157 tons each. The whole machine weighs 3500 tons. It is highly economical and has an automated control system which increases operating reliability and makes the work of the operators easier.

Installation of the turbine was entrusted to fitters from the Zaporozhye sector of the Teploenergomontazh Trust. Altogether, specialists building the Yuzhno-Ukrainskaya AES already have behind them construction of the Uglegorskaya, Starobeshevskaya and Zaporozhskaya GRES's and the Kurskaya and Chernobyl'skaya AES's. The backbone of the collective is those who put up the Krivorozhskaya GRES. They set the tone, they are the standard of comparison, they set the example. Valuable initiatives such as the competition among related industries begun at the Nurekskaya GES on the "worker express" principle, the Rostov initiative "To Work Without Laggers" and "To Improve Work Efficiency and Quality," have found support in the builders collective. V. I. Polishchuk's fitters brigade from the Donbassatomenergomontash sector was the first brigade to do one million rubles worth of construction-installation work in 1979.

The creative activeness of the workers is of considerable importance to successful completion of construction of the first line of the Yuzhno-Ukrainskaya AES. Suffice it to say that since the start of construction, the economic impact of introducing efficiency proposals has been about two million rubles. Labor productivity increased four-fold just through the pouring of concrete without forms.

Construction of the first power unit is entering its concluding phase. The equipment is being installed, but builders already face new tasks in installing the second power unit.

11052
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ELECTRIC POWER

OPERATING CONDITIONS FOR PRESSURIZED WATER, NUCLEAR POWER REACTORS

Moscow EKSPLUATATSIONNYYE REZHIMY VODO-VODYANYKH ENERGETICHESKIKH YADERNYKH REACTOROV in Russian 1979 signed to press 3 Jul 79 pp 2, 3, 4-8, 287-288 second edition

[Annotation, foreword, introduction, and table of contents from a book by Fedor Yakovlevich Ovchinnikov, Lev Ivanovich Golubev [deceased], Vyacheslav Dmitriyevich Dobrynin, Viktor Ivanovich Klochkov, Vladimir Vladimirovich Semenov, and Valentin Mikhaylovich Tsybenko, Atomizdat, 4100 copies, 288 pages]

[Text] The basic operating conditions for pressurized water, nuclear power reactors (PWR) are considered, the principles of neutron physics, thermal hydraulics, and physical-chemical processes occurring in reactors of this type are discussed, as are the reliability, safety, and economical operation of AES [atomic electric power station]. The discussion is based on data for the VVER-440 and VVER-1000 reactors.

The second edition of this book (the first was published in 1977) contains revisions and additional material on the VVER-1000 in plant V of the Novovornezhskaya AES. A number of changes and corrections has also been made.

This book is designed for engineering and technical workers at AES with PWR reactors. It may be useful for students in electric power fields at institutions of higher education and students at electric power tekhnikums, where personnel are trained to work in the nuclear power field.

This book contains 69 figures, 52 tables, and 132 bibliographic entries.

FOREWORD

The program for the development of nuclear power in the USSR envisions the construction of a large number of AES, where pressurized water reactors (PWR) are used as the thermal power source. Generalization of the data obtained during the operation of actual PWR is of special significance. Some special problems connected with the operation of PWR are considered in part in the book by F. Ya. Ovchinnikov et al., "Operation of Reactor Plants at the Novovoronezhskaya AES," published by Atomizdat in 1972.

The reader will find that most of the attention is this book is given to analyzing the operating condtions for PWR.

The principles of neutron physics, thermal hydraulics, and physical-chemical processes occurring in PWR are discussed, and domestic and foreign data on the operating conditions for reactors of this type are systematized and generalized. In considering the methods for design analysis of the basic neutron-physics and thermal hydraulics characteristics of PWR, the authors rely on the corresponding developments at the Institute of Atomic Energy imeni I. V. Kurchatov, which were carried out under the direction of Doctor of Technical Sciences V. A. Sidorenko, Candidates of Technical Sciences G. L. Lunin, A. N. Novikov, and V. A. Voznesenskiy, et al. The operating conditions are discussed on the basis of the VVER-440 and VVER-1000 reactors of plant V at the Novovoronezhskaya AES.

In the second edition of the book the revisions and additions mainly affect the sections on the VVER-1000. The order in which the materials are discussed is different, and refinements and corrections have been made. In the opinion of the authors, this book can be used as a textbook for training engineering and technical personnel at AES to operate PWR rectors and its various systems or to work in laboratories of this type. It will be useful for students at electrical power, physico-technical, and engineering physics specialties at institutions of higher education and students at electrical power tekhnikums.

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INTRODUCTION

Nuclear power, which has traveled a long way in the more than 20 years of its existence, is largely based at the present time on thermal neutron reactors using natural or enriched uranium fueld, including pressurized water reactors (PWR) which are widely used throughtout the world - in the USSR as well as other countries that are members of CMEA [1, 2]. Basic information on the design of equipment for reactor plants and engineering systems used in domestic electrical power units with PRW can be found in the published literature [3-5].

The commercial use of PRW in the domestic nuclear power industry began on September 30, 1964, when unit I of the Novovoronezhkaya AES (NVAES) with a VVER-210 reactor was connected to an electrical power system.

In analyzing the stages of development of AES with domestic reactors of the pressurized water type, it is convenient to divide these reactors into three generations: 1) the VVER-210 (unit I of NVAES) and the VVER-70 (the Rheinsberg AES in the GDR); 2) VVER-440; 3) VVER-1000. The VVER-365 of unit II of NVAES is intermediate between the first and second generations: it essentially belongs to the second generation but its basic equipment belongs to the first.

Improvements in PWR and AES led in three directions: 1) optimization of the fuel cycle; 2) optimization of the thermal power cycle; 3) providing for the safe operation of AES.

The first unit of the NVAES served as a pilot plant to check the correctness of the scientific and technical principles embedded in it, the planning and design work, and the industrial operating conditions associated both with the fuel and thermal power cycles and with the safety problems concerning the entire process of converting fission energy into electricity. Similar technical solutions were checked operationally at another first-generation reactor (VVER-70), erected in the GDR with the participation of the USSR at the Rheinsberg AES.

The construction of subsequent AES plants was accompanied by a constant improvement in the technical and economic indicators. In this sense the main trend should be considered the increase in unit power of the units, accompanied by an increase in the power and productivity of the basic equipment. Specific capital expenditures are decreasing, while the required growth rate in electrical power is maintained.

The scientific and technical research carried out on unit I and the improved unit II [3] led to the design and construction of series electrical power units with an output of 440 MW from second-generation VVER-440 reactors. The main power units with VVER-440 reactors went into operation at the Novovoronezhskaya AES (units III and IV) in 1971 and 1972 [5].

The experience gained in constructing and operating VVER-440 reactors at NVAES allowed a program, beginning in 1973, of accelerated introduction and operation of series units of this type to be carried out at the Kol'skaya and Armenian AES, the Bruno Loishner AES in the GDR, and Kozloduy in Bulgaria.

A new stage in the development of the domestic nuclear power industry was reached by 1000 MW plants using third-generation VVER-1000 reactors with improved technical and economic indicators [6, 7]. The main plant in this series is unit V at NVAES.

Reactor	VVER-440	VVER-1000
Thermal power, MW	1375	3000
No. of circulation loops (pumps, steam generators)	6	4
Flow rate of coolant through the reactor, m/h	34,000	59,700
Working pressure of coolant, kgsec/cm^2	125	160
Average coolant temperature at the entrance to the reactor, °C	267	290
Average heating of coolant, °C	28.8	31.9
Surface heat transfer from fuel elements, m^2	3150	4850
Uranium mass in core, m	41	66.3
Number of fuel rods	349	151
Number of elements in mechanical system controlling reactivity	73	109
Height of reactor vessel (without upper unit), m	11.8	10.88
Maximum vessel diameter, m	4.27	4.57
Vessel mass, m	200.8	304
Inner diameter of main circulation tubes, mm	500	850
Steam Generator		
Productivity, m/h	455	1470
Saturated steam pressure, kgsec/cm^2	47	64
Heat transfer surface (rated), m^2	2500	5040

Reactor	VVER-210	VVER-440	VVER-1000
Total volume of nonuniform heat release	4.8	2.4	2.35
Nonuniform power of separate fuel elements	2.75	1.65	1.60
Total flow rate of coolant, m/h	29,000	34,000	59,700
Specific coolant flow rate, m/h/MW (ther. unit)	38.2	24.7	19.9
Total length of fuel elements, m	77,000	110,000	170,000
Total surface of fuel elements, m^2	2460	3150	4850

The nonuniform heat generation in the core was reduced by an optimum placement of the fuel in the reactor and an improvement in the power control system.

An increase in the total length of the fuel elements and a reduction in the nonuniform bulk heat generation kept the linear thermal load of the fuel elements within the tolerances and thereby avoided the fusion of the cores due to an increasing reactor power.

The increase in the coolant flow rate through the reactor was generally held back by two factors: a) discrepancy between the increase in the power and the productivity of the pumping units units, leading to an increase in amount of generated electrical power expended on its own needs; b) a practical limit on the increase in the flow rate in the bundle of fuel rods (6 - 7 m/sec) due to vibrations. Below, we give comparative hydraulic parameters of the PWR at NVAES.

Reactor	VVER-210	VVER-440	VVER-1000
Maximum flow rate of coolant in fuel rod bundles, m/sec	3.6	4.1	5.7
Pumping head at the operating point, $kgsec/cm^2$	4.0	4.6	6.5

Research has shown that the limit of the linear thermal load at which fusing of the cores of uranium dioxide fuel elements is absent roughly equals 700 W/cm. The rated limit of the linear load for the VVER-440 and the VVER-1000 is 500 W/cm [6]. The energy capacity of the fuel in the PWR at NVAES is described by the following data:

Reactor	VVER-210	VVER-440	VVER-1000
Average linear energy generation of fuel elements, W/cm	98.7	125	176.4
Energy capacity of core, kW/liter	46.5	84	111.1
Energy capacity of fuel, kW/kg U	19.5	33	45.5

A reduction in the reserves between the working and the limiting values of the parameters is acceptable only under the following conditions:

1) a reliable knowledge of the limits that an actual process can approach safely. This information can be obtained by a close study of the processes (thermal, critical, hydraulic) occurring in the reactor and a refinement of the theoretical models and experimental relations. Such research had led, in particular, to a reduction in the safety factor of critical heat heat transfer from 3 - 5 (in the first stages of PWR design) to $\sim$2 (in the last stage);

2) elimination of the ambiguity in the initial state of the reactor. This goal involves improvements in the system of intra-reactor measuremnts and an increase in the accuracy of the design methods. Measurement and design should complement each other so that reliable operational data can be obtained.

3) an increase in the reliability of heat removal systems.

In the VVER-1000 reactor the pumps have external electric motors with flywheels. This arrangement provides a stable coolant circulation through the reactor even with significant breakdowns in the electric power supply to the pumps. All of the stand-by cooling developed is directed toward increasing the thermal rating of the reactor.

The rate of fuel burnup at high-power operation requires that corrections be made in enrichment, amount of burnup, and periodic replacement of the nuclear fuel. In the VVER-1000 the load was increased up to 75 tons UO_2 with a 4.4% enrichment, and the average of amount of burnup rose to 40,000 MW-day/ton U.

The above data indicate that a new qualitative level has been reached in PWR development.

The safe operation of the basic technological process at an AES requires a perfected reactor design and a strict observance of the specifics of the operating conditions. The PWR as a thermal energy source producing steam for AES turbine generators is a "heat exchanger" of the vessel type with internal heat sources.

On the other hand, the operation of the reactor and an AES as a whole should take into account the specific nuclear features of individual segments of the process used in obtaining thermal energy in a PWR.

To improve the thermodynamic efficiency of the steam power cycle of each PWR generation, the parameters of the second, and also the first, loops were improved, which led to changes in the thermohydraulic and neutron physics characteristics of the reactor plant.

Experience in operating different PWR generations has confirmed the correctness of the scientific and technical solutions used in the design and operation of reactors of this type and has shown that they are reliable and safe sources of thermal power for AES, which have shown by their technical and economic indicators that they are at least competitive with traditional sources of electrical energy [5-7].

TABLE OF CONTENTS

Foreword 3

Introduction 4

Chapter 1. Principles of Nuclear Physics for PWR 9

1.1. Fission of heavy nuclei 9

1.2. Nuclear conversion of uranium isotopes and transuranium elements 10

1.3. Sources of ionizing radiation in the reactor plant 17

Chapter 2. Neutron Physics Characteristics of PWR Core 24

2.1. Neutron balance and reactivity 24

2.2. Neutron spectrum in core 29

2.3. Characteristics of fuel lattices under different reactor operating conditions 32

2.4. Neutron physics characteristics of VVER-1000 core 39

Chapter 3. Start-up Conditions for Reactors 44

3.1. Reactor kinetics of prompt and moderated neutrons 44

3.2. Reactivity of reactors 47

3.3. Requirements for control and shielding systems for PWR 56

3.4. Reactor start-up 64

Chapter 4. Neutron Physics Characteristics of the Core for Power Operation of Reactors 71
4.1. Distribution of energy release in the core 71
4.2. Change in the reactivity for power operation 77
4.3. Regulation and adjustment of PWR 88

Chapter 5. Thermal-Hydraulic Power Operation of a Reactor 94
5.1. Heat transfer from heat producing elements to the water 94
5.2. Hydraulic characteristics of fuel cladding and the reactor 97
5.3. Permissible power level of fuel elements, cladding, and the reactor 107
5.4. Determination of thermal power of the reactor 114
5.5. Heat removal from the reactor under normal and transitory conditions 120
5.6. Efficiency of AES plant with PWR 126
5.7. Restrictions on permissible reactor power associated with electrical power supply for the primary circulating pump 131

Chapter 6. Reactor Shut-down 137
6.1. Stopping the reactor 137
6.2. Ensuring heat removal after reactor shut-down 144

Chapter 7. Conditions for the Use of Nuclear Fuel 151
7.1. Set-up of fuel assemblies in the core 151
7.2. Calculation of neutron physics characteristics of the reactor 159
7.3. Calculation of heat release distribution in fuel assemblies 168
Appendix: Design of fuel load (overload) in the VVER-440 reactor 174

Chapter 8. Work Capacity of PWR Fuel Elements 179
8.1. Properties of uranium dioxide and fuel element cans made from zirconium alloy 179
8.2. Estimate of fuel element state in an operating reactor 184
8.3. Monitoring the hermetic sealing of fuel element cladding during reactor shut-down 190
8.4. Study of depleted nuclear fuel in a hot cell 191

Chapter 9. Work Capacity of Design Materials for Equipment and Water-Chemical Conditions in the Primary Reactor Loop 196
9.1. Requirements for materials in primary loop 196
9.2. Features of water-chemical conditions in the primary loop 200

9.3. Methods for controlling the water quality in the primary loop 201
9.4. Purifying the water in the primary loop 205
9.5. Reprocessing and disposal of liquid radioactive wastes 211
9.6. Monitoring the sate of the equipment in reactor plants 213

Chapter 10. PWR Safety 223
10.1. An approach to the problem of safety 223
10.2. Radiation safety under normal reactor operation 224
10.3. Ensuring nuclear safety when working with fuel assemblies 226
10.4. Most probable emergencies in a reactor 229
10.5. Estimate of possible energy release during an emergency 235
10.6. Preventive and protective measures 237

Chapter 11. Features of the Operation of a Power Plant with a VVER-1000 242
11.1. The reactor unit 242
11.2. Steam turbine unit 248
11.3. Monitoring, control, and prevention system 254

Chapter 12. Economic Operation of an AES with PWR 258
12.1. Cost of electrical energy produced by an AES 258
12.2. Operating conditions and indicators of an AES in an energy system 265
12.3. Methods for increasing the amount of nuclear fuel burnup and the reactor operating time 271
12.4. Utilization of depleted PWR fuel 274
12.5. Reduction of neutron losses in a reactor 277

Bibliography 280
Subject index 286

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