UPGRADING OF A RELIABLE WATER SUPPLY
SYSTEM AT THE KOLA NUCLEAR POWER
PLANT FOR SERVICE LIFE EXTENSION

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Measures taken to develop and put into operation three new exterior channels for emergency process water with two additional 60VTs pumping units, which remain operational even during an earthquake and were installed in the second block pumping station, are described. In addition, the three existing 12NDS horizontal pumping units were used as a basis to develop a third channel for the emergency process water. Above-ground water ducts with thermal insulation and heating systems to prevent freezing during the anticipation state, which is the constant state of the emergency system, were laid.

As a result of upgrading with the development of three channels, the emergency process water feeding reached an adequately safe level of reliability.

The design of the first phase of the Kola nuclear power plant with two VVÉR-440 power-generating units was developed at the end of the 1960s and beginning of the 1970s in accordance with the norms, standards, and rules in use at that time. The first unit was put into operation in 1973 and the second in 1974. The design incorporates protection and design measures, corresponding to the limited size, adopted for these reactors, of the maximum coolant leak from the first loop and the role which was given to preventative measures and to training and teaching the plant personnel to recognize and overcome situations which are dangerous from the standpoint of the safety of a nuclear power plant, taking account of the high inertness and stability of the unit and the fact that the nuclear plant is located far from populated points.

The program for developing nuclear power in our country provides for service life extension for operating nuclear power plants, including the first two units at the Kola nuclear power plant. The first step in implementing this program is to determine the sequence of measures for extending service life and ensuring an acceptable safety level for first-generation VVÉR-440 reactors. One measure for increasing the safety of the first two units of the Kola nuclear power plant, including service life extension, is developing a two-channel reliable water supply for crucial users. For this, a technical task was developed to upgrade the system for emergency introduction of boron, the sprinkler system, the systems for supplying water for crucial needs and for reliable power supply to the power-generating units. The task provided for development of all external hydroengineering structures for organizing a two-channel system for reliable water supply, which operates under emergency conditions (no electrical power, earthquakes). Under the normal operating conditions of a nuclear power plant, it was proposed that the process-water pumps in the machine room be kept in operation. A two-channel system for cooling the core with the required reconstruction in the reactor compartments and the machine room was organized and each channel was equipped with its own power supply under normal and accident regimes, including loss of power.

The upgrading of the reliable water supply system for the first two units of the Kola nuclear power plant is described in the present paper.

Main Water-Supply System under Normal Operation. Water for the Kola nuclear power plant is taken from the Lake Imandra, which is the largest lake on the Kola Peninsula. The lake consists of three, largely autonomous, parts:
Bol’shaya, Iokostrovskaya, and Babinskaya Imandra. Bol’shaya Imandra is the northern part of the lake; it extends in the meridional direction. Iokostrovskaya and Babinskaya Imandra are oriented in the latitudinal direction. A cascade of three hydroelectric power plants was built on the Niva River, flowing out of the Lake Imandra; at the end of the 1950s, the Lake Imandra was converted into a reservoir. The siting of an electric power plant on the long narrow peninsula, separating Iokostrovskaya Imandra from Babinskaya Imandra predetermined the organization of a circulating water-supply system, using the adjoining waters of the Lake Imandra for cooling. The cooling water is taken from one side of the peninsula, and the heated water is discharged along the other side of the peninsula and then returned to the water uptake through the Shirokaya Salma channel. Since the distance from the water uptake site to the discharge site reaches 30 km, the water is completely cooled, and the circulating system is equivalent, with respect to the water temperature, to a direct-flow system.

In summary, the overall scheme for supplying water to the Kola nuclear power plant is as follows: water from the bay of the deep western part of the Iokostrovskaya Imandra is collected by an open feed channel and delivered to the first block pump station (first phase, first two power-generating units) and the second station (second phase, next two units). Water is fed from the block pump stations, along steel pressurized water ducts, to the turbine condensors, placed in the machine compartment of the main loop, and then from each phase of the nuclear power plant along two circuits of closed water ducts the water is diverted in the direction of the reactor compartments to the regulating structures (siphon trap wells). The heated water is discharged, behind the regulating structures along an open discharge channel, into the Molochnaya bay of the Babinskaya Imandra.

Operating Reliable Water-Supply System for Cooling the First Two Power-Generating Units. This system is designed in accordance with the main system for cooling the turbine condensors and its structural features, which reduce to the following:

- the overall arrangement of the structures is tied to local conditions of the hilly surface, which predetermined siting the supply channel on the side of the turbine compartment and the discharge channel on the side of the reactor compartment;
- as a result of the presence of rocky soil in the foundation of the structures, the discharge water ducts are placed under the basements of the turbine and reactor compartments in the form of steel, concrete covered Du 3600 mm pipes in a rocky trench; heated water is discharged in these pipes directly from the turbine condensors; one Du 3600 mm water duct is provided for two turbines of one power-generating unit.

In addition, the low water temperature in the Lake Imandra makes it possible to use the cooling water successively. At the present time, the reactor compartments of the power-generating units under normal conditions are cooled with water which has passed through the turbine condensors. To feed this water, pumps are placed in the turbine compartment; the pumps take up water from the gravity-flow discharge Du 3600 mm water ducts and discharge the heated water into the same ducts downstream and then through the regulating structure into the open discharge channel on the reactor-compartment side.

An emergency system for feeding water from additional pumps, placed directly in this pump station and connected to the backup diesel electric power plant, is provided for the case where power to the nuclear power plant is lost and water stops flowing from the first block pump station into the turbine condensors. For this, three emergency 12NDS horizontal pumps for pumping process water are installed in the ends of the pump station; two of the pumps are operating pumps and the other is a backup pump. The intakes of all three emergency pumps are connected to pure-water chambers 1, 2, and 8 of the main vertical OP-2-110 circulation pumps. Additional pumps are placed 6.75 m below the normal support level of the reservoir of the Lake Imandra, which guarantees that the pumps will start up with the minimal possible water level in the lake. One common steel underground Du 700 mm water duct, constructed for start-up of the first power-generating unit in 1973, is provided from these pumps to the machine room of the main building.

However, this system does not meet the modern normative requirements with respect to the number and quality of independent cooling channels for each power-generating unit and with respect to extreme natural and technogenic actions.

General Principles for Building External Hydraulic-Engineering Structures of the Two-Channel System. Preliminary analysis has shown that it is difficult and expensive to make the systems for reliable cooling of the first phase meet all requirements of modern norms. Consequently, a variant of a reconstruction in a reduced volume was developed; this corresponded to the first stage of upgrading and allowed for the development of only two external new channels for process water on the basis of a reconstruction of the second block pump station. Thus, two new channels with their own pumps, fix-