Methods for performing neutron-physical calculations of a reactor and the experiments performed during physical startup and subsequent operation are described. Starting with the simplest one-dimensional calculations during the reactor design process, the operation of the reactor is completed with three-dimensional calculations taking account of the heterogeneous structure of the core.

Among the experiments investigations of the effect of water entering the graphite masonry during an accident with the fuel assemblies on the reactivity should be singled out.

The method of partial fuel reloading, making it possible to decrease fuel-assembly burnout, has been implemented for the first time for the AM reactor.

The reactor in the first nuclear power plant built in the world, conventionally called the AM reactor, operated from June 26, 1954 to April 29, 2002.

The first physical calculations of the AM reactor, determining its features, were performed in 1950 at the Laboratory of Measurement Devices of the Academy of Sciences. The authors of the report published in December 1950 were the director of sector No. 14 Doctor of Physicomathematical Sciences S. M. Feinberg, senior scientific staff member, Candidate of Physicomathematical Sciences P. É. Nemirovskii, and junior scientific staff member Yu. N. Zankov. I. V. Kurchatov approved the report. The characteristics of the reactor were determined in the report – graphite moderator, tubular fuel elements, water coolant, and uranium loading and enrichment.

In March 1951, I. V. Kurchatov proposed that the scientific supervision of the development of the AM reactor and the construction of a nuclear electric power plant on the basis of the reactor be transferred to Laboratory V (the future Physics and Power Engineering Institute in Obninsk). N. A. Dollezhal’ remained the main designer of the reactor.

As D. I. Blokhintsev writes in his memoirs, the main theoretical calculations of the reactor for the nuclear power plant were concentrated in A. K. Krasin’s division and were performed by M. E. Minashin’s group with participation of Yu. A. Sergeev and other associates [1].

The first results of the physical and thermal calculations of the reactor at the nuclear power plant were published in the journal “Atomnaya Énergiya” after the plant was started up in 1956 [2]. The neutron-physical calculations were performed by the two-group method for a one-dimensional core geometry. Resonance integrals were used in an attempt to take account of absorption and multiplication of neutrons in the intermediate energy range.

The difficulties of the physical calculation of the reactor at that time were due to the uncertainty in the composition of the core and in the cross sections of the interaction of neutrons with the nuclei of the materials used in the reactor. The construction of the fuel elements was finalized only in 1953, i.e., a year after the reactor was started up. Although the AM
reactor is a thermal-neutron reactor, 15% of the uranium fissions occurring in it are due to superthermal neutrons. Together with the “intermediate nature” of the neutrons, resonance absorption of neutrons in $^{238}$U and molybdenum also had an appreciable effect on the criticality of the reactor. Molybdenum was used as a technological additive to the metallic uranium in order to increase the radiation resistance of uranium. Together with fragmentary foreign data on nuclear cross sections, domestic data, specifically, the semiempirical dependences for the resonance absorption of neutrons in $^{238}$U [3], were also used in the calculations.

As the startup and operation of the reactor subsequently showed, the computed neutron-physical characteristics remained close to the values used in the design. For the 5% uranium enrichment chosen, the first reactor run was equal to 2.5 effective months. Subsequently, the uranium enrichment was increased on the basis of the experience gained, and the fuel assemblies started to operate in the reactor for several years.

The article by A. K. Krasin, B. G. Dubovskii, E. Ya. Doil’nitsev et al. published in 1956 in the journal “Atomnaya Énergiya” is devoted to an experimental study of the physical characteristics of the reactor at the nuclear power plant [4]. The article discusses the physical characteristics of the reactor measured during physical startup. Among the large volume of experiments, the runs studying the effect of water on the reactivity of the reactor should be specially noted. Since the core with a graphite moderator is relatively small, neutron leakage from the AM reactor is substantial (about 20% of the neutrons produced by uranium fission). As a result, if the core loses water the reactor becomes subcritical. If the steel pipes of the fuel assemblies or channels of the safety and control system accidently rupture, the graphite masonry of the reactor could become wet. Then the effect of reactivity could be negative or positive. If water enters the reflector, the reactivity decreases, and if water enters the core the reactivity increases. This feature of the reactor which the calculations revealed was confirmed by special experiments during reactor startup. To this end, a special experimental channel simulating a fuel assembly with an increased amount of water around the fuel elements was fabricated. It was concluded on the basis of the experimental results that the maximum increase of reactivity when the graphite cladding is filled with water could be 3% within the core. The absorbing emergency protection rods and the control rods compensated this increase of reactivity easily. Subsequently, it was established that irradiated graphite absorbs water more rapidly than unirradiated graphite. Experiments on the effect of water on reactivity in various cells of the core were repeated. For this, a new experimental channel holding a large amount of water was built.

A computational analysis taking account of the dynamics of filling of the masonry with water showed that, in contrast to previous investigations, the total increase of reactivity becomes less but the rate of growth increases. To improve safe-