The results of research on the possibility of replacing in neutron radiation monitors in helium counters by their analog with a solid boron coating are presented. It is shown that under $^3$He deficit conditions such a replacement is not only possible but it can improve the performance of the monitors and lower their cost.

Radiation monitors for monitoring neutron radiation play the main role in the prevention of unauthorized transfer of plutonium, which emits neutrons in amounts large enough for detection. The conventional, efficient, simple and convenient to operate detectors used in such monitors are still gas-discharge counters filled with $^3$He. In recent years, alternative detectors have been sought in connection with a shortage and increasing cost of $^3$He [1, 2]. In some cases, for example, for detection of significant neutron fluxes with the aid of bias methods, these detectors in neutron coincidence counters and elsewhere can replace helium counters [3].

In investigations of alternative detectors, the detection efficiency is of primary interest. A characteristic feature of radiation monitors is the detection of a neutron flux at the background level. For this reason, in this case a low background of the detector is no less important than the detection efficiency. Compared with helium detectors, most alternative detectors have high efficiency but a significant background [4], which limits their use in radiation monitors.

Boron detectors do not compete with helium detectors because the detection efficiency is much lower. Nonetheless, since they have good background characteristics and they are cheaper and more accessible, boron detectors can be regarded as replacements for helium counters in neutron radiation monitors. In the present article, we present the results of investigations of such a possibility in application to monitors produced at VNIIA.

Several experimental boron counters in the design of the serially produced SNM18 helium counter were fabricated in 2012. The inner surface of the counter was covered with a solid compound of boron enriched with $^{10}$B. The design of the SNM18 counter was chosen as a basis because this counter is used in detection blocks of TSRM85 neutron radiation monitors produced by VNIIA. The counter’s counting characteristics determined using a neutron-fission source based on $^{252}$Cf are shown in Figs. 1–4. Only the region of the plateau in the discrimination characteristics is shown in Figs. 3 and 4. One of the parameters presented is the quality factor $Q$, defined as the ratio of the squared pure count to the background and characterizing the suitability of the detector for radiation monitoring [5].

The count characteristic of the counter has a ~150 V plateau with respect to the supply voltage and about 1 V with respect to the discrimination level. The background and quality factor vary very little in these intervals. The working supply voltage of the counter is half that of its helium analog. The spectra of the counter pulses are shown in Fig. 5. The optimal level of discrimination of the helium counter is chosen, as a rule, at the start of the spectral plateau. Because it is more uniform, the spectrum of the boron counter is less convenient for practical determination of the optimal level of discrimination. In this case, it is necessary to measure the background characteristic. The boron counter is more noise-resistant and stable in operation, which is important for radiation monitors, which are often used under noisy conditions.
The main working characteristics obtained for SNM18 boron and helium counters using a thermalized neutron flux under identical geometric conditions in optimal working regimes are as follows:

Fig. 1. Neutron count of the source $N (I)$ and background $B (2)$ versus the supply voltage of the boron counter.

Fig. 2. Quality factor versus the supply voltage of the boron counter.

Fig. 3. Neutron count of the source $(I)$ and background $(2)$ versus the discrimination level of the count pulses of the boron counter.