USE OF RADIATION MONITORS FOR PERSONNEL CONTAMINATION DETECTION

A. V. Shumakov

It is shown that the TSRM61 and TSRM82 radiation monitors produced at the Dukhov All-Russia Research Institute of Automatics (VNIIA) can be used for detecting the limit of the contamination of the clothing, footwear and skin of the personnel in radiation enterprises. The main radionuclides corresponding to the decay products of VVER, RBMK, and fast reactor fuel are examined.

Pedestrian and vehicle radiation monitors are stationary means for detecting photon and (or) neutron radiation. They are placed at checkpoints in enterprises that manufacture, use or store nuclear and (or) radioactive materials. Some enterprises of this kind are equipped with pedestrian γ-radiation monitors of the type TSRM61 and TSRM82. Operation has revealed cases where such monitors have detected personnel contamination, which was the reason for studying the possibility of using these devices not only for their intended purpose of inventorying and monitoring nuclear materials but also for radiation monitoring.

Preliminary assessments have shown that the TSRM61 and TSRM82 monitors can be used to detect significant contamination of personnel. A more complete study, from the standpoint of the radiation safety and monitor sensitivity norms, of the possibility of using them to detect the limit of the contamination of clothes, shoes, and skin of personnel at radiation enterprises is the objective of the present work. The decay products of VVER, RBMK, and fast reactor fuel are taken as the contaminants.

The TSRM61 radiation monitor is intended for automatic detection of nuclear materials and radioactive substances by the detection of γ-radiation. It includes a power supply, control block, and detection blocks based on a 220 × 45 × 10 mm CsI(Tl) scintillators. The number of detection blocks (from 1 to 8) and the distance between them depend on the configuration of the monitored zone and the detection threshold requirements (Fig. 1).

The TSRM82 monitor is an improved variant of TSRM61; the automation level and operational stability are higher, and the mass and size are smaller. Since the foundation of the detectors – type of scintillator and its dimensions – is the same for both systems, their sensitivity and detection threshold are the same (Table 1).

For effective monitoring of personnel contamination, it is best to use eight detection blocks arranged in two columns along four blocks 5–10 cm from the surface of the body on the face and back sides. This permits monitoring personnel in a single standard position. The arrangement of the contaminated region can be determined by activation of one detector and the source itself with even higher accuracy with a group of detectors. The nominal designation of this modification is TSRM82-08.

However, such an arrangement of the detection blocks can be implemented only under special conditions, for example, in sanitary zones. At checkpoints, as a rule, the distance to the monitored object is significantly greater and the monitoring time is limited. It is precisely such an arrangement of the monitors that we shall examine. To simplify the calculations,
we shall assume the distance between the detectors and the monitored object to be 1 m and the measurement time 1 sec. This distance is somewhat greater than that corresponding to the standard arrangement of four detection blocks in the most commonly used modification of the monitor. The time is determined by continual monitoring without stopping personnel.

**Contamination Dose Limitations.** The radiation safety norms establish the admissible $\alpha$- and $\beta$-contamination of the skin and special clothes as the most dangerous from the standpoint of the dose effect on the body, especially if the contamination is internal. It is determined as the flux of $\alpha$- and $\beta$-particles from the main limits of the yearly equivalent dose limits of irradiation of the crystalline lens of the eye, skin, feet, and wrists [1]. These requirements are reflected in the health regulations of enterprises, for example, NPP [2]. However, as noted in [3], the admissible levels may not take account of the real dose load in the event that the $\alpha$- or $\beta$-activity of a nuclide is very low and, conversely, the $\gamma$-radiation is intense.

The TSRM61 and TSRM82 monitors cannot detect $\alpha$-radiation and are not suited for efficient detection of $\beta$-particles. For this reason, they can be used to detect contamination due to $\gamma$-emitters only. The present work examined mostly $\beta$-emitters forming possible radioactive contamination: $^{51}\text{Cr}$, $^{54}\text{Mn}$, $^{59}\text{Fe}$, $^{60}\text{Co}$, $^{90}\text{Sr}$, $^{95}\text{Zr}$, $^{134}\text{Cs}$, $^{137}\text{Cs}$, $^{152}\text{Eu}$, $^{154}\text{Eu}$, and $^{155}\text{Eu}$ (Table 2). Almost all of them are also $\gamma$-emitters.

The possibility of monitoring contamination according to the $\gamma$-radiation flux is determined by the ratio of the yield of $\beta$- and $\gamma$-emitters. In other words, the admissible dose limit for the $\beta$-radiation of a nuclide can occur sooner than this nuclide can be detected according to the $\gamma$-radiation. In the first approximation, this is possible when the photon and $\beta$-particle yields presented in Table 2 are comparable [4, 5]. This condition is necessary but insufficient and is realized for all nuclides studied except $^{90}\text{Sr}$, whose accompanying photon yield is 10000 times lower than that of $\beta$-particles. A sufficient condition is determined by the ratio of the dose characteristics corresponding to the $\beta$- and $\gamma$-radiation $D_\beta/D_\gamma$ [6]. If the $\gamma$-dose is comparable or greater than the $\beta$-dose, then this nuclide should be monitored according to the $\gamma$-radiation. Otherwise, it is

---

**TABLE 1. Detection Thresholds of the TSRM61 and TSRM82 Monitors**

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Detection threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{235}\text{U}$</td>
<td>1.8 g</td>
</tr>
<tr>
<td>$^{239}\text{Pu}$</td>
<td>0.15 g</td>
</tr>
<tr>
<td>$^{137}\text{Cs}$</td>
<td>107 kBq</td>
</tr>
<tr>
<td>$^{60}\text{Co}$</td>
<td>93 kBq</td>
</tr>
</tbody>
</table>

Fig. 1. Overall view of the constituent parts of TSRM61 (a) and TSRM82 (b) (top – control block, bottom – detection block).