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New portal monitor systems to ensure the safety of the population

Introduction

Thanks to technology, information spreads from one end of the world to the other in units of seconds. This human convenience carries with it certain risks associated with its unfair use, for example, in terrorist attacks, or just a threat to an individual, even if only in the form of panic. In addition to organized crime, extremism, religious, national and social conflicts, the integration of migrants into mainstream society and economic or environmental risks, terrorism remains one of the major security challenges of today's world. The threat of terrorism as a method of forcibly pursuing political or other goals (e.g. religious, economic, criminal, etc.) is consistently high. A characteristic feature is the existence of transnational networks of loosely connected groups, which, even without a unified command, share ideology, goals and plans for their fulfillment, financial resources and especially information. They are able to directly endanger human lives and health, but also critical infrastructure. Terrorism is one of the global security threats, and the probability of a terrorist attack is real for the Czech Republic as well, and therefore it is reasonable to prepare for a possible attack. Various technological tools can be used to increase the safety of citizens, for example by supporting new measures to protect the population from the malicious use of radioactive substances. This goal has been, is and will be the effort of applied research (following the situation in national and international security) using the latest detection technologies.

Use of radiation detectors in common working conditions

Of course, radiation detection devices and instruments occur wherever radioactive radiation sources are used. The radiation source can either be permanently installed in an industrial plant, or in the industrial process only samples are taken, which are studied and analyzed by nuclear methods at special workplaces. Various applications use changes in radiation absorption (e.g. flaw detectors, fire detectors, thickness gauges, densitometers and level gauges), or the generated electrically charged particles cause electrical conductivity of the air which can dissipate, for example, unwanted electric charge accumulated by friction on polymer fabrics or foils, or static electricity discharges can be prevented in areas where there is a risk of explosion and the like.

An ordinary citizen of the population who does not move in these facilities will hardly encounter radiation detection devices in direct contact. An exception is healthcare, where X-rays are most often used, as well as various radiopharmaceuticals and thus the corresponding detection equipment. Radiation detectors can also be found at places of processing and collection of metal waste, in smelters, municipal waste incinerators, at EU entrances (e.g., international airports, docks, railways, etc.), where large-volume portal detectors are installed, which serve as indicators of radioactive material.

All the above-mentioned uses of radiation detectors are targeted at specific locations or its use. However, there are almost no devices on the market that can be used in public spaces, or that can be easily transported and placed in the required places, even if only for a limited time. The need for the existence of these facilities is constantly growing, especially with increasing demands on the security of places with a large number of gatherings (metro, stadiums, etc.), key buildings (ministries, authorities, etc.), airports, NPP sites, etc.

The systems presented in this paper were developed within “The new generation of portal monitors to ensure the security of the population” project by SÚRO, v.v.i. in cooperation with NUVIA, a.s. and they are designed to protect the population could also serve as a backup in the event of a nuclear accident, for pilot screening of persons and equipment coming from contaminated areas.

Detection system requirements

To ensure radiation safety and early detection, the protection systems use the detection devices whose primary purpose is both detection and tracing (by hand-held measuring instruments) and the specifications of the radioactive substance. Their weakness is the limited screening capacity and the fact that detectors located in the area of interest often disrupt the natural character of the monitoring area. Possible false positive signals can also be a problem, e.g. due to the presence of people after the application of radiopharmaceuticals or natural radionuclides in the technical equipment.

Different requirements are thus imposed on the detection devices to be used in the public space, but some are common: portability or transportability, easy installation and operation and low energy requirements. However, the real technical requirements depend on the intended method of use as well as on the type of detected radiation and on the activity of the source at a defined distance. For equipment that will be located in the field, resistance (degree of protection - IP) to weather conditions, or mechanical resistance (e.g., vandalism, etc.) is also required. Some conditions of use are solved in such a way that the devices are so-called hidden, for example by incorporation into devices or things that are common in the area, or by placing them, for example, in means of transport that are inaccessible to outsiders.

General properties of used detectors

The basic detection material used is a plastic scintillator. Thanks to its production capabilities of various volumes and shapes, as well as its relatively low price, it is the best choice. Due to the properties of plastic detectors, in which the dominant mechanism of gamma radiation deposition is Compton scattering, the energy range of detection is chosen up to 2000 keV, in which potential sources of gamma radiation can be affected. For the purposes of testing the developed equipment, ^{241}Am, ^{137}Cs, ^{60}Co sources were used, as these radionuclides are commonly used sources especially in industry and represent the above-mentioned energy range.

Mobile portal detector - vehicle type van

The system consists of 4 pieces of large-volume plastic scintillation detectors. Each detector has volume 25 liters and dimensions of 1000 mm x 500 mm x 50 mm. The individual detectors are arranged in pairs (the detectors are placed vertically next to each other in a pair) and are located in the cargo space on the sides, where each pair is oriented to cover the right and left side of the vehicle. One pair can be take out of the vehicle on its own support device with wheels and thus create a through corridor. The system can be remotely controlled via Wi-Fi, which can be used significantly in hidden monitoring, or it can be controlled via Ethernet technology, thanks to which data can be transmitted to any point on the network. A camera system that provides time-synchronized visual data can be connected to the control unit.

Therefore the system is designed to have several possible uses: hidden monitoring even while the vehicle is driving (with very high sensitivity with light and sound signaling for the operator) or screening with a defined corridor, e.g. for the passage of persons or inspection of vehicles on the road, see Fig. 1 and Fig. 2.

Due to the large working volume of the detectors, the minimum detectable activities of gamma radiation sources are low, which results in a high probability of source detection. The device was tested for the sensitivity of the system while driving at different speeds and distances of the source from the vehicle, see Table 1. This can also be used in the opposite geometry, where the radiation source moves and the measuring car is stationary. All peripherals provide the control unit the data (with a time period of 1 second) which are automatically evaluated (e.g., exceeding alarms) and stored for possible later use. A signal receiver from the global satellite positioning system is also included.

The minimum detectable activities (hereinafter referred to as MDA) for the geometry of the source at a distance of 30 and 50 meters are in the range of several tens of MBq for ^{137}Cs, respectively for ^{60}Co (with normal radiation background), see Table 2. For a moving source, the MDA values increase depending on the speed by 0.5 to 1 MBq at a speed increase of 10 km/h.

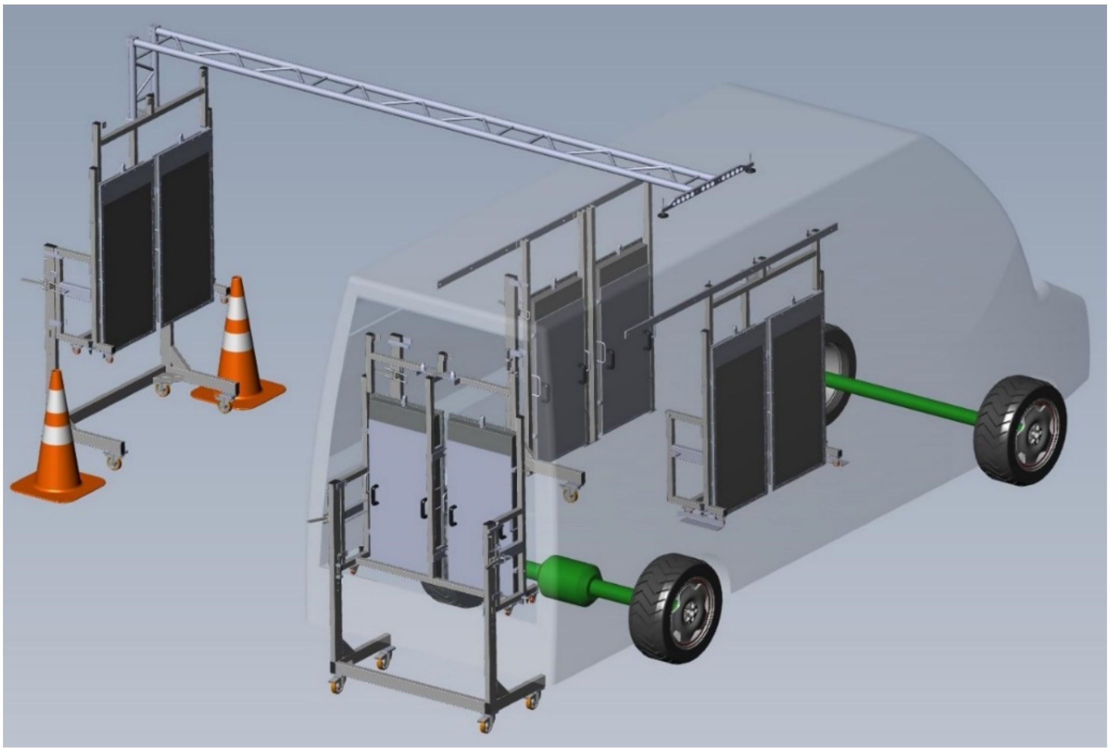

Fig. 1 A view on the positions of the detectors inside and outside the vehicle and the position during their handling (taking out the detectors through the rear door) for the geometry of the corridor.

Fig. 2 A side view of the storage space of the van (left) with the detectors installed in the measuring position; a pair of detectors taken out of the vehicle (right) for measuring the geometry of the corridor

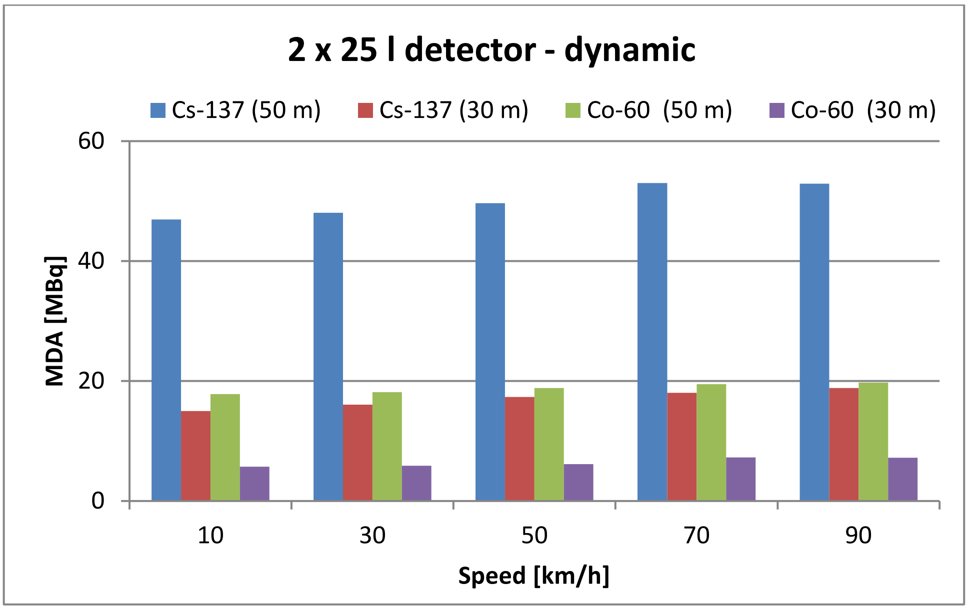

Table 1 Minimum detectable activities for different radionuclides in a moving source configuration at different speeds - for the van system

The device can be used as a corridor in various widths of the passage. The widths of 50 cm, 100 cm and 250 cm of Table 2 for MDA correspond to the center of the corridor, so the width of the corridor is doubled. From the values from the Fig. it can be read that the values of source activities, which the system can certainly distinguish, is very low, at the level of calibration standards used for the spectrometric instruments.

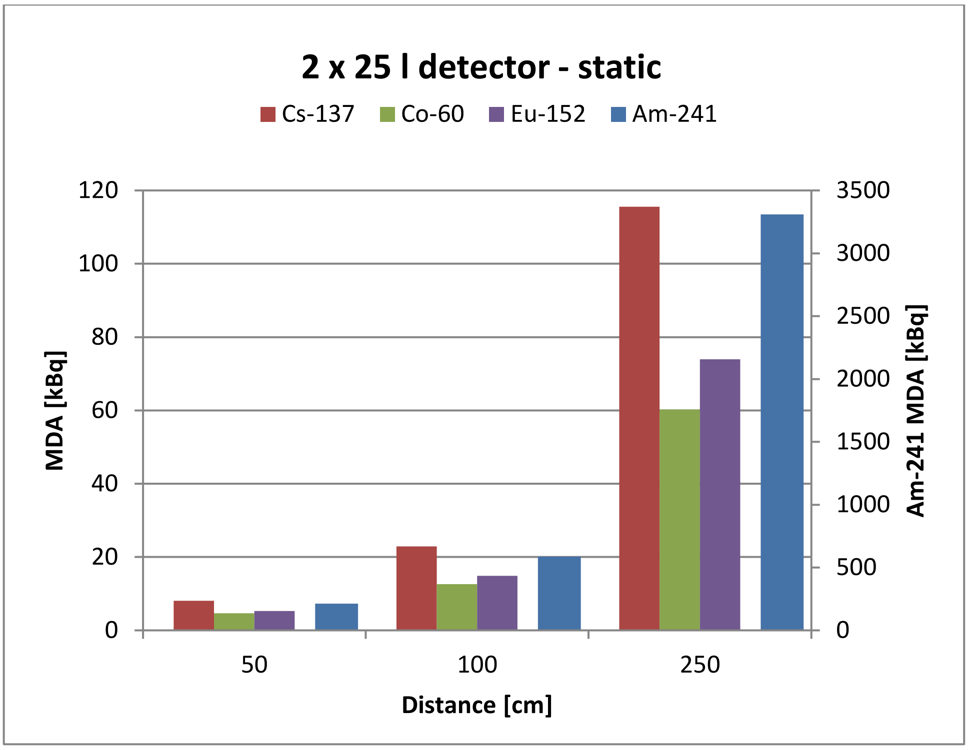

Table 2 Minimum detectable activities for different radionuclides in a corridor configuration with three different passage widths - for the van system

Mobile portal detector – personal vehicle

The system consists of one neutron sensor and 2 pieces of plastic scintillation detectors. Each plastic detector with a volume of 10 litres and dimensions 620 mm x 325 mm x 50 mm are located on the sides of the cargo space in a metal structure, see Fig. 3. An independent battery box and a control unit is located between the directional detectors. The device also includes a GPS signal receiver. All peripherals send the data to the control unit (with a time period of 1 second) which are automatically evaluated (e.g., alarm exceeded) and stored for possible later use. The device described above can be removed from the vehicle and assembled into a through-corridor with a width of 80 cm, see Fig. 4.

Therefore the system is designed with several possible uses: hidden monitoring even while the vehicle is driving (with very high sensitivity with light and sound signalling for the operator) or the screening in a predefined corridor. The system can be remotely controlled via Wi-Fi, which can be used significantly in hidden monitoring, or it can be controlled via Ethernet, thanks to which data can be transmitted to any point in the network. A camera system that provides time-synchronized visual data can be connected to the control unit.

Due to the large working volume of the detectors, the minimum detectable activities of gamma radiation sources are low, which results in a high probability of source detection. The device was tested for the sensitivity of the system while driving at different speeds and distances of the source from the vehicle, see Table 3. This can also be used in the opposite geometry, where the radiation source moves and the measuring car is stationary.

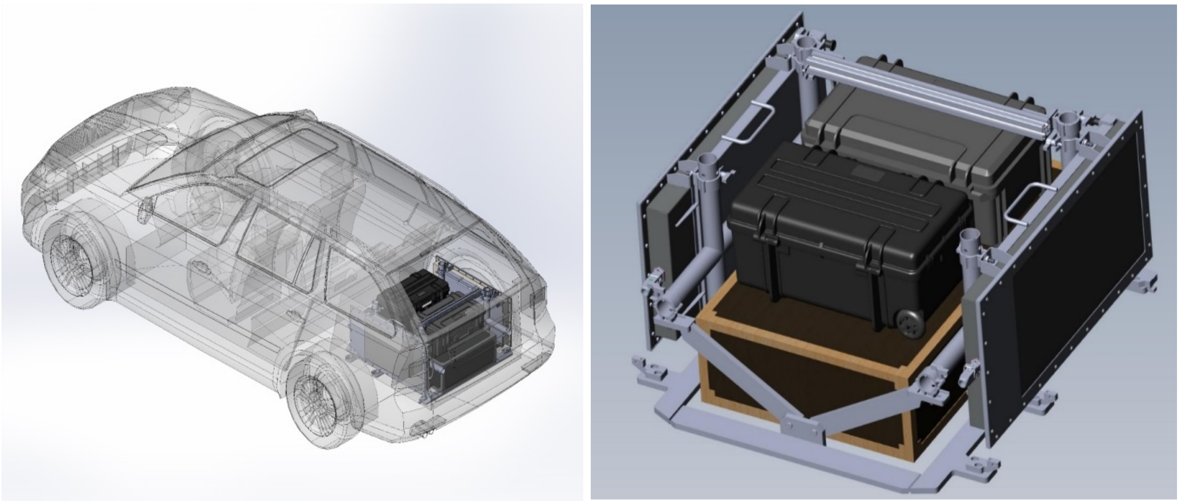

Fig. 3 A view of the location of the detection device in the passenger car (left) and the arrangement of the detection assembly (right).

The minimum detectable activities for the geometry of the source at a distance of 30 and 50 meters are in the range of several tens of MBq for ^{137}Cs respectively ^{60}Co (with normal radiation background), see Table 3. For a moving source, the MDA values increase depending on the speed by 0.5 to 1 MBq at a speed increase of 10 km/h.

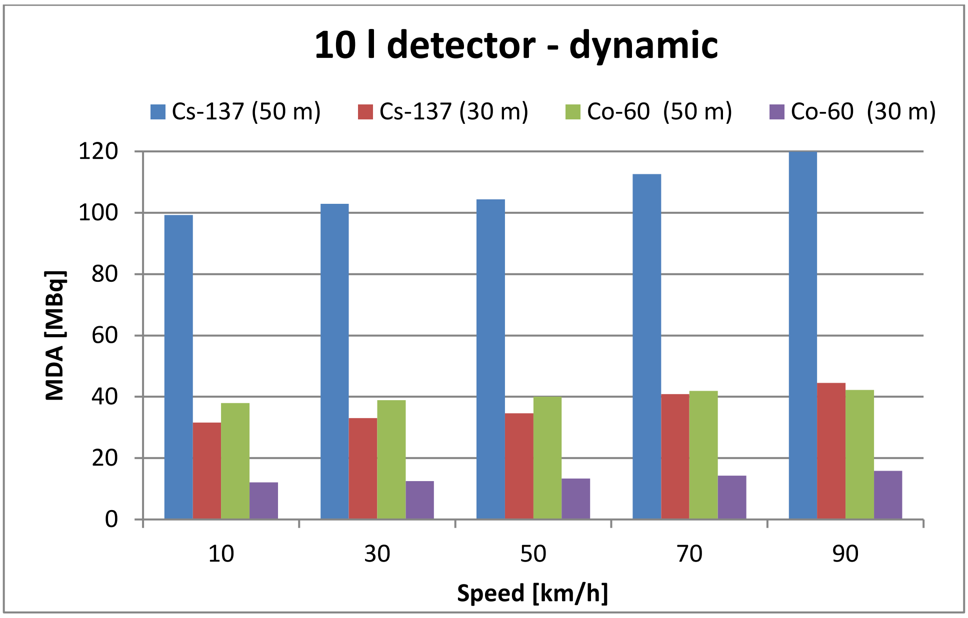

Table 3 Minimum detectable activities for different radionuclides in a moving source configuration at different speeds

The device can be used as a corridor in a width of 80 cm, or it is possible to produce a wider connecting or anchoring upper member according to requirements, see Fig. 4. The width of 40 cm for MDA in Table 4 corresponds to the center of the corridor. The other two values, 50 cm and 100 cm, indicate the MDA values for the alternative widths of the created corridor. From the values in Table 4, it can be seen that the values of source activities, which the system can certainly distinguish, are very low, at the level of calibration standards used for the spectrometric instruments.

Fig. 4 "Mobile portal detector - passenger car" when measuring people in the corridor configuration

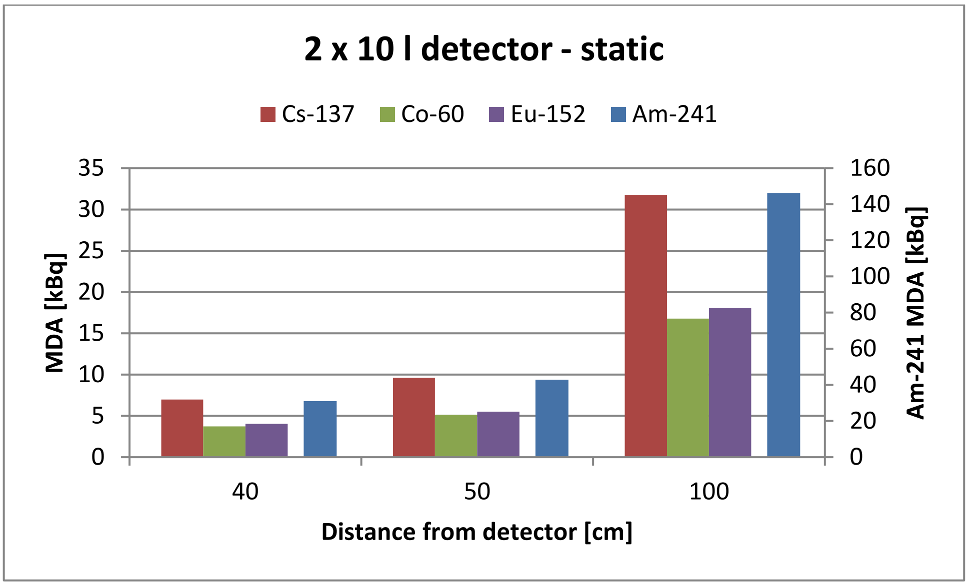

Table 4 Minimum detectable activities for different radionuclides in a corridor configuration with three different passage widths

Conclusion

The cornerstone of all planning and preparation of measures not only in the fight against terrorism and ensuring the internal security of the Czech Republic in general must be the protection of the population. Important tasks that must be emphasized also include the protection of critical infrastructure and other potentially significant targets of terrorist attacks. For this reason, it is necessary to perceive the condition of early detection of threats from radioactive substances as an effort to actively search for them.

The developed devices, which are designed mainly to ensure the safety of the population, are simple independent modular devices that can be operatively placed in locations where it would be difficult to ensure radiation safety.

Due to the fact that plastic scintillators are significantly cheaper than other precise spectrometric detectors, the developed devices will be more affordable. In addition, thanks to its simple operation, it can be used by institutions, organizations (e.g., police, fire brigade, etc.) or companies (e.g., security agencies,etc.) that have no experience in the field of radiation detection.

Due to the placing of the detection device in vehicles with a weight limit of 3.5 tons, it can be transported to the destination by a person with a group B driving license. The fact that the developed devices are placed in commonly used cars do not disturb the local character of the environment and their use is more efficient and natural with regard to the behavior of both those present and people in the vicinity.

The developed monitoring systems are suitable for use in important state organizations, such as Fire brigades, Police or the Customs Administration of the Czech Republic, but also in other places where there is an accumulation of large number of people, such as airports, railway stations, subways or stadiums. The detection systems described above can be supplemented, for example, with a camera system or other sensors for more complex monitoring at a given location.

The system with basic equipment or supplemented by other sensor accessories will facilitate the activities of security forces in particular.

Acknowledgement

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Literature

International Organization for Standardization (ISO). Determination of the characteristic limits (decision threshold, detection limit and limits of the confidence interval) for measurements of ionizing radiation - Fundamentals and application. ISO 11929, Geneva, ISO, 2010.

IEC 62244:2006 - Radiation protection instrumentation - Installed radiation monitors for the detection of radioactive and special nuclear materials at national borders)

Ministerstvo vnitra České republiky. Strategie České republiky pro boj proti terorismu. 3. Praha: Ministerstvo vnitra ČR, Odbor bezpečnostní politiky, 2013. Dostupné z: https://www.mvcr.cz/soubor/3-nap-2013-material-pdf

SICILIANO, Edward R.; ELY, James H.; KOUZES, Richard T.; SCHWEPPE, John E.; STRACHAN, Denis M.; YOKUDA, Satoru T. Energy calibration of gamma spectra in plastic scintillators using Compton kinematics, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 610, Issue 2, 1 November 2009.

SICILIANO, Edward R., ELY, James H.; KOUZES, Richard T.; MILBRATH, Brian D.; SCHWEPPE, John E. and David C. STROMSWOLD. Comparison of PVT And NaI(Tl) Scintillators for Vehicle Portal Monitor Applications. United States: N. p., 2005.

LOPRESTI, Charles A.; WEIER, Dennis R.; KOUZES, Richard T. and John E. SCHWEPPE. Baseline Suppression of Vehicle Portal Monitor Gamma Count Profiles: A Characterization Study. United States: N. p., 2006.

ELY, James H.; KOUZES, Richard T.; SCHWEPPE, John E.; SICILIANO, Edward R.; STRACHAN, Denis M. and Dennis R. WEIER. The Use of Energy Windowing to Discriminate SNM from NORM in Radiation Portal Monitors. United States: N. p., 2006.

R E S U M É

Plastové detektory mají po řadu let významné využití jako radiační monitorovací portály. Pro kontrolu vozidel se využívají především stacionární velkoplošné detektory s délkou a šířkou řádově až 100 centimetrů a tloušťkou jednotek centimetrů. Pro další aplikace jako skenování osob při průchodu na hromadné akce apod. lze využít detektorů menších rozměrů. Přestože plastové detektory vykazují spektrometrické vlastnosti při detekci záření gama, nelze je používat přímo k identifikaci nuklidů, jsou ale velmi vhodné jako signální detektory např. pro monitorování procházejících osob.

Příspěvek popisuje vyvinuté detekční systémy na bázi plastových detektorů, které se zaměřují na skryté monitorování ať už statické, tak dynamické (pohybující se vozidla s detekční technikou), či fixní nebo mobilní umístění. Fakt, že vyvinuté přístroje nenarušují lokální ráz prostředí a jsou umístěny do již používaných zařízení, je jejich využití efektivnější a přirozenější s ohledem na chování přítomných osob. Nové detekční systémy tak usnadní činnosti složkám zabývající se bezpečností jako je policie, hasiči, celní správa, bezpečnostní agentury, ale také i na dalších místech, kde dochází ke kumulaci většího, či velkého počtu osob, jako jsou letiště, nádraží, metro, stadiony a další.

Klíčová slova: Terorismus, portálové monitory, radiace, veřejná bezpečnost.

S U M M A R Y

GRYC, Lubomír; GRÍSA, Tomáš: NEW PORTAL MONITOR SYSTEMS TO ENSURE THE SAFETY OF THE POPULATION

Plastic detectors have been used extensively as radiation monitoring portals for many years. Stationary large-area detectors with a length and width of the order of up to 100 centimeters and a thickness of units of centimeters are mainly used for vehicle inspection. Smaller detectors can be used for other applications such as scanning persons heading for mass events, etc. Although plastic detectors have spectrometric properties in the detection of gamma radiation they cannot be used directly to identify nuclides, but they are very suitable as signal detectors, e.g. for monitoring passers-by. The paper describes the developed detection systems based on plastic detectors, and is focused on covert monitoring, both static and dynamic (moving vehicles equipped with detection technology), fixed or mobile location. The fact that the developed devices do not disturb the local character of the environment and are placed in already used devices the use of those is more efficient and natural with regard to the behavior of persons present. Thus, the new detection systems will facilitate the activities of security forces such as the police, fire brigade, customs administration, security agencies but also in other places where there is an accumulation of large number of persons, such as airports, railway stations, subways, stadiums, etc.

Keywords: Terrorism, portal monitors, radiation, public safety.