DVIN-1 – PORTABLE DETECTOR OF HIGH EXPLOSIVES

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Abstract

DVIN-1 portable detector is meant for search of high explosives using the associated particle imaging technique. The detector consists of ING-27 portable neutron generator with a built-in 9-pixel silicon α-detector, BGO-crystal γ-detector, electronics for data acquisition and analysis, power supply and user interface. The detector operates in the automatic mode and makes decision without operator's actions. Software algorithms are based on the analysis of data collected over more than 300 experiments. The detector is capable of detecting over 30 types of high explosives, the minimum detected mass for 10 min is 25 g.

1. Introduction

HE detectors that use the associated particle imaging (API) technique have been considered a lot recently [1-10].

In the API, the inspected item is irradiated with fast 14-MeV neutrons that are generated as the result of a binary nuclear reaction $d+t \rightarrow \alpha+n$. The neutrons excite the nuclei of material. The excitement is released by emitting a γ-rays with energy up to 10 MeV. Each material has its own characteristic γ-spectrum, which allows identifying it.

A neutron is tagged by detecting an accompanying α-particle using a special α-detector. This allows determining the neutron flight direction. By measuring the time interval between the signals of α- and γ-detectors, it is possible to measure the distance to the point, where the γ-ray was generated, since the neutron speed is constant and equals to 5 cm/ns. Thus, there is a capability to identify all the three coordinates of the region that generates gammas.

Neutron tagging allows getting the data on the time of flight that can be used to select the events from a specific time interval only. This significantly reduces the background. It has been demonstrated [6-9] that use of (α-γ)-coincidence can reduce the signal-to-background ratio over 200X, thus, significantly improving the conditions of hidden item detection.

Another advantage of API is that the use of fast neutrons and sufficiently energetic gammas allows scanning rather large inspection items. The API detectors have been developed that enable scanning mined cars, large transport vehicles and maritime containers.

It is important that the identification is unmanned, without operator's actions.

The Comprehensive Program of national transportations safety, endorsed by the Russian Government on 06/30/2010, includes equipping the instrumental checkpoints at the entrances to all metro stations in Russia with portable systems for HE detection based on the API with fast neutrons.

As of today, 76 DVIN-1 detectors have been delivered to the railway stations of the North-Caucasus and the October railroad, Kazan and Vladivostok, as well as to the metro stations in Moscow, Saint-Petersburg, Kazan and Novosibirsk.

2. Description of Detector

DVIN-1 detector (Fig. 1) consists of inspection module, cabled with the operator's PC. The dimensions of the inspection module are 740×510×410 mm, and weight is 40 kg. Inside the inspection module there are neutron source, γ-detector and data acquisition electronics. The inspection module is energized from 220 V mains or from an independent battery. The consumed power is 300 W.

The detector is controlled by one operator, whose responsibility is position the system correctly relative to the inspected item and start the measurement. All the other HE detection operations are automatic.

Fig. 1. DVIN-1 portable HE detector

The major advantage of DVIN-1 compared to gas analyzer is that the detector can not only determine the potential presence of HE, but also identify the exact location of HE within the inspected item. Unlike the X-ray systems that detect the density contrast, the API detectors respond to elements that compose the material. They identify *per se*, what amount of various elements, e.g. hydrogen, nitrogen, or oxygen, there is in the material. This enables to detect various solid and liquid HE, including nitrogen-free.

Algorithms of DVIN-1 software are based on the analysis of data collected over more than 300 experiments. The detector is capable of detecting over 30 types of high explosives, the minimum detected mass for 10 min is 25 g.

The detector can be adjusted to detect chlorine, fluorine, potassium and thus can be used to monitor the trafficking of strong toxins. The API detectors have been tested for the detection of various drugs, such as cocaine, heroin, hashish, solutan, sodium oxybate. In the passive mode, with neutron generator turned off, DVIN-1 detector can be used as a detector of radioactive materials.

3. Radiation Safety

Radiation safety of DVIN-1 operation has been tested by Rospotrebnadzor experts in the course of testing in the inspection area of "Ladozhskaya" metro station in Saint-Petersburg. After the tests, the medical & epidemiological certificate has been prepared that confirms the lack of any induced activity within the inspection object or in the environment. The physical justification for that is that fast neutrons, unlike thermal or slow ones, weakly interact with material. This fact, combined with low irradiation time (less than 10 min) and low intensity of neutron generator (5×10^7 s^{-1}) leads to the complete lack of any radiation above background.

Rospotrebnadzor experts have defined the size of the safe distance between the detector and the operator during irradiation, which is 8.5 m.

It is important that API detectors are not and will not be used to irradiate humans. These detectors will not be used in the selective monitoring of the luggage at checkpoints. They will be used only to inspect the left-behind items and suspicious objects. The current procedures for such events provide for calling the police dog and putting cordons round the scene, evacuating all people. This provides for the conditions for safe use of the API detectors. The Rospotrebnadzor certificate contains the equivalent dose rate, generated by DVIN-1 at 20 m, which is 0.4 μSv. For comparison, dose of negligible low radiation risk, which is beyond accounting at all, is 10 μSv per year, and the permissible annual dose for population is 1000 μSv. I.e., a common civilian can go past a surrounded site with operating DVIN-1 2.500 times a year without any health risk.

Turned off DVIN-1 detector does not emit any ionizing radiation. Therefore, there are no additional requirements to the DVIN-1 storehouse.

DVIN-1 detector contains a tritium target, encapsulated into a tightly sealed neutron tube. The Rospotrebnadzor certificate emphasizes that a turned off unit is of no radiation hazard and can be transported in the standard package, e.g., in a trunk of a car as per transport category I according to the requirements of SanPin 2.6.1.1281-03.

Conclusion

DVIN-1 detectors are serially produced in Dubna by OOO «Neutron technologies». Various modifications of the detector are being developed, e.g., for the operation in the field. To detect small amounts of hidden materials, a modification with higher grain of tagged beams has been developed, which enables irradiating the inspected items with 64 beams of tagged neutrons. Detailed information on the API detectors can be found on the web-site http://ntech.jinr.ru.

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