INSTRUMENTAL TECHNIQUE FOR THE DETECTION AND IDENTIFICATION OF RADIOACTIVE, FISSILE AND EXTRA HAZARDOUS SUBSTANCES

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Abstract

The threat of terrorism and organized crime activity all over the world demands the development of hazardous substances detection techniques.

The branch of atomic science and nuclear engineering – radiation technique is promising for many practical tasks of detection and identification of radioactive, fissible and extrahazardous substances.

To detect and identify them minding their physical nature and properties, it is worthwhile to employ passive and nuclear-physical techniques.

At present a number of mobile and transportable systems used to detect lost gamma radiation sources have been designed and tested. **RITPA** is among those who implemented the above approaches, that has become possible due to the development of new types of counters.

Active techniques are successfully employed for quantitative analysis of nuclear fuel in products. This technique is the base one and reliable to ensure metering and testing and the inspection by IAEA specialists.

To analyse the composition of material, **RITPA** produces portable X-ray fluorescence equipment of **RLP** type that allows us to determine toxic materials and identify materials at the site of an explosion. The device is designed in the shape of a case and has an X-ray tube with autonomous power supply. The detection threshold is 0.1 ppm.

We offer to employ method of computer tomography with diffused radiation to solve special tasks to detect and identify explosive gelatine in the condition of one-sided access.

The present state of developments features qualitative shifts in the equipment due to the use of computers, the employment of improved gauges and radiation detectors, the optimization of characteristics and power of X-ray that allows us to significantly improve accuracy, sensitivity, efficiency and to use the received data for automatic testing.

Key words: terrorism threat, hazardous substances detection, radioactive, fissile materials

Using conventional radiometers is the simplest way to detect radioactive materials. For example, a tester for detection of fissile materials by spontaneous fission neutrons enabled fissile materials to be identified in packages, backfilling and wells. This tester also proved highly efficient in detecting fissile materials on vehicles in transit.

At present, there are mobile (transportable) systems for lost gamma-ray source search, designed according to the above principle, that feature a set of detectors – gamma counters. The mutual arrangement of the sensors allows both availability of and direction to a sought-for source to be determined within the system geometry. It should be emphasized that the second component improving the instrument performance is making use of not only high-sensitivity sensors but also of those featuring a high signal-to-noise ratio. This allows a possible radiation background to be taken into account and systems to be normalized. Besides, a single circuit uses both gamma and neutron counters. . This made it possible not only to detect a source, but also to identify its type. The above approaches were implemented due to newly developed types of counters, including those designed by the Research Institute of Technical Physics and Automation (VNIITFA).

Active methods have been successfully used for quantitative analysis of nuclear fuel in products. As a matter of fact, this is a basic method for handling guarantee matters in control and accounting as well during IAEA inspections. Gamma and neutron radiation may be used as exciting radiation in active methods. The penetration distance of exciting radiation may vary between a few units to several tens of g/cm^3.

The basic reaction used to identify fissile materials is a fission reaction caused by fast and slow neutrons or gammas wit energy of about 8 MeV. The result is prompt and delayed neutrons or gamma radiation, which may be employed to identify fission materials. The time of exposure is in the order of minutes. For instance, prompt neutrons may be used in exposure in the amount of about 200 l mass U-235 from 5 to 50 g over a period from 5 to 20 sec.

Small-size sets, for example, UNV-1 designed for fissile material identification are most suitable for on-line testing purposes. UNV-1 basic components are a pulsed neutron generator (14 MeV) and cassettes with SNM-55 counters.

Use of gamma radiation for excitation is most suitable for detection of fissile materials in large containers, such as railroad cars or trucks.

It should be noted that, if combined, passive and active methods will help improve performance of the sets and enhance identification reliability.

At present, VNNITFA produces the RLP-3 portable X-ray fluorescence equipment for compositional analysis (ores, metals, salts and toxic materials). Analysis is made in a wide range of high-sensitivity element atomic numbers (including uranium). The equipment provides a rapid on-the-spot sample analysis. The tester weighs 3 kg and is designed as a briefcase, its radiator featuring an X-ray tube with a self-contained power supply system. In uranium and plutonium identification, the detection threshold is 0.1 ppm. For a sample of 10 g, the absolute value of recorded contents is 1 mcg. Using its own X-ray radiation, the tester also performs uranium and plutonium analysis.

As distinct from radiometric instruments, the X-ray fluorescence tester ensures fast detection of lower uranium contents and low-enriched uranium. It is for many years that the Russian Customs Service has taken advantage of such equipment to inspect transported products.

Fig.1. Appearance of the RLP-3 Apparatus

The required identification precision is from 3 to 10% rel. For example, the uranium detection threshold in mine water must be at the mcg/l level. The present-day classical X-ray fluorescence analysis is capable of providing detection at the mg/l level.

Use of the traditional digital gammagraphy and computer tomography methods to detect local radioactive sources, nuclear materials and exploders has become widespread nowadays.

Using bundled software, digital gammagraphy allows real-time (on-line) detection and identification, for example, of a clock-operated bomb.

Fig. 2. Introscopic Digital Watchwork Image

Fig.3. Appearance of the RIN-1Tb X-ray Introscope

Active methods have a successful record of application in qualitative analysis of nuclear fuels in products. This is actually a basic method for handling guarantee matters in control and accounting as well during IAEA inspections.

Fig. 4 and Fig. 5 illustrate the possible uses of transmission and emission methods of computer tomography to detect nuclear materials in fuel assemblies, special containers and other closed tanks.

Fig.4. Introscopic Image (Left) and Tomogram (Right) of 7-pin Assembly of a Research Reactor

a) b)

Fig.5. Introscopic Image (a), Tomogram (b) of a Steel Container with Radioactive Phosphate Glass Inside

To detect and identify plastic backfilling with one-way access to an object, it is recommended to apply the computer tomography method using scattered radiation. Making measurements while exposing the object to a narrow beam X-ray radiation and recording scattered radiation may provide information needed for tomographic imaging (reconstruction).

Fig.6. X-rayed Object Measurement Diagram

Fig.7. Reconstructed (Simulated) Roadbed (Average Density 1.2 g/cm^3) with Gravel Inclusions (2.6 g/cm^3), Pores and a Plastic Box (Backfilling 1.4 g/cm^3).

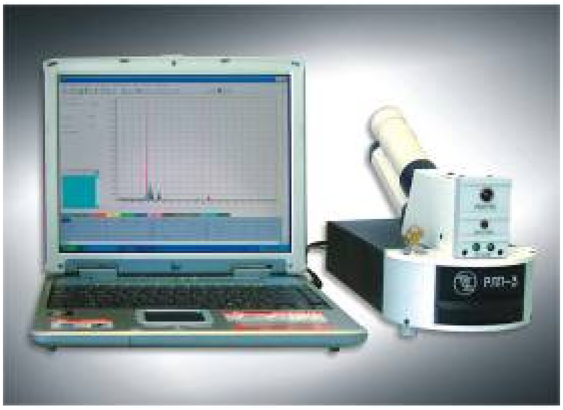
The current situation in the field is as follows: qualitative changes are being made to equipment design, involving extensive use of computer technologies, improved converters and radiation detectors, and optimization of characteristics and power of radiation sources. This allows accuracy, sensitivity and efficiency parameters of equipment to be dramatically improved and the obtained data to be used for control automation.

Conclusions:

The growing threat or terrorism and organized crime rates worldwide call for improvement on hazardous material detection methods.

One of the areas of nuclear science and technology – radiation facilities – is capable of handling many practical issues of detection, identification radioactive, fissile and especially hazardous materials.

Given their physical nature and properties, radioactive and fissile materials are best detected and identified by means of passive and active nuclear physical methods.



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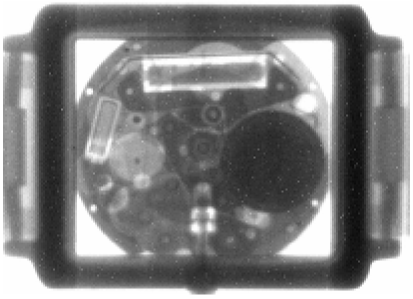

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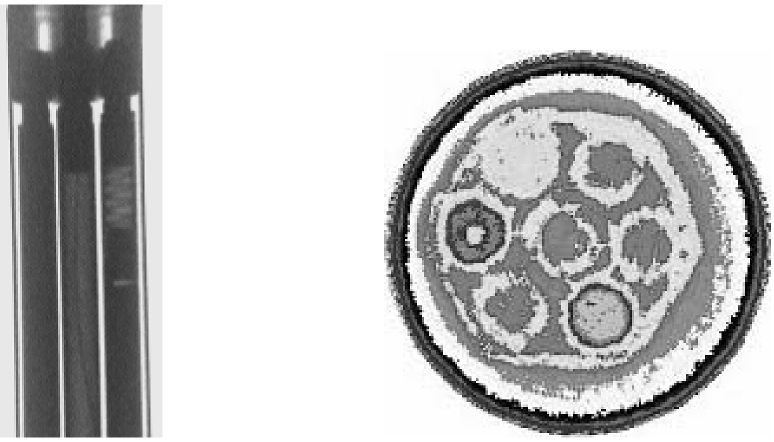

Fig.4. Introscopic Image (Left) and Tomogram (Right) of 7-pin Assembly of a Research Reactor

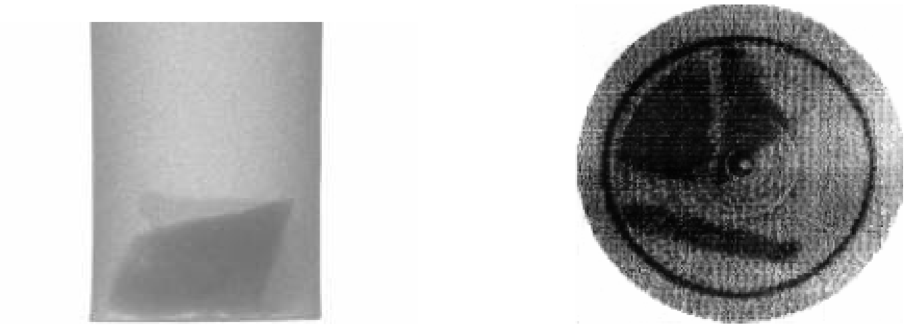

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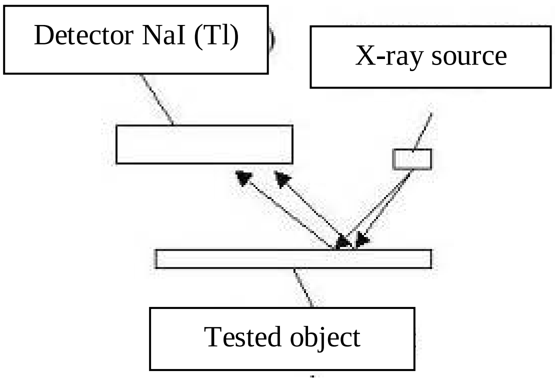
Fig.5. Introscopic Image (a), Tomogram (b) of a Steel Container with Radioactive Phosphate Glass Inside



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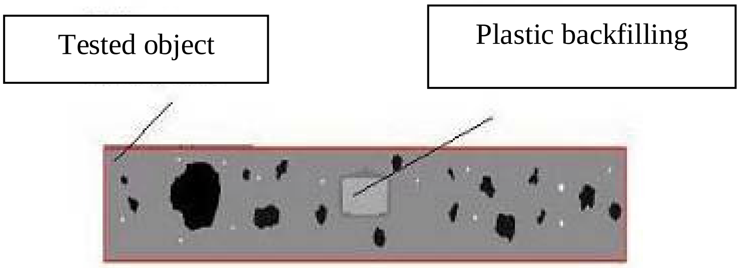

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