New Inspection Systems Based on the Registration of the Backscattered X-rays

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Abstract

X-ray systems are used in a wide range of security applications: inspection of luggage and carry-on items, inspection of vehicles, personal inspection, inspection of unattended items, industrial safety (testing of castings, honeycomb structures). To acquire an image, such systems use X-ray radioscopy method, which requires two-sided access to the inspected object, which in some cases limits the application.

The report focuses on the experience of developing of inspection systems on the basis of registration of the backscattered X-radiation, which enables image acquiring with one-way access to the object of control. A characteristic feature of the method is also a small radiation dose to the inspected object and low level of unused radiation. The systems of various design and function are considered: portable one for operational inspection of personal belongings and unattended items, stationary for personal inspection, mobile for vehicles inspection.

There are discussed the technical data of the systems, their application results, the possibility of use in the field of industrial safety.

Keywords: Radiographic testing (RT), X-ray, radioscopy, NDT, backscattering

1. Introduction

X-ray transmission systems are used in a wide range of security applications. However, in some cases, their application is limited by the fact that they require two-sided access to inspected object. There could be mentioned, for example, examination of an unattended object, that stands in a corner and is suspected to have an explosive device, or examination of parked cars in town environment. Also, transmission X-raying has limitations for personal inspection, as it gives significant radiation dose of inspected person and the image quality is reduced for people with large physical dimensions. To avoid these restrictions, scanning systems based on the registration of backscattered X-radiation can be used. They allow control with one-sided access and give small radiation dose of the inspected object (0.05 µSv and less per one scan).

“Flash electronics” company and Scientific-Research Institute of Introscopy “Spectrum”, both Moscow, Russia, have carried out a joint study of testing capabilities that method of registration of the backscattered X-radiation gives depending on the conditions of testing. Based on the results of the conducted research, it has been developed a number of systems of various design and function: a portable one for operational inspection of personal belongings and unattended items, stationary for a personal inspection, mobile for inspection of vehicles, and mastered their serial production.

2. Portable inspection system

Portable X-ray system "Phoenix" (Fig. 1) consists of a scanner that has dimensions 430×320×170 mm and weight 13.5 kg, and a laptop computer that serves to control the scanner and display the obtained image. Data transmission between the laptop computer and the scanner can be carried out either by cable 10 m length, or by means of a wireless connection from a distance of up to 100 meters. The scanner and the computer is powered by built-in autonomous power sources. Scanner is placed in a lightweight reinforced case, that
can be used both in operation (see Fig. 2) and transportation. For operator convenience, the case has wheels and telescopic handle.

Figure 1. X-ray system "Phoenix". Exterior look

Figure 2. X-ray system "Phoenix". Examination of a briefcase with one-sided access
The system can be used for screening of bags, boxes, packages, unattended items, for operative screening of vehicles to detect weapons, explosives, drugs. The system also can be used for the examination of premises (walls, furniture) to detect explosive devices and bugging devices. The resolution of X-ray image is 0.5 mm. Scanning duration is 20 seconds. Penetration ability of the system comprises:
- wood, plastic - 45 mm;
- plaster, gypsum board - 30 mm;
- steel - 1 mm.

![Image of Phoenix X-ray system](image1.png)

Figure 3. X-ray system "Phoenix". Image samples
a) traumatic gun in a bag
b) contents of a briefcase

The "Phoenix" systems are used by police forces of Russia. In particular, the "Phoenix" systems have been used during the XXII Olympic winter games in Sochi in 2014 for operative screening of different items. The systems are also used in the aircraft industry for detection of moisture in cell structures.

3. Personal inspection system

Stationary X-ray system "Rubezh" is designed to detect dangerous items, including metallic and non-metallic weapons, explosive devices, communication equipment, in clothing and on the body of inspected person. It can be used for personal inspection of visitors, staff, passengers on transport infrastructure facilities (airports, railway stations, subway stations), public facilities (concert halls, stadiums), in governmental and administrative institutions.

The "Rubezh" system (Fig. 4) consists of two inspection cabins with dimensions (width x height x depth) 1200x720x2230 mm and weight of 250 kg each, which provide simultaneous imaging of a man with two sides (see Fig. 5). Scan duration is 4 seconds.

Each of the inspection cabins has its own touch-screen display, that allows to control the system operation and watch the images obtained. If necessary, the inspection cabins can operate independently on each other. In places with limited space to installation, the inspection can be carried out using only one inspection cabin. In this case two sequential scans are required to obtain images with two sides.
Figure 4 – X-ray system "Rubezh". Exterior look

Figure 5 – X-ray system "Rubezh". Image samples
X-raying method provides high efficiency of personal screening. It allows to detect objects on the body and in clothing regardless of objects’ electrical conductivity, magnetic properties, vapors pressure, temperature gradients and other physical characteristics. It is insensitive to clothing - image quality is not reduced in the presence of a winter garment (coats) and wet clothes.

Compared with X-ray transmission systems, "Rubezh" system gives much smaller exposure dose on the inspected person: no more than 30 nSv for one scan, which corresponds to the dose received by airline passengers for 1-2 minutes of flight. Another advantage over transmission systems is that the image quality is not reduced for people with large physical dimensions. The "Rubezh" systems are used by security services of Russia to ensure security of state and government institutions. Long operating experience has shown their high efficiency.

4. Mobile system for vehicles and cargo inspection

For screening vehicles in order to detect dangerous items (weapons, explosives, drugs) and hided people as well as for cargo inspection, the mobile inspection system "MRK-1" is designed (Fig. 6).

The system provides X-ray images with a resolution of 5 to 20 mm, depending on the speed of the system (from 2 to 10 km/h, respectively). Individual exposure dose of inspected object is no more than 130 nSv per scan at a speed of 5 km/h. The same is applied to any other object located on the right of the direction of the system. Outside the working beam, the dose rate does not exceed 1 µSv/h. Low dose levels allow to use the system for operative activities in town environments.

The system can also be used at checkpoints in stationary mode for screening of vehicles passing by the system. In this case, a safety zone with size of 18x18 m is required.

Figure 6 – X-ray system "MRK-1". Exterior look

The "MRK-1" system have been used during the XXII Olympic winter games in Sochi in 2014. More than 200 vehicles of various types have been inspected: trucks, minivans, other commercial and passenger vehicles. The system showed a high efficiency in controlling their contents.
Figure 7 – X-ray system "MRK-1". Image samples