

# CUSTOMS INSPECTION SYSTEMS BASED ON LINEAR ELECTRON ACCELERATORS

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The present state of the development of customs inspection systems based on 6...10 MeV accelerators at NPK LUTS is considered. These systems are intended for the examination of vehicles and large-scale containers without their opening. The main performances of the equipment of these systems are presented, and various layout versions are discussed.

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The increasing volume of world trade and the use of large-scale containers for the transportation of goods by auto, sea and air raise a problem of fast and effective inspection of cargoes at customs points. In this connection, the customs inspection systems of high throughput intended for the examination of vehicles and large-scale containers without their opening have been developed in NPK LUTS. These systems give an opportunity to compare the actual contents of inspected containers with the cargo declared in the cargo manifest and to expose contraband goods.

Radioscopic examination of objects is performed by means of an X-ray beam, which is generated by a linear electron accelerator. Radiation penetrated through the object is registered by detector line. Special software processes data from the detector line and visualizes a high-resolution image of the inspected object on screen of the workstation in the real time mode thus allowing visual analysis of the object and zooming of suspicious objects or their separate section (Fig.1,2). The quality of images obtained allows the detection of smuggled goods and also gives an opportunity to compare the actual contents of inspected containers with the cargo declared in the cargo manifest.

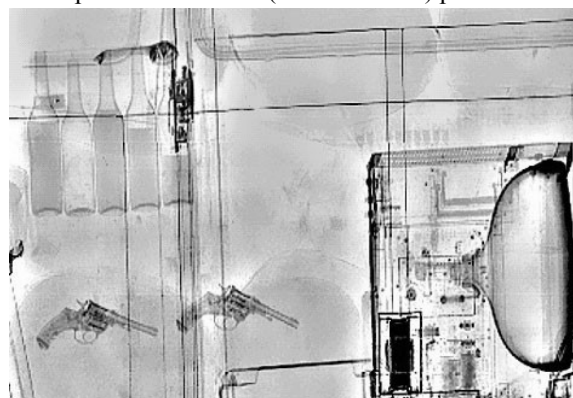


*Fig.1. Mini-bus image on the screen of inspector's workstation*

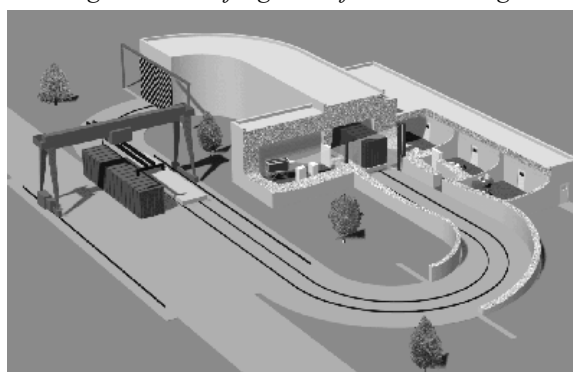
Depending on the objects inspected, customs inspection systems "EFASCAN", "EFASCAN-2", "EFASCAN-3" have been designed.

The "EFASCAN" system (Fig.3) is intended for application at customs security checkpoints at airports seaports and motor roads. The inspection takes place in a special radiation shielded hall. During the scanning, the transportation system moves an object inspected across an X-ray beam with 0.4 m/s constant speed (energy of ac-

celerated electrons is 9 MeV). The throughput of the system is up to 25 containers (2.5×2.5×12 m) per hour.



*Fig.2. Zoomed fragment of mini-bus image*



*Fig.3. General view of the "EFASCAN" system*

The basic (minimal) set of this system consists of a linear electron accelerator, an X-ray beam collimation system, a detector line, a data transfer system, a data processing and visualization system, a transportation system of the object inspected ("EFASCAN"), a transportation system of linac, detector line and X-ray beam collimation system ("EFASCAN-2"), a radiation, electrical and mechanical safety system, an automated control system, an input system of cargo shipping documents and an archiving system.

The "EFASCAN" system can be completed with the following options:

- System with two accelerators and doubled set of equipment allows obtaining X-ray images of the container inspected in horizontal and vertical projections.

- System with dual energy of accelerator provides the discrimination of groups of materials according to their average atomic number. Colored information on the material of cargo inspected and distribution of integral absorption is visualized on screen of inspector's workstation.

The "EFASCAN-2" (Fig.4) is designed for the examination of motor vehicles at roads with high cargo traffic. The irradiator of the accelerator (energy of accelerated electrons is 6 MeV) has local radiation shielding. The accelerator, detector line and X-ray beam collimation system are installed on a special transportation system ensuring their travel relative to an object under inspection.

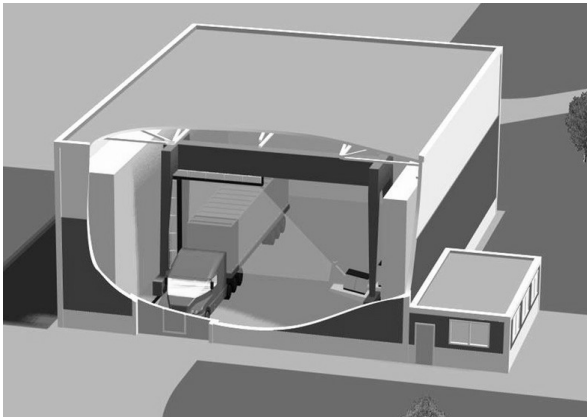


Fig.4. General view of the "EFASCAN-2" system

Notice that a small-scale accelerator with local radiation shielding designed and constructed in NIIIEFA is successfully operated on mobile customs inspection facilities HCV-MOBILE of the Smiths Heimann firm. The result of rational layout of the accelerator and block structure of radiation shielding was a highly compact machine weighing 1480 kg with dimensions: 850×200×975 mm (Fig.5). The energy of electrons can be chosen from 1.9 up to 4 MeV without changing the sizes of irradiator by varying the number of accelerating cells.

The "EFASCAN-3" (Fig.6) system is intended for the inspection of freight trains at railway stations. During the scanning the freight train moves across X-ray beam with a constant speed up to 15 km/h. Special detection system applied allows obtaining spatial resolution up to 10 mm and density resolution up to 1%. Special mound, local shields and remote control of the accelerator ensures effective and reliable protection against ionizing radiation.

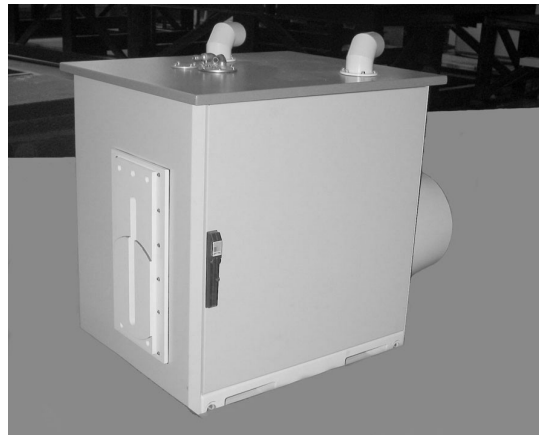


Fig.5. The irradiator with local radiation shielding

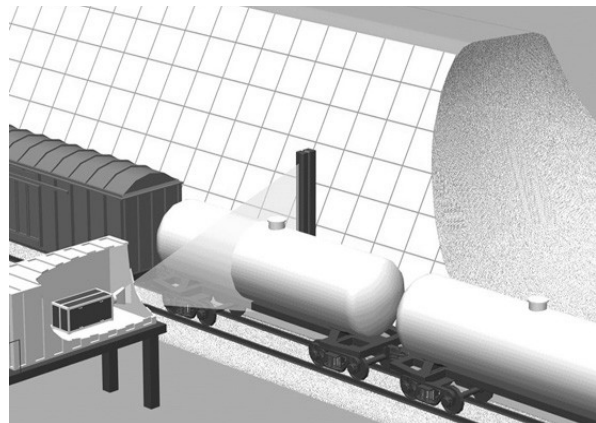


Fig.6. General view of the "EFASCAN-3" system

Major advantages of the above systems:

- Continuous round-the-clock operation of customs checkpoint resulting in its higher throughput, efficiency and quality of inspection with lower expenditures.
- Obtaining most exhaustive real-time information on object under inspection.
- High-speed data processing and high quality of images ensured by the software applied.
- Opportunity to compare the actual contents of the containers inspected with the cargo declared in cargo manifest.
- Archiving the data obtained.
- Opportunity of scrupulous analysis of suspicious objects with no reduction of the complex throughput due to several available workstations.

Tables 1, 2, 3 below show the major technical specifications of these systems and major technical specifications of linear electron accelerators used in them.

Table 1. Major Technical Specifications of "EFASCAN" and "EFASCAN-2"

Parameters	"EFASCAN"	"EFASCAN-2"
X-ray source energy, MeV	9	6
Radiation penetration depth in steel equivalent, mm	380	320
Spatial resolution, mm	3	3
Spatial resolution for high contrast objects, mm	1	1
Density resolution, %	1	1
Throughput (2.5×2.5×12 m), containers per hour	up to 25	up to 25

**Table 2. Major Technical Specifications of "EFASCAN-3"**

Radiation penetration depth, mm	
- for steel	350
- for mineral oil	3000
Spatial resolution, mm	5
Density resolution, %	1

**Table 3. Major Technical Specifications of Linear Electron Accelerator Used in Systems**

Parameters	Accelerator		
	UEL-10-D		UEL-6-D
Complex	EFASCAN	EFASCAN-3	EFASCAN-2
X-ray source energy, MeV	9	10	6
X-ray dose rate at 1 m from target, Gy·m <sup>2</sup> /min	25...40	40	15
Repetition rate, Hz	150	300	150...300
Focus spot diameter, mm	< 2	< 2	< 2

### **ИНСПЕКЦИОННО-ДОСМОТРОВЫЕ КОМПЛЕКСЫ НА БАЗЕ ЛИНЕЙНЫХ УСКОРИТЕЛЕЙ ЭЛЕКТРОНОВ**

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Рассматривается состояние разработок в НПК ЛУЦ таможенных инспекционно-досмотровых комплексов на базе ускорителей с энергией 6...10 МэВ. Комплексы предназначены для досмотра транспортных средств и крупногабаритных контейнеров без их вскрытия. Рассмотрены основные технические характеристики оборудования, входящего в состав комплексов и различные варианты их компоновки.

### **ІНСПЕКЦІЙНО-ДОСМОТРОВІ КОМПЛЕКСИ НА БАЗІ ЛІНІЙНИХ ПРИСКОРЮВАЧІВ ЕЛЕКТРОНІВ**

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Розглядається стан розробок у НПК ЛУЦ митних інспекційно-досмотрових комплексів на базі прискорювачів з енергією 6...10 МеВ. Комплекси призначені для огляду транспортних засобів і великогабаритних контейнерів без їхнього розкриття. Розглянуто основні технічні характеристики устаткування, що входить до складу комплексів і різні варіанти їхнього компонування.