

Radiation Safety of Interoscope Operators at Border Customs Control Posts

Salomova Feruza^{1,*}, Qutlimurodov Yodgorbek², Kodirov Dilmurod³

¹Professor, Tashkent State Medical University, Uzbekistan

²Assistant, Tashkent State Medical University, Uzbekistan

³Assistant, Center for the Development of Professional Qualifications of Medical Personnel, Uzbekistan

Abstract The increasing use of ionizing radiation sources in border security systems has led to growing attention toward occupational radiation safety of interoscope operators. Interoscope scanners are widely applied at customs checkpoints, airports, railway terminals, and border inspection posts for cargo and baggage screening. Although these systems significantly improve national and transport security, long-term occupational exposure to low-dose ionizing radiation may negatively affect workers' health. This study evaluates the hygienic and radiation safety conditions of interoscope operators working at selected border control points. The research included assessment of ambient dose equivalent rate, analysis of occupational exposure levels, evaluation of workplace microclimatic parameters, and comparison of obtained indicators with international and national radiation safety standards. Radiation measurements were carried out using modern dosimetric equipment including Identifinder-2, Verifier and Polimaster devices. The obtained results demonstrated that radiation dose rates in the majority of workplaces remained within permissible limits. However, increased radiation levels were detected near scanning tunnels during periods of intensive workload. The study also identified the importance of workplace ventilation, temperature regulation, and organizational control measures for reducing cumulative occupational exposure. The results of the study may serve as a scientific basis for improving occupational hygiene standards, optimizing radiation protection systems, and strengthening preventive measures for interoscope personnel [1,2].

Keywords Radiation safety, Interoscope, Occupational exposure, Ionizing radiation, Dosimetry, Border control, Radiation hygiene, Occupational health

1. Introduction

Radiation safety is one of the most important components of occupational hygiene in workplaces where ionizing radiation sources are used. In recent years, interoscope scanning systems have become widely implemented in customs services, border control points, airports, railway stations, and strategic security facilities. These systems are designed for rapid inspection of luggage, cargo, and vehicles using X-ray technologies [3].

Despite their effectiveness in ensuring public safety and preventing illegal transportation of hazardous materials, interoscope systems expose operators and technical personnel to low doses of ionizing radiation during daily work activities. Long-term chronic exposure, even at relatively low dose levels, may increase the risk of stochastic effects, including oncological diseases and genetic changes [4,5].

According to recommendations of the International Commission on Radiological Protection (ICRP), occupational exposure of category "A" workers must be continuously monitored and optimized according to the ALARA principle (As Low As Reasonably Achievable). International studies show that improper shielding, insufficient ventilation, long working shifts, and poor workplace organization may contribute to increased occupational exposure among scanner operators.

In Uzbekistan, the number of border interoscope systems has significantly increased during the modernization of customs infrastructure. Therefore, hygienic assessment of radiation conditions and evaluation of workplace factors affecting interoscope operators have become highly relevant scientific and practical tasks.

The purpose of this study was to evaluate radiation safety conditions of interoscope operators at selected border control posts and to assess occupational risk factors associated with ionizing radiation exposure [6,7,8,9].

The purpose of the study

This study evaluates the hygienic and radiation safety conditions of interoscope operators working at selected border control points. The research included assessment

* Corresponding author:

salomova@yahoo.com (Salomova Feruza)

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of ambient dose equivalent rate, analysis of occupational exposure levels, evaluation of workplace microclimatic parameters, and comparison of obtained indicators with international and national radiation safety standards.

2. Methods of Research

The study was conducted at selected border customs control posts equipped with stationary X-ray interoscope systems. Radiation-hygienic investigations were performed during 2023–2025.

The following dosimetric devices were used during the study: Identifinder-2, Verifier Radiation Detector, Polimaster Dosimeter.

Radiation dose rate measurements were carried out in the following areas: operator workplaces, scanning tunnel entrance and exit zones, cargo inspection areas, adjacent administrative rooms.

The study also included evaluation of occupational microclimatic parameters: air temperature, relative humidity, air movement velocity, workplace ventilation efficiency.

Measured indicators were compared with hygienic standards and occupational safety recommendations.

The obtained data were statistically processed using comparative and hygienic assessment methods.

3. Results and Discussions

The study demonstrated that radiation dose rates varied depending on the distance from the scanning tunnel and intensity of cargo inspection procedures.

The highest radiation indicators were recorded near the tunnel entrance and exit zones, where scattered X-ray radiation was most intensive. Nevertheless, measured values remained below occupational exposure limits (Table 1).

The operator workstations demonstrated relatively stable radiation conditions due to protective shielding and increased distance from radiation sources.

The obtained results indicate that annual occupational doses did not exceed permissible limits established for category “A” radiation workers. However, continuous occupational monitoring remains necessary because cumulative exposure may increase over long-term employment periods (Table 2).

The majority of microclimatic indicators corresponded to recommended occupational hygiene standards. However, temporary increases in room temperature were observed during periods of intensive scanner operation and insufficient ventilation (Table 3).

These findings indicate that optimization of shielding systems near tunnel zones may substantially reduce cumulative occupational doses (Figure 1).

Table 1. Radiation Dose Rate at Different Workplace Areas

№	Workplace Area	Average Dose Rate (μSv/h)	Maximum Recorded Value (μSv/h)	Hygienic Assessment
1	Operator workstation	0.18 ± 0.02	0.25	Acceptable
2	Tunnel entrance zone	0.42 ± 0.03	0.61	Increased control required
3	Tunnel exit zone	0.39 ± 0.02	0.58	Increased control required
4	Cargo inspection area	0.27 ± 0.01	0.34	Acceptable
5	Administrative room	0.11 ± 0.01	0.16	Optimal

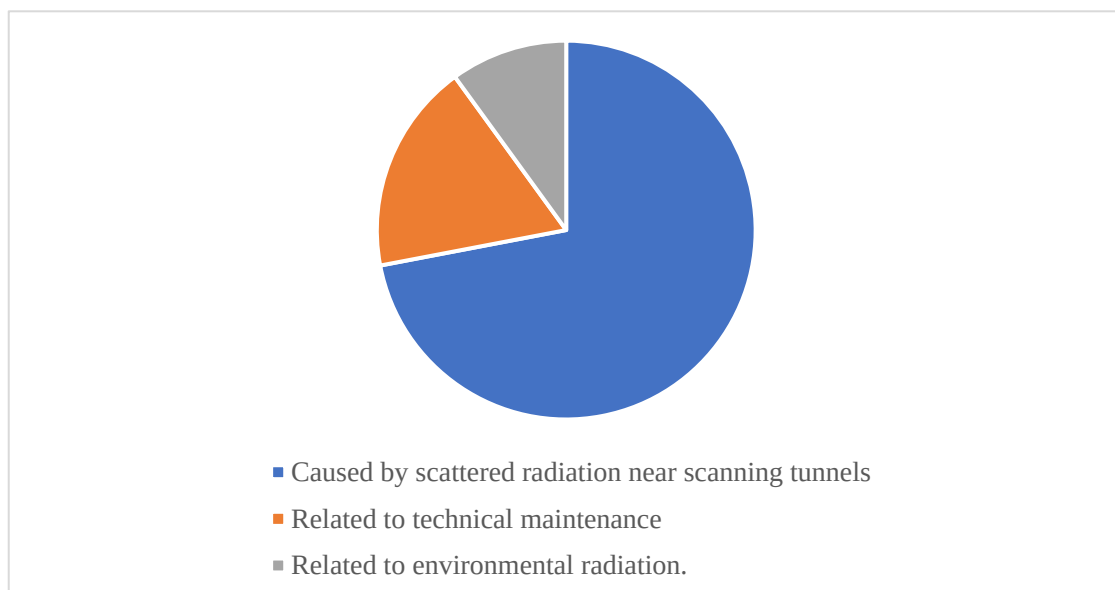


Figure 1. Structure of Occupational Exposure Sources Analysis of exposure structure demonstrated that approximately

Table 2. Based on annual workload calculations, cumulative occupational doses for interoscope operators were estimated. Estimated Annual Occupational Radiation Doses

№	Employee Category	Average Annual Dose (mSv/year)	Permissible Limit (mSv/year)	Risk Level
1	Interoscope operator	2.8 ± 0.3	20	Low
2	Technical maintenance staff	1.9 ± 0.2	20	Low
3	Security personnel	1.1 ± 0.1	20	Minimal

Table 3. Microclimatic parameters significantly influence operator performance, fatigue development, and occupational well-being. Microclimatic Indicators in Interoscope Rooms

№	Indicator	Measured Value	Recommended Range	Hygienic Evaluation
1	Air temperature	23.6 °C	20–24 °C	Optimal
2	Relative humidity	46%	40–60%	Acceptable
3	Air movement velocity	0.18 m/s	0.1–0.2 m/s	Optimal
4	Noise level	63 dB	≤65 dB	Acceptable

4. Conclusions

1. The conducted study demonstrated that radiation conditions in interoscope workplaces generally correspond to occupational safety requirements. Measured radiation dose rates and annual occupational exposure levels remained below permissible standards.
2. At the same time, the study identified workplace areas requiring strengthened radiation protection measures, particularly near scanning tunnel zones where scattered radiation levels were elevated.
3. Microclimatic conditions in interoscope rooms were mostly satisfactory; however, optimization of ventilation systems and reduction of thermal load during intensive operation are recommended.
4. The obtained results confirm the necessity of continuous dosimetric monitoring, improvement of radiation protection systems, and implementation of preventive occupational hygiene measures for interoscope personnel.

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