

Ambient dose equivalent rate in the environment of objects and materials

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Abstract— Measurement of ambient dose equivalent rate in the environment of objects and materials is a dosimetric measurement which is carried out by controlling the radioactivity of goods during import, export and transit. The procedure must be carried out in order to prevent illegal traffic of radioactive and nuclear material across the border. The dosimetric measurements of goods at one border crossing, which are carried out relying on legal regulations, are presented.

Keywords—ambient dose equivalent rate, border crossing, hand-held devices

I. INTRODUCTION

The ambient dose equivalent rate in the environment refers to the radiation dose rate present in a particular area due to natural or artificial sources of radiation. This rate can vary depending on factors such as geographical location, altitude, local geology, and human activities [1]. Measuring and monitoring the ambient dose equivalent rate is crucial for assessing radiation exposure levels in environment, especially in areas where there may be concerns about radiation safety. This information helps in implementing appropriate safety measures and regulations to protect human health and the environment from the potential harmful effects of radiation.

At border crossings, controlling the radioactivity of goods during import, export, and transit is an essential aspect of radiation safety and regulatory compliance. Dosimetric measurements play a crucial role in this process, particularly in assessing the ambient dose equivalent rate in the environment of objects and materials. These measurements involve using radiation detection instruments to quantify radiation levels emitted by objects and materials. Measurement results help ensure that goods being transported do not pose a radiation hazard to human health or the environment, and can ensure

that goods comply with radiation safety standards and regulations during their transportation across borders.

II. DOSIMETRIC TECHNIQUES

Various dosimetric techniques and instruments can be employed for controlling the radioactivity of goods during import, export and transit, including:

-Radiation detectors: These devices, such as Geiger-Mueller counters, scintillation detectors, and semiconductor detectors, are used to measure radiation levels emitted by objects and materials.

-Dosimeters: Dosimeters are personal radiation monitoring devices worn by individuals to measure their cumulative radiation exposure over time. These can also be used for assessing radiation levels in the environment.

-Spectroscopic analysis: This technique involves analyzing the energy spectrum of emitted radiation to identify specific radionuclides present in objects and materials.

Dosimetric measurements provided:

Prevent Contamination: Detecting and controlling radioactive materials in goods helps prevent the accidental spread of contamination. By identifying and mitigating potential sources of radiation, it can safeguard against incidents that could lead to widespread contamination and its associated health and environmental risks.

Ensure Compliance: By monitoring the radioactivity of goods, regulations and standards regarding the permissible levels of radiation in imported, exported, and transit items are applied. This ensures that goods meet safety requirements and do not pose a risk to public health or the environment.

Dosimetric measurements provide dose data that are important for workers involved in the handling, transport and inspection of goods. By monitoring and knowing radiation levels, appropriate safety measures can be implemented to minimize occupational exposure. Measurement of ambient dose equivalent rate in the environment of objects and materials are essential tools for managing radiation risks associated with the movement of goods across borders.

There are different devices for measuring the radioactivity of goods at border crossings:

-Hand-held devices: pocket-type instruments used to detect the presence of radioactive materials [2]; hand-held gamma and neutron, which are used to identify the location of radioactive material [3]; hand-held radionuclide identification devices (with greater sensitivity than the pocket-type instruments) are radiation detectors which can identify radionuclide based on the energy spectrum (the gamma spectrum is compared with gamma lines or reference spectrum of certain radionuclide). The radionuclides of greatest interest are nuclear, medical, industrial, and naturally occurred radioactive material (NORM) [3].

-Portal monitors: Stationary detection systems can be installed at border crossings that continuously scan goods as they pass through checkpoints (road and rail border crossings). Portal monitors are used for personnel, vehicles, packages and other cargo in a variety of venues [3].

-Detection in laboratory condition: if the presence of radioactive materials in the goods is suspected, samples can be taken and analyzed in a laboratory to confirm or rule out the presence of radioactivity. In that case, gamma spectrometric measurements are performed.

Rulebook on radioactivity control of goods during the import, export, and transit ("Official Gazette of the Republic of Serbia", no. 86/19, 90/19, 55/23) [4] regulates: type of goods that require radioactivity control during the import, export and transit, and methods and manner of radioactivity control during import, export and transit.

III. THE DOSIMETRIC MEASUREMENTS OF GOODS AT ONE BORDER CROSSING

Radiation and Environmental Protection Department, Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia is authorized legal entity for measurement of ambient dose equivalent rate, by the Serbian Radiation and Nuclear Safety and Security Directorate. This method is accredited with the Accreditation Body of Republic of Serbia under the Standard 17025/2017.

For measurement of ambient dose equivalent rate in the environment of objects and materials at border crossing digital radioactive radiation meter DMRZ-M15 are used (Figure 1), developed in 2015, in Radiation and Environmental protection Department, Vinča Institute [5-7]. Radiation meters are calibrated in Radiation and Environmental Protection Department, Vinča Institute and certified by Directorate for Measures and Precious Metals, Republic of Serbia. Due to the possibility of using different probes, it has a wide application and a large measurements range.

The results of the dosimeter measurement is expressed in Sv/h in accordance to Rulebook on active photon radiation dosimeters used in protection against ionizing radiation [8]. It is recommended that a hand-held instrument be checked, to verify its continued ability to detect radiation. Quality control is carried out using a ^{60}Co closed point source, product number 9031-OL-591/09 with activity of 732.9 kBq on 01.08.2011, produced by Czech Metrology Institute. The source was kept in the original protective lead casing and an absorber was placed over it. Absorber is a 12 high cylinder made of polystyrene, which provides that the dose rate originating from the source is not too high [9,10].



Fig.1. Digital Radioactive Radiation Meter DMRZ-M15 [7]

Before the controlling the radioactivity of goods during import, export and transit at one border crossing with monitors, the background of gamma radiation is determined prior to taking measurements of the object (hand-held detector is located one meter above the ground and not closer than five meters from the measured object from the measured object). When using handheld detectors to detect radioactive material, it is important to hold the instrument as close as possible to the surface of the measured object to increase the probability of detection. The measurements are taken at several points to ensure thorough coverage. It is also necessary to move the instrument slowly to detect radiation.

As already mentioned, Rulebook [4] regulates: type of goods that require radioactivity control during the import, export and transit. At one border crossing in the Republic of Serbia, for the two first months in 2024, 26 dosimetric measurements were performed using DMRZ-M15 for waste of aluminum, waste of copper in accordance with [4].

The background ranged from 0.049 to 0.067 $\mu\text{Sv/h}$. For waste of aluminum, ambient dose equivalent rate were in range 0.057 to 0.070 $\mu\text{Sv/h}$. For waste of copper, ambient dose equivalent rate were in range 0.065 to 0.072 $\mu\text{Sv/h}$. A dosimetric examination is carried out for goods that are imported. No radioactive sources or contamination were found.

The Rulebook [4] and Law on Radiation and Nuclear Safety and Security [11] defined the procedure for the use of stationary radiation monitors and handheld radiation detectors at border crossings, and the intervention procedure in case of

unauthorized trade in radioactive materials across the border of Serbia. These legal regulations prescribe the procedure to be followed if the authorization holder, who performs the measurements, after the dosimetric measurement of the goods, determines the increased radioactivity of the goods due to the presence radioactive source or contamination.

IV. CONCLUSION

In accordance with the legislation in the Republic of Serbia radioactivity control of goods during the import, export, and transit at border crossing must be performed. Radiation and Environmental Protection Department, Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia as authorized legal entity for measurement of ambient dose equivalent rate conducts these measurements. A digital radiation meter (DMRZ-M15) is used to measure the ambient dose equivalent rate of gamma radiation, as well as for the detection of radioactive sources and contamination. Based on the presented results of dosimetric measurement of goods (aluminum and copper waste) during import at one border crossing, no radioactive sources or contamination were found. All measurements were performed in accordance with defined procedures.

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