BEAM APPLICATIONS, DETECTORS AND DETECTING NUCLEAR RADIATIONS

CONTINUOUS CONTROL OF RADIOACTIVE EMISSIONS FROM PROTON LINAC

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On line control of atmospheric radioactive emissions is carried out by measuring the gamma-activity of radioactive gases in the special ventilation system of the proton linac with use scintillation gamma-ray detector. The distributed network detectors placed in INR territory allows carry out on line control of radiation situation near to Troitsk urban area. This monitoring system consists of the central server и gamma DKS-AT1121 dosimeters.

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INTRODUCTION

The beam of high intensity proton linac creates a secondary gamma and neutron radiation, which represent radiating danger to the personnel and the population. The main role here belongs to thermal neutron capture reaction, fast hadrons in (p, pn) and (n, 2n) reactions. The interaction of protons and the secondary radiation with the targets, structural materials, water and air leads to the formation of radioactive nuclides. In this form all radioisotopes are up to Ar-41 [1]. The radionuclides are radiation hazard to population living in the area of the linac. One of the factors of radiation hazard is a release of radioactive aerosols and air from the linac ventilation system through the special ventilation pipe in height 60 m. There are calculated the emission source contributions to the radiation safety factor of individual radionuclides and exposure pathways [2]. The characteristics of the most important radionuclides is showed in Table.

The radionuclide release rates W_i (in curies per year), annual effective dose equivalents D_i, radionuclide concentrations in the ventilation system Φ_i and at ground level φ_i

Radionuclide	W_i, Ci/yr	D_i, μSv	Φ_i, kBq·m^{-3}	φ_i, Bq·m^{-3}
^{3}H	0.4	10^{-3}	10^{-2}	$2\cdot10^{-4}$
^{7}Be	10	6	0.2	0.005
^{11}C	30300	35	583.2	11.50
^{13}N	56100	56	1079.8	16.43
^{14}O	20900	2	402.6	0.18
^{15}O	82200	15	1583.7	3.43
^{24}Na	3.4	5	0.1	0.03
^{29}Al	150	1	2.9	0.03
^{31}Si	16	3	0.3	0.01
^{38}Cl	106	8	2.0	0.05
^{41}Ar	16200	29	311.9	6.30

In accordance with the design data of the maximum radiation dose among the population due to the work of linac does not exceed 300 μSv in year. A level of surface concentration of the radionuclides is so low that control them in the surface layer is practically impossible. The radionuclide release rates can effectively lead to a dose rate of gamma radiation emitted airborne radioactive emissions in the tunnel ventilation system. A control of doses received by the public can lead to a dose rate of gamma radiation at ground level on the border of INR territory.

1. RADIOACTIVE EMISSIONS CONTROL

A control technique is based on measuring the volume activity of the radioactive gases and aerosols emitted by the special ventilation system of INR proton linac. The main factor for radiation hazard to population is a gamma and beta radioactivity of short-lived radionuclides in atmospheric radioactive emissions of the proton linac. The basic contribution to an environment radioactivity (95%) give short-lived radionuclides (^{11}C, ^{13}N, ^{14}O, ^{15}O, ^{41}Ar) from radioactive clouds. This radioactive gases are gamma emitters with energies of 0.511 to 1.5 MeV and radioactive emissions control can effectively lead to a dose rate of gamma radiation from radioactive emissions in the ventilation pipe.

Decay time determined by the rate of air flow and distance to the release of radionuclides to the accelerator complex is estimated of ≥ 5 minutes. This is allows us to ignore the radionuclides with half-lives less than 10 seconds. The method provides a measurement of volumetric activity of radioactive emissions in the ventilation pipe with use BDMG-08R scintillation gamma detector [3]. This detector can measure the dose of gamma radiation from radioactive emissions in the range (0.1…100) μSv/hour. Calculations and measurements show that the specific concentrations of gamma-nuclides and the dose rate in the ventilation pipe for the design parameters of the linac would amount to $4\cdot10^{6}$ Bq·m^{-3} and 22 μSv/hour respectively [4]. This is provides a measurement of volumetric activity of radioactive gases and aerosols in the range of (10^{2}…10^{7}) Bq·m^{-3}.

The measurement system consists of a gamma-detector and a terminal controller, connected to a computer. Software in real time allows you to define the gamma radiation intensity [5]. The system automatically performs measurements for the period of 10 seconds, displays data on the screen to the operator, summarizes and records the reading of the detector in a file on disk (Fig. 1).

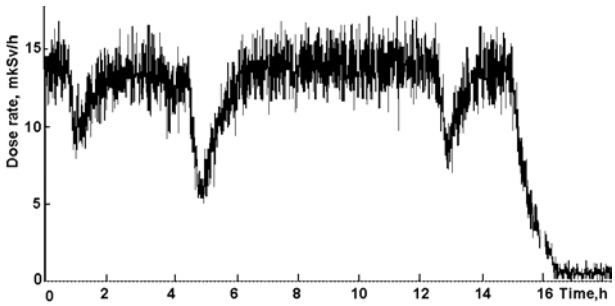

Fig. 1. The dose rate into the special ventilation system

The number of measurement pulses is converted into a dose rate.

2. RADIATION SITUATION MONITORING

For measuring a dose rate from an external gamma and beta radiation is developed the continuous radioactivity monitoring system (CRMS). This system allows to carry out in real time continuous monitoring of radiation situation in urban area (Troitsk, Moscow). At present the distributed network of CRMS detectors is placed in INR territory and on border of a sanitary-protective zone. The monitoring system consists of the monitoring server, X-ray, gamma, beta DKS-AT1121 dosimeters, which are connected to a local PC (or RS232-Ethernet converter) through data cable (Fig. 2).

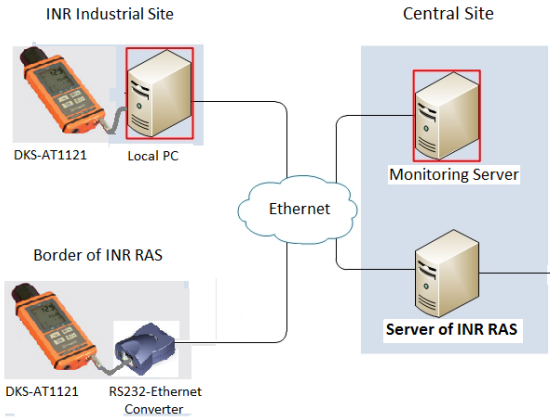

Fig. 2. The continuous radioactivity monitoring system

The DKS-AT1121 dosimeter is based on tissue equivalent scintillator and has a threshold measurement of equivalent dose of 50 nSv/hour in the range of energies from 15 keV to 10 MeV and the operating temperature of -30 to +50°C.

The local PC sends collected information to the central server using secure data protocol communication. In case of unavailability of the server all the data is stored locally and when the connection is restored the collected data will be automatically transferred. The central server has the following functional capabilities: storage and processing of data from the detectors; to display map of the detectors, the spectra and the results (the last measurements of capacity of a dose and the last results of a dose); presentation of results in a text and graphic form on a web page. CRMS software modules used to convert results of measurements to spectra and reports. The server has built-in Web-server to display the required data. Access to data gathered on the central server is possible from the local network of INR and the Internet.

CONCLUSIONS

The continuous radiation monitoring systems are designed for day and night monitoring radioactive emissions from the special ventilation system of the intense proton linac and the radiation background at INR territory, and in the sanitary protection zone.

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НЕПРЕРЫВНЫЙ КОНТРОЛЬ РАДИОАКТИВНЫХ ВЫБРОСОВ ЛИНЕЙНОГО УСКОРИТЕЛЯ ПРОТОНОВ

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В режиме реального времени осуществляется контроль атмосферных радиоактивных выбросов путем измерения гамма-активности радиоактивных газов в специальной системе вентиляции протонного ускорителя с использованием сцинтилляционного детектора гамма-излучения. Распределенная сеть датчиков, размещенных на территории ИЯИ РАН, позволяет осуществлять on-line контроль радиационной обстановки вблизи территории города Троицка. Система радиационного мониторинга состоит из центрального сервера и гамма-дозиметров ДКС-АТ1121.

БЕЗПЕРЕРВНИЙ КОНТРОЛЬ РАДІОАКТИВНИХ ВИКИДІВ ЛІНІЙНОГО ПРИСКОРЮВАЧА ПРОТОНІВ

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У режимі реального часу здійснюється контроль атмосферних радіоактивних викидів шляхом вимірювання гамма-активності радіоактивних газів у спеціальній системі вентиляції протонного прискорювача з використанням сцинтиляційного детектора гамма-випромінювання. Розподілена мережа датчиків, розміщених на території ІЯД РАН, дозволяє здійснювати on-line контроль радіаційної обстановки поблизу території міста Троїцька. Система радіаційного моніторингу складається з центрального сервера і гамма-дозиметрів ДКС-АТ1121.