CO10-1 Aerosol Size Measurement in Accelerator Rooms in the Presence of Radioactive Gas

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INTRODUCTION: Various radioactive nuclides are formed in air of accelerator rooms during machine operation. The nuclides are transported by ambient aerosols existing in the air. Therefore, measurement techniques for properties of the aerosols are very important for estimating behavior of aerosols bearing radioactive nuclides, that is, radioactive aerosols. One of useful techniques applicable to size measurement of nano-size aerosols in operating accelerator facilities is the graded screen array (GSA) method [1]. The GSA is an array of stainless steel wire screens with different screen mesh size. Sample air is passed through the GSA in the air flow direction of coarse screen to fine screen. As the diffusion process of aerosols dominantly governed the penetration of aerosol particles through screens in the size range of nm to μm, smaller aerosol particles are easily diffused and collected on coarser screen. From the activity of each screen, size distribution can be calculated by a fitting method to the theoretical curves of the penetration ratio of the aerosols. However, when the same radioactive nuclides exist in both gas and aerosol forms in the air, condensation of a part of the radioactive gas on the screens may lead to systematic errors in the size calculation of the aerosols.

In this work, a new GSA system that compensates the effects of the gas condensation was developed.

EXPERIMENTS: The conventional GSA consists of 100, 200, 300, 500, 635 mesh size screens and a PTFE backup filter. The new GSA system comprises two sets of the conventional GSA, as shown in Fig. 1. The second GSA has a PTFE filter in front of the stack of screens to remove aerosols. The radioactivity detected on the screens of the second GSA is due to condensation of the radioactive gas. Net radioactivity due to only radioactive aerosols can be obtained by subtracting the activity of the screen of the second GSA from that of the first GSA.

To examine the characteristics of the new GSA system, it was applied to the actual accelerator aerosols. The air irradiation experiment was performed in the 46-MeV electron linear accelerator in the Kyoto University Research Reactor Institute. Aerosol-free air was irradiated with bremsstrahlung of 30 MeV (max. energy). The irradiated air was sampled to measure the particle size distributions of the aerosols just after formation. A screen-type diffusion battery [2] was also employed for comparison since the diffusion battery is not affected by the coexisting radioactive gas.

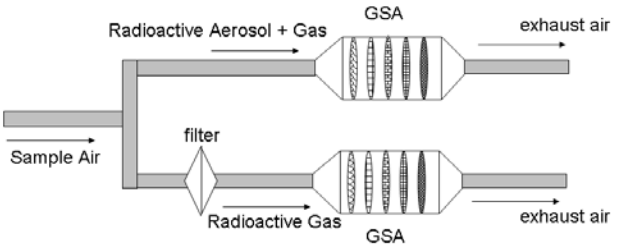

Fig. 1 New GSA System for accelerator aerosol measurement

RESULTS AND DISCUSSION: As the principal radionuclide, ^{13}N was analyzed in the irradiation experiment. Figure 2 shows preliminary results of the particle size measurement obtained with the new GSA, the conventional GSA and the diffusion battery as a function of the irradiation time of air. The systematic discrepancy of geometric mean diameter was observed between the conventional GSA and the diffusion battery. The discrepancy is due to condensation of the ^{13}N gas on the screens. In the irradiation experiment, more than 90 % of ^{13}N atoms were found to exist in the gas form. In such condition, the conventional GSA was found to be much influenced. On the other hand, the new GSA system showed fair agreement with the diffusion battery system. It indicated that the new GSA system effectively compensated the influence of the coexisting radioactive gas. The new GSA is a promising instrument for precise measurement of aerosol particle size in accelerator facility.

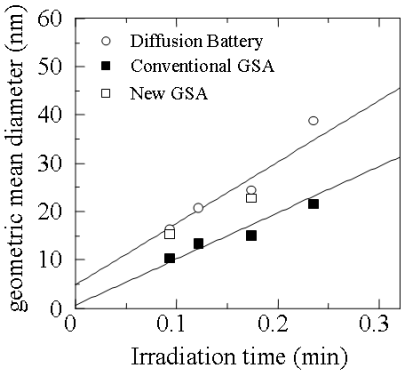

Fig. 2 The comparison of analyzed geometric mean diameter

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[2] Y. S. Cheng and H.C. Yeh, J. Aerosol Sci., **11** (1980) 313-320.

採択課題番号 20026　　放射線施設の高線量放射線場における環境測定　　共同通常
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CO10-2 Evaluation of Production and Behavior of Tritium in Facility

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INTRODUCTION: Radioactive particles are known to generate in the working field of accelerator. Then, the concentration of radioactive particles in the working field of fixed Field Alternating Gradient Accelerator (FFAG) is necessary to be measured before and after working FFAG. However, gaseous radioactive particles were difficult to be measured under working FFAG in 2008. The present work was measured alternately the concentration of gaseous radioactive particles with and without HTO contained in the exhaust gas of the neutron generator used for producing fast neutrons by the $^{3}H(d,n)^{4}He$ reaction in the KUCA facility in order to the examine the measuring system.

EXPERIMENTAL: Gaseous radioactive particles (Gas A) were provided from the exhaust gas of the neutron generator installed in the KUCA facility. The neutron generator used for producing fast neutrons by the $^{3}H(d,n)^{4}He$ reaction of which output is of the order of $10^{10}s^{-1}$ per mA beam current for a 148 GBq tritium target at A core. Gaseous radioactive particles without HTO (Gas B) were prepared by separating HTO from gaseous radioactive particles by the use of Vycor glass wall. A activity of gaseous radioactive particles was measured by using radioactive gas monitor (Ohkura Electric Co., RD-1,200) and ion chamber (Ohkura Electric Co., I-409602, 1,000cm^{3}). The output of ion chamber was digitally recorded by a detalogger (Graphtec Co., midi LOGGER GL200). Measuring gases were exchanged by four sets of three ways solenoid valve. The concentrations of Air, Gas A and Gas B were measured in Operation I, II and III, respectively.

RESULTS AND DISCUSSION: Figure 1 shows the concentrations of gaseous radioactive particles contained in the exhaust gas of the neutron generator from March 13 (Friday) to March 18 (Wednesday) in 2009. The concentration of gaseous radioactive particles in air (operation I) was appeared to increase with elapse time, and was slightly higher than that of Gases A (operation II) and B (operation III), while the concentration of gases A and B decreased slightly. The concentration of Gases A was similar to that of Gas B in this experimental period, that is, Gas A contained of negligibly little of HTO. These results suggest that an automatic measuring system used by this experimentis applicable for the evaluation of production and behavior of gaseous radioactive particles.

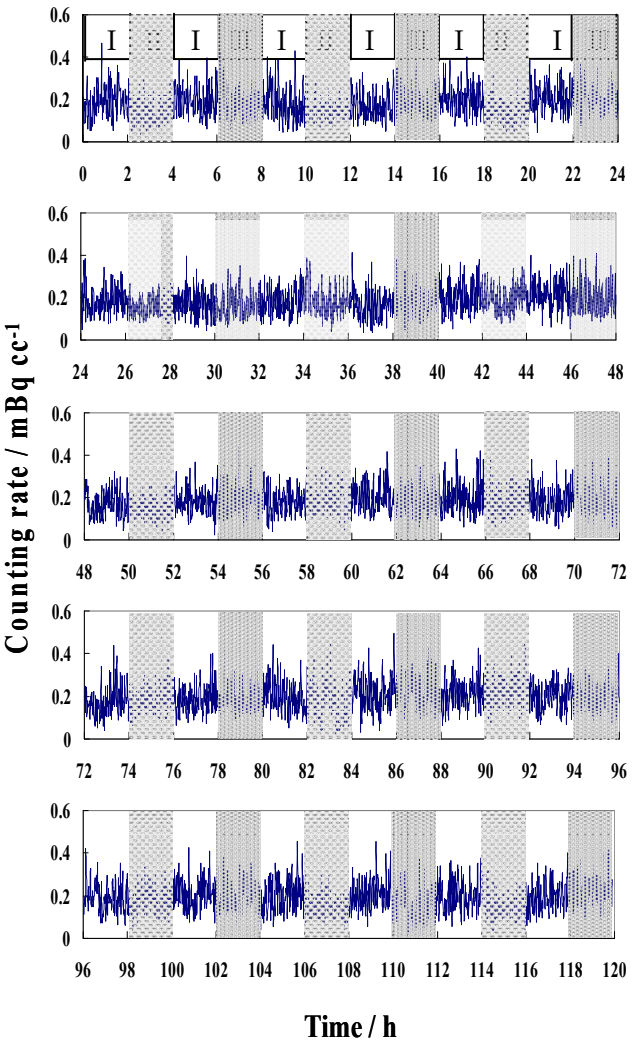

Fig. 1. The concentrations of gaseous radioactive particles contained in the exhaust gas of the neutron generator.

採択課題番号 20027 施設建家内のトリチウム生成･動態評価 共同通常
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CO10-3 Estimation of Internal Dose Distribution in Worker's Body Due to Leaking External Radiation in the Case of Critical Situation

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INTRODUCTION: Identification of internal dose distribution pattern inside the human body together with ESD (Entrance Surface Dose) under the neutron and photon mixed exposure situation is useful to evaluate the effective dose. An imaging plate (IP) is a two-dimensional detector so it may be helpful for the determination of dose distribution pattern according to PSL values. But PSL values depend on energy and type of radiation; therefore it is needed to develop methods for separating and identifying PSL due to neutron and photon doses and also to convert PSL distribution to the depth dose distribution.

EXPERIMENTS: The first step of the experiment was planned to obtain PSL distribution due to photon and neutron doses by using IPs. An IP (BAS-MS or BAS-ND) was placed between two water phantoms and exposed to neutron and photon mixed fields. Amount of exposure doses at front and back side of water phantoms were measured by using neutron and photon personal dosimeters. (Fig. 1)

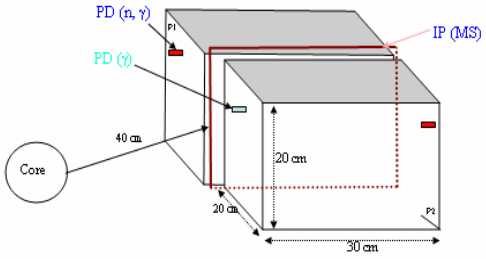

Fig 1: Experimental setup of Experiment No.1

The second experiment was planned to identify the gamma and neutron dose distribution with different depths of water phantom. TLDs (UD-136N and UD-137N) to be taped inside a plastic bag fulfilled with water were placed between two water phantoms and exposed to neutron and photon mixed fields. The experiment was repeated in 2 cases of the different radiation fields of gamma and neutron contribution. In the first case, the large part of reflector (polyethylene) of reactor was removed but in the second case, only the small part of reflector of reactor was removed. An amount of exposure dose in the front and back of water phantoms was measured by using neutron and photon personal dosimeters, too. (Fig. 2)

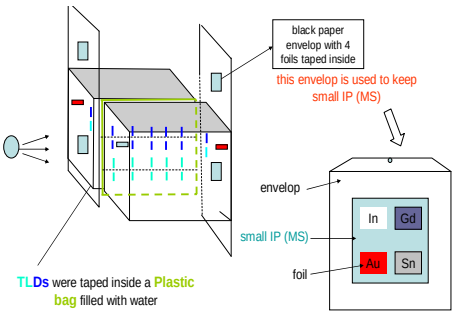

Fig 2: Experimental setup of Experiment No.2

RESULTS: BAS-MS is not directly sensitive to neutron, but BAS-ND is sensitive to both neutron and photon. Therefore, obtained PSLs from BAS-MS are mainly due to photon but those from BAS-ND are due to both neutron and photon. However, in fact PSLs from BAS-ND are smaller than those from BAS-MS. It means that response of BAS-ND to photon is so smaller than that of BAS-MS and it is essential to calibrate both BAS-ND and BAS-MS with the same photon doses.

The amount of exposure dose inside the water phantoms was measured by using UD-136N and UD-137N TLDs. UD-137N is not directly sensitive to neutron, but UD-136N is sensitive to both neutron and photon. Therefore, obtained readings from UD-137N are mainly due to photon but obtained readings from UD-136N are due to both neutron and photon. But UD-136N is more sensitive to photon than neutron so neutron doses are determined by subtracting readings of UD-137N from those of UD-136N then to be multiplied with the correction factor.

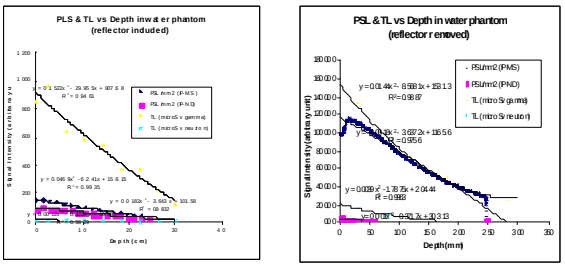

Fig 3: Relationship between radiation dose and PSL

Corrected PSL values from BAS-ND and BAS-MS and radiation doses are shown in Fig.3. The dependences of PSLs and radiation dose (neutron and photon) on water depth have the same trend so we may use PSL values to estimate the internal dose distribution in water phantom. However, the further study on sensitivity of BAS-ND with various energy of photon should be carried out to evaluate the internal dose distribution in worker's body.

採択課題番号 CA20102　臨界時洩漏放射線による作業者の外部被ばくに関する体内線量分布の評価　　共同通常

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