Performance of radon/aerosol chamber at NIRS, Japan

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abstract. A chamber, which provides a well-controlled radon/aerosol environment, is essentially important for all radon studies such as characterization, measurements, simulation modeling, etc. In 2002, a new walk-in type radon/aerosol chamber of 25 m^3 was constructed at the NIRS (National Institute of Radiological Sciences) in Japan. It is controlled for temperature, humidity and aerosols in addition to radon concentration. Radon source is a Ra-226 ceramic calcined about 400 degrees and the concentration is monitored continuously with a scintillation cell type radon monitor or periodically with an ionization chamber. Solid and/or liquid aerosols are generated by vaporization-condensation method. The aerosol concentration is monitored continuously with a condensation nucleus counter. The number size distribution is measured with a screen-type diffusion battery, an electrical mobility sizer, a cascade impactor, etc. An emanation from the ceramic radon source was a stable for long-term and the emanation rate was very high. The radon concentration in the chamber is maintained ranging from 100 Bq/m^3 to 20,000 Bq/m^3. A level of the background aerosols was below 100 particles/cm^3, and the number concentration was automatically controlled up to 50,000 #/cm^3. In a size distribution measurement of radon decay products aerosol, a typical bi-modal size distribution was observed with NIRS's graded screen array. The peak size of unattached fraction was found to be around 1 nm, and the other peak of attached fraction was located between the number-weighted mean size and the surface-weighted one. Many experimental studies including such measurements have been conducted by using the chamber. And also a preliminary inter-comparison excise was conducted with the participants from over 10 laboratories and universities in Japan. These results will be reported in near future.

1. Introduction

Up to now, radon reference chamber had not been available in Japan. So our radon detectors and radon measuring instruments have been checked and/or calibrated by using the reference chambers at the NRPB (National Radiological Protection Board) in UK and the EML (Environmental Measurement Laboratory) in USA. In 2002, a walk-in type radon/aerosol chamber of 25 m^3 was constructed at the NIRS (National Institute of Radiological Science) for radon research and radon reference. The feature is to make a well-defined radon and aerosol environment. Aerosol is a very important and key parameter to clear the properties and behaviors of radon decay products. The basic feature of the chamber was described in our previous report [1]. Here we introduce our radon/aerosol chamber and show the performance in the advanced study.

2. Radon source and flow system

Solid sources of radium-226 were developed as radon gas source [2]. The source was made with porous ceramic for high stability of radon emanation for long-term. The activity of radium contained in source disc was ranged from 1.85 kBq to 18.5 MBq. The sources over 100 discs were prepared. For example, one source disc of 6.2 MBq-radium can continuously make a radon concentration of 1,000 Bq/m^3 in the radon/aerosol chamber of 25 m^3 at a ventilation rate of 5 times per hour. In order to prevent a leakage of radon from inside of the chamber to outside, the air pressure in chamber is maintained slightly less than atmosphere. The exhausted air from the chamber is treated with high efficiency air filter for radon decay products and physical adsorption column using activated charcoal for radon gas. The radon concentration and its EEC (equilibrium equivalent concentration) in the exhausted air are monitored with two radon monitors. The Japanese legal limit is 20 Bq/m^3 as an average EEC for 3 months.

3. Radon and carrier aerosol monitoring

Radon concentration in the chamber is continuously monitored with Lucas cell type scintillation counter. And the concentration is periodically checked by simultaneous measurement with an ionization chamber, which reliability has been checked with other laboratories. Figure 1 shows the radon concentration measured the scintillation counter for every 10 min interval. Temperature, relative humidity and pressure difference between the inside of chamber and the outside are also shown.
In order to input carrier aerosols, two generators are equipped with the chamber. Solid and/or liquid aerosols are generated by vaporization-condensation method. The aerosol size and concentration are monitored with a scanning type mobility particle sizer (SMPS) and/or a screen type diffusion battery (SDB). The size of carrier aerosols is controlled in a range from 50 nm to 1,000 nm in diameter. The maximum number concentration in the chamber is about 50,000 particles/cm^3.

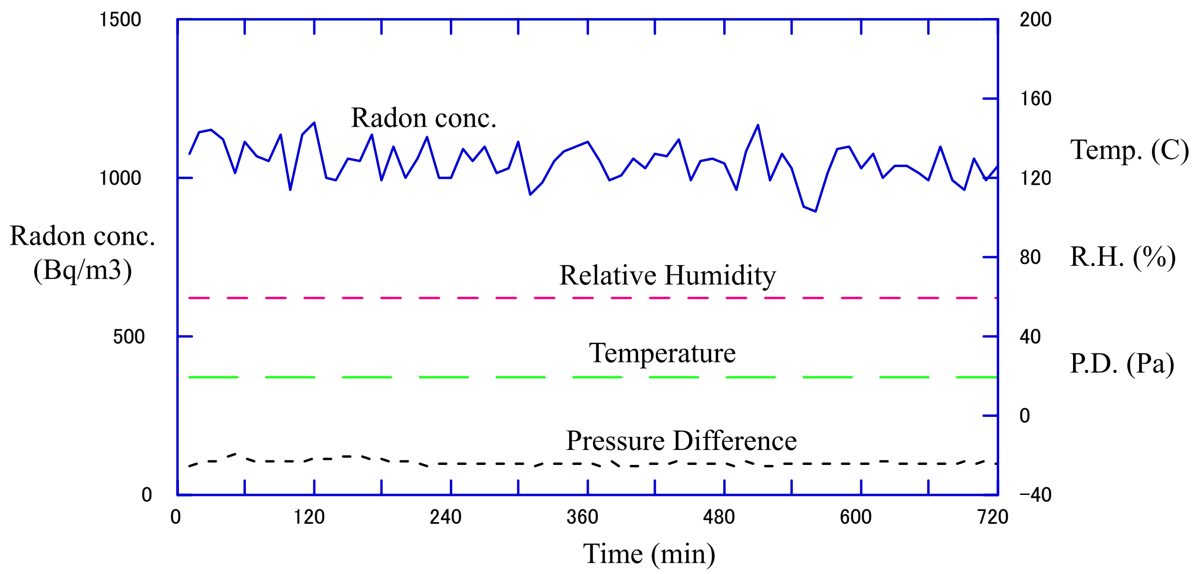

FIG. 1. Stability of radon concentration, temperature, relative humidity and pressure drop in a radon/aerosol chamber

4. Measuring of radon decay products

Characterization of radon decay products is carried out on request. The sampling is made through sampling port installed on the chamber wall. There are two sizes in the port diameter, and sampling device such as 47 mm filter holder can be placed apart from the inner wall. The concentration of radon decay products is measured with grab sampling method and/or continuous radon progeny monitor. The size distribution of radon decay products is measured by using a cascade impactor and/or a graded screen array (GSA). The activities of samples classified to each size are evaluated by gross alpha counting method and/or alpha spectrometry. The typical bi-modal size distribution determined by our original GSA [3] is shown in Fig. 2. The distributions of unattached fraction and attached fraction were discriminatively measured. The peak of unattached fraction was found to be around 1 nm and the distribution was very sharp and narrow. On the other hand, the size distribution of attached fraction depended on the injected carrier aerosols. In this case, the peak size is approximately 200 nm, which was consistent with the result estimated from the SDB measurement.

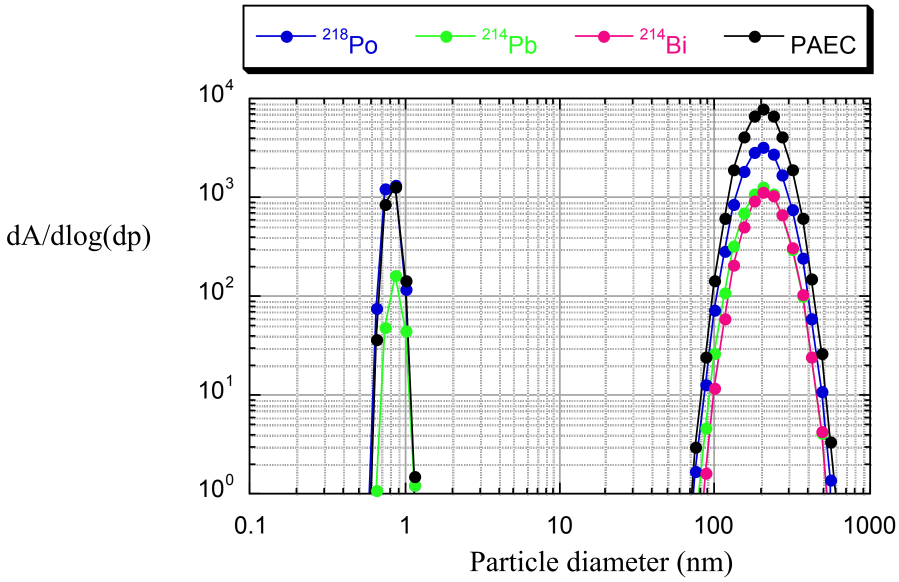

FIG. 2. Typical size distribution of radon decay products measured with the GSA

5. Conclusions

A radon/aerosol chamber was established at the NIRS in Japan. Many experimental studies have been conducted by using the chamber. And also a preliminary inter-comparison excises, as shown in Fig. 3, was conducted with the participants from over 10 laboratories and universities in Japan. These results will be reported in near future.

FIG. 3. Inside view of the radon/aerosol chamber at the 1st inter-comparison experiment at the NIRS

REFERENCES

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