§6. Performance Evaluation of High-Sensitivity Tritium Gas Monitoring System Developed by Employing Two-Parameter Spectrometer (Effect of Rise Time Analysis)

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For the purpose of developing a high-sensitivity tritium gas monitoring system, we employed ingenious techniques including a two-parameter-pulse height analyzer (two-para spectrometer). Two parameters are a pulse height and a rise time of signal arose from radiation detected by a proportional gas counter (PG counter), where the PG counter arise pulse signals corresponding to incident radiation energy. After several-year study, a tritium gas monitoring system was manufactured by ourselves as shown in Fig.1. This prototype system composed of three parts, a gas supply unit, a tritium detector, and a two-para spectrometer.

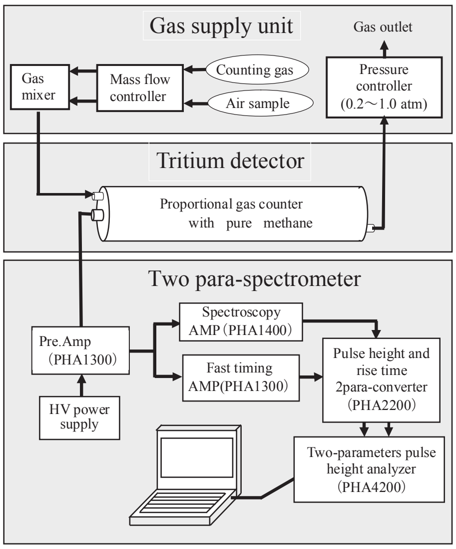

Fig.1 Schematic of the tritium gas monitoring system with a two-para spectrometer.

In the gas supply unit, a proper amount of air sample is mixed in counting gas and the tritium concentration contained in the air sample is measured using the mixture of counting gas and air sample as counting gas of the counter. The pressure of the mixture gas inside the PG counter is reduced below one atmospheric pressure (atm) by a pressure controller to effectively eliminate the adverse influence of air in the counting gas on peaks in spectra.

The tritium detector is a cylinder shaped PG counter that was manufactured of stainless steel with 400 mm in length and 60 mm in inside diameter. An active volume is approximately 1000 cm^3. A gold-coated tungsten wire with 0.02 mm in diameter is stretched along the centerline of the cylinder of the counter. Pure methane is used as counting gas.

In the two-para spectrometer, it was supposed that the pulse height was very low and rise time was very fast because the energy of beta-rays emitted from tritium were very low and electron-ion pairs were ionized in a narrow space, being quickly collected by an anode of the detector and causing pulses with very fast raise time. Using the features of low pulse height and fast rise-time, true tritium signals could be discriminated from all other noise signals due to incident gamma rays from external sources such as cosmic radiation.

To evaluate the performance of our own developed system, two-para spectra were measured using pure methane counting gas with and without an enclosed ^{55}Fe-radiation source. The ^{55}Fe-radiation source was used because energy of X-rays was almost the same to the average energy (5.7KeV) of beta-rays emitted from tritium. Typical two-para spectra are shown in Fig. 2 (A) and (B). (A) is a background spectrum with 1000 sec measurement, and (B) is that of the ^{55}Fe source with 200 sec measurement. In (A) and (B), X and Y axes are energy and rise time

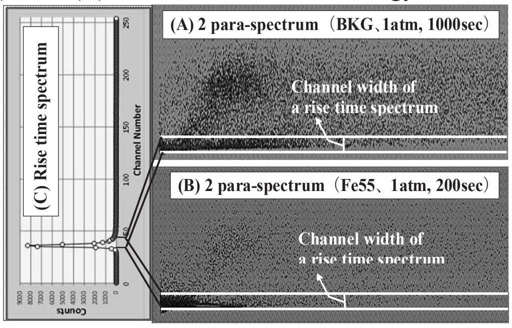

Fig.2 Typical 2-para and rise-time spectra measured by a 2-Para spectrometer.

channels, and grayscale intensity reflect radiation counts in respective X and Y channels. (C) is a projection image of (B) called a rise time spectrum and a peak is found at lower channel regions, which attributes to X-rays emitted from the ^{55}Fe source. (C) is used to determine the peak channel region. The rectangular parts surrounded in a white line in (A) and (B) are corresponding to the peak channel region in two-para spectra.

In this study, to quantitatively evaluate the effectiveness of rise time spectra employed for improving the system, S/N ratios and detection limits were calculated using total

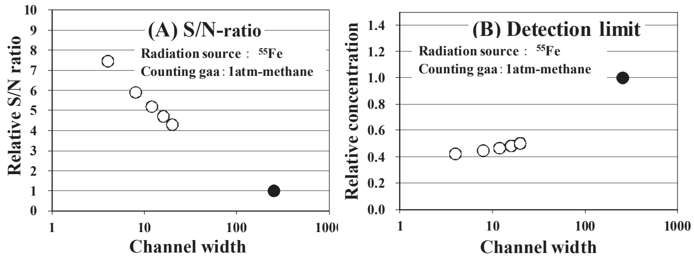

Fig.3. Dependence of S/N ratio and detection limit on channel width in rise

counts in both the rectangular parts surrounded in a white line. The results are shown in Fig.3. In Figs.3 (A) and (B), X axes are channel width centered around the peak position in Fig.2 (C), and Y axes are relative values of S/N ratios and detection limits. Where black circles in Figs.3(A) and (B) are the unity, meaning the relative values of S/N ratios and detection limits without employing rise time spectra.

It is found that the relative S/N ratios changed from 7.5 to 4.3 as channel width increases from 4 to 20. And relative detection limits changed from 0.42 to 0.5. It was concluded that, assuming channel width is 8, S/N ratios and detection limits will be improved by about 6 times larger and by 50 % smaller, respectively.