RELATIVE CALIBRATION OF ^{241}Am FIRE ALARM SOURCE

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ABSTRACT

According to the requirements of improving production of ^{241}Am source used for smoke-sensitice fire alarm making, a method and equipment of its fast relative calibration have been developed. Six measuring equipments have being successfully applied at production lines of ^{241}Am fire alarm source and factories of automatic smoke-sensitive fire alarm making.

Keywords: ^{241}Am fire alarm source α particle emission rate Relative calibration

1 INTRODUCTION

^{241}Am fire alarm source is made by powder metallurgy technology. Radioactive ^{241}Am is saadwiched between gold (or gold-palladium alloy) layer (the upper one) and silver-layer the thickness of the gold layers is only a few μm. The α emission rate on the surface of the source is mostly in a range of 0.7×10^4 to 2.5×10^4 particle number per second, 2π.

^{241}Am fire alarm source is applied in the detector of smoke-sensitive automic fire alarm. The detector has a measuring ionization chamber and compensation one in it, and two ^{241}Am sources which are required that the 2 particles emission rate emitted from them have definite pairing proportion are fixed in each one. Smoke can get into the measuring ionization chamber easily, but hardly get into the compensation one, the air which is in the test measuring ionization chambers is ionized by the α rays, cations and anions are formed. When fire is going to happen, the smoke get into the measuring ionization chamber causing the ionization electricity to decrease and alarm signal is given off when this change is increased to a certain value. It will affect the reliability of alarm if the error caused in measurement of α emission rate is too big. Therefore, this quality index of ^{241}Am fire alarm source is checked rigorously.

2 RADIOACTIVE SOURCE, DETERMINATION METHOD AND EQUIPMENT

2.1 Radioactive source

^{241}Am fire alarm source is made by powder metallurgy method. The schematic diagram of the source is shown in Fig.1. There is a gold (or gold and palladium alloy) layer on the upper surface of ^{241}Am source flake. The α energy is between 2.5 MeV to 4.5 MeV generally[1], and the α spectra of this kind of sources are different each other. In order to compare the spectra, an ^{241}Am reference source made by electroplating method was measured with silicon barrier semiconductor detector, and an ^{241}Am fire alarm source was measured at the same conditions. The spectra are shown in Fig.2. The radioactive ^{241}Am in the source belt is not well-distributed. The count rate of this kind of radioactive sources is between 0.7×10^4 and 2.5×10^4 cps generally. Hundreds even thousands of the sources must be measured everyday.

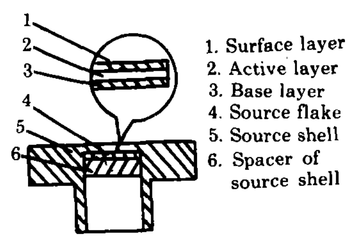

Fig.1 Schematic diagram of ^{241}Am fire source

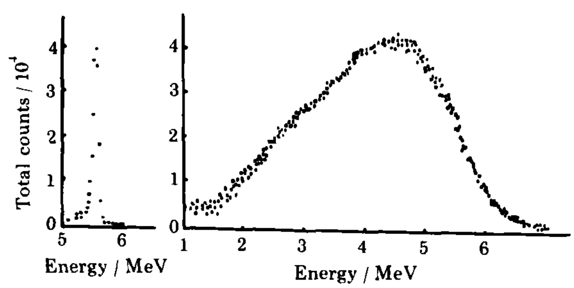

Fig.2 The α spectra of reference source (a) and fire alarm source (b)

2.2 Calibration method and equipment

The distance between the source to be measured and the detector must be close possibly in order to reduce the counting loss of α particles with small energy. The sources are only measured in whole area considering that ^{241}Am in the source flake is not well-distributed. It is the better way to measure the α emission rate of the source in α relative determination method.

The quality of ^{241}Am fire alarm sources would be affected seriously if we did not do dead time correction. For example, the pairing proportion of α particle emission rates of the two ^{241}Am fire alarm sources is 1:1.7 required in a factory. Assuming that the dead time of the measuring equipment is 4 μs, it is not difficult to calculate with formula

$$n = m / (1 - m\tau) \tag{1}$$

where n is true count rate, m is measuring value of count rate, τ is dead time and find that the pairing proportion of α particle emission rates of the sources will deviate 0.04 to 0.08 in the count rate range of 0.7×10^4 to 2.5×10^4 cps. It would cause lots of troubles that hundreds even thousands of sources must be measured and corrected in a day.

A new type of relative calibration equipment had been developed in 1989 for determination of emission rate of ^{241}Am fire alarm source according to the requirement of the production line. The detector of the new measuring equipment is silicon barrier semiconductor having thin window, low noise and high-efficiency. The main character of this measuring equipment is using a fast preamplifier and fast main amplifier which were specially developed for this measuring purpose. The equipment was fitted with an automatic turning plate for location of radioactive sources. Ten radioactive sources can be put on the plate each time. The turning plate and the scaler synchronize perfectly.

3 MAIN FUNCTIONS

3.1 Output pulse of the main amplifier

The output pulses of main amplifier were measured by a oscilloscope model COS5041 with a 200 V voltage applied, and pulse-forming time constant of main amplifier was 0.2 μs. The output pulse figure of the main amplifier is shown in Fig.3. It can be seen from Fig.3 that the bottom width of a pulse is less than 1 μs.

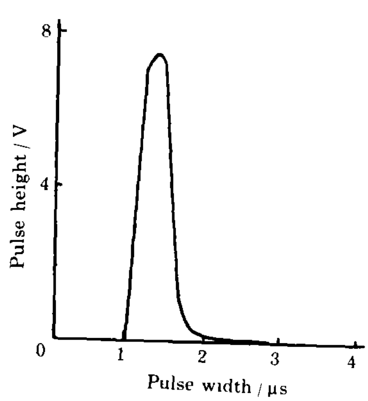

Fig.3 Output pulse figure of the main amplifier

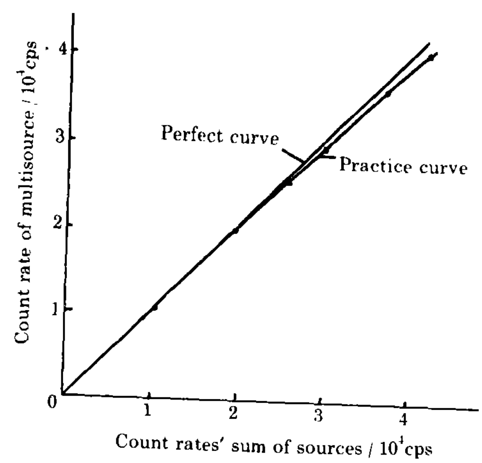

Fig.4 The curve of determination of pile−up and loss pulses

3.2 Dead time of the equipment

The dead time of the equipment was measured with double sources method. The radioactive sources used were two ^{241}Am source flakes ——semicircles with radia of 2 mm. The counting rate of each source flake was about 2×10^4 cps. The two source flakes were sticked on a disk having a diameter of 20 mm. They are located just like a circle with a central small slit. Then, the disk was put right under the detector of measuring equipment, the two source flakes can be divided to detect with the covering method. The dead time of the measuring equipment can be calculated with the formula

$$\tau = (\triangle - n_b) / (2 \times n_1 \times n_2) \tag{2}$$

where τ is dead time, n_b is counting rate of background, n_1 is measuring counting rate of the source flake number 1, n_2 is measuring counting rate of the source flake number 2, n_{12} is measuring counting rate of the two source flakes, $\triangle = n_1 + n_2 - n_{12}$

The measuring result shows that the dead time of measuring equipment is about 0.93 μs. The background can be neglected during the determination.

3.3 Determination of pile—up and loss pulses

The determination of pile-up and loss pulses was done by multi-source method on the equipment. The measuring method was that a few source flakes with $< 4 \times 10^3$ cps were sticked on a disk, certain slits were remained between them, the disk was placed under the detector, the source flakes which were not used could be covered during the measuring. The data of determination of pile-up and loss pulses are shown in Fig.4.

3.4 Determination of pairing proportion of ^{241}Am fire alarm sources

The ^{241}Am fire alarm sources have been measured with a multiwire proportional counter as an absolute determination method. Then, 6 pair sources from them were chosen for 1:1.7 pairing proportion determination. Afterwards, the 6 pair sources have been counted again on the new equipment to compare the measurement results. The comparison showed that difference between the results from the two methods were less than 0.02. The highest counting rate in this batch of sources was 2.5×10^4 cps, and the measuring results from the new equipment did not correct in dead time.

4 CONCLUSION

It had not needed to do dead time correction to the measurement data of each source when the α particle emission rate of ^{241}Am fire alarm source is determined since the method and the equipment have been applied at the production line of ^{241}Am fire alarm source, and the product factory of automatic fire alarm by particle sense smoke as the dead time of the equipment is less. The measuring speed have been quickened, and the product quality have been improved obviously.

Since 1989, 6 new equipments have been well used at the production line of ^{241}Am fire alarm source and factories of automatic smoke-sensitive fire alarm making. The long-term stability of the equipments gave and gives the factories much extra profits.

REFERENCE

1 Cheng Jintai, Cong Huiling, Yao Chuenbing. Journal of Isotopes (in Chinese). 1988; 1(2):7