A POSSIBILITY OF IMPROVING THE ROUTINE MEASUREMENTS OF ARTIFICIAL BETA ACTIVITY IN THE AIR

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Abstract

Routine measurements of gross beta activity are discussed. It is shown that if the aerosol beta activity is measured with two different absorbers, considerably more information is achieved, e.g. the age of fission products can be estimated from relatively small samples.

Regular reports concerning daily gross-β-activity in the air are available from many countries. These reported values are achieved either by measuring with a G-M-tube directly from the filter or by first ashing the filter and then measuring with a thin window counter. In the first case G-M-tubes with windowthicknesses varying between some 0.9 and 35 mg/cm² are used. Often the measuring arrangement is standardized against K^{40} or an »average» fission product energy. If, however, the total absorbing mass is of the order of 10 mg/cm² or more, high systematical errors depending on the age and composition of the fall-out will arise. The ashing method usually gives more comparable results, but is more laborious and also with this method systematical errors easily appear and only very careful work can avoid occasional errors.

A considerable part of these routine β-measurements are made for the purpose of controlling biologically dangerous isotopes. The average

energy of the longlived β-components in fission products is relatively high. Thus the window (wall) thickness of the counter is not critical.

As the aerosol β-activity reports, however, have appeared to be valuable *e.g.* in meteorological synoptic studies, in air pollution problems, as indicators of relative subsidence rates etc., systematical differences of 15% or even less between observation sites have been found to be of interest. This especially as the number of determinations of special isotopes are far from sufficient in this connection.

The following method has been found convenient as a simple way to get comparable results from the air filter measurements and in addition some extra information that is usually connected with more laborious measurements has been obtained.

The hard component of the β-activity is first measured with a counter that has a window (wall) thickness of some $30-50$ mg/cm². This system has to be standardized against at least K^{40} and Cl^{36} by measuring filters prepared with standard solutions.

The unknown filters as well as the standard K^{40} and Cl^{36} filters are then measured directly from the surface with a thin window counter. This counter does not necessarily have to cover the whole filter area. On the contrary, more information can be achieved by measuring several spots on the same filter. The error due to absorption in the filter must now be corrected by measuring the filter with the exposed side to the counter (A_1), with the unexposed side to the counter (A_2) and with a clean filter between the exposed side and the counter (A_3). A good value for A_0 gives now

$$A_0 = A_1 \sqrt{A_2/A_3}$$

Each filter is now characterized by a β-energy index *i.e.* the ratio between the count rate from the thick-window counter to that from the thin-window one. This ratio is high if hard betas are dominating and can be zero if only soft betas are present (assuming that the effect of γ-activity is subtracted).

This energy index together with the usually very convenient measurement with thick window counters, gives a good value for the total β-activity on the filter. In addition it gives as will be shown some extra information.

Fig. 1 shows these indexes for aerosol samples from Maarianhamina, Jyväskylä and Ivalo measured on the 3rd day after the end of the sampling period. The hard β-component has been measured with a large
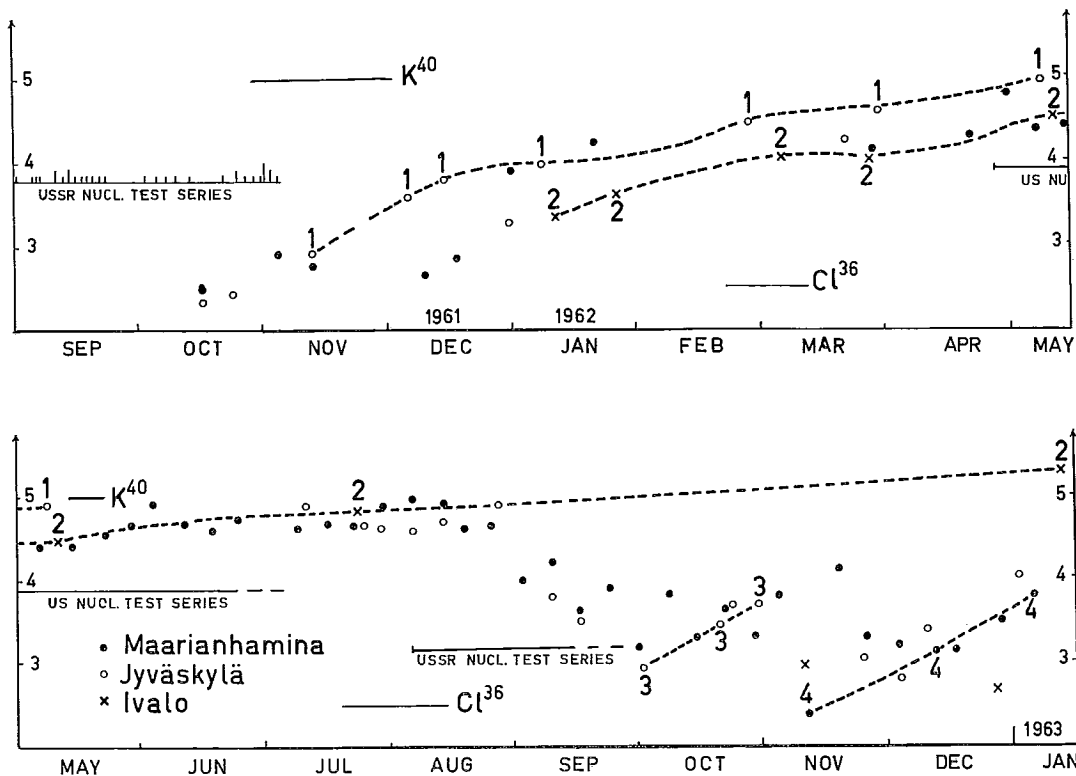
Fig. 1. Variation of the ratio of beta activity measured with a thin and a thick window counter on aerosol samples from three observation stations in Finland.

diameter cylindrical β-counter (BZ-45 Laboratorium Prof. Dr. Berthold, Wildbad) and the soft component from 6 different areas of the filter using approx. 2.4 mg/cm² end window counters (TGC-1 Tracerlab Inc.). Some of the samples have been measured several times in order to get reference curves. A γ-spectrum has been taken from a rich sample, numbered 4 in Fig. 1, on the 19th of November 1962 for the sake of comparison (Fig. 2). The energy index for K^{40} has been set to 5.0. For Cl^{36} the same index in this system became 2.5. The indexes have generally been found to be logical *i.e.* they have been the same for all the stations within the same air mass and have been changing in time along the empirically achieved reference curves. Exceptions make samples in which a considerable part of the activity is carried by one or a few »hot» particles which often differ in composition from the average long
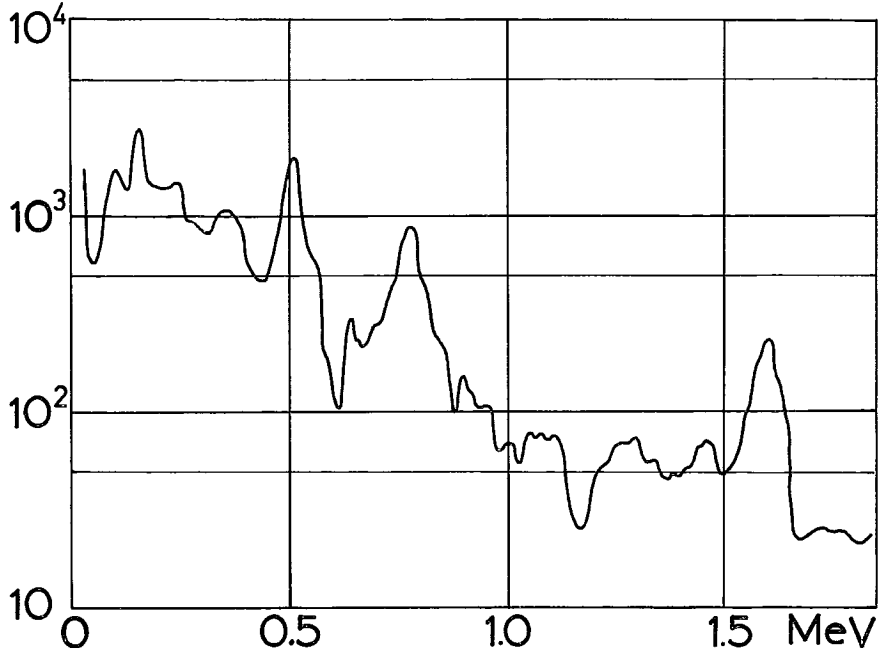
Fig. 2. A gamma spectrum taken from the sample marked No. 4 in Fig. 1. measured
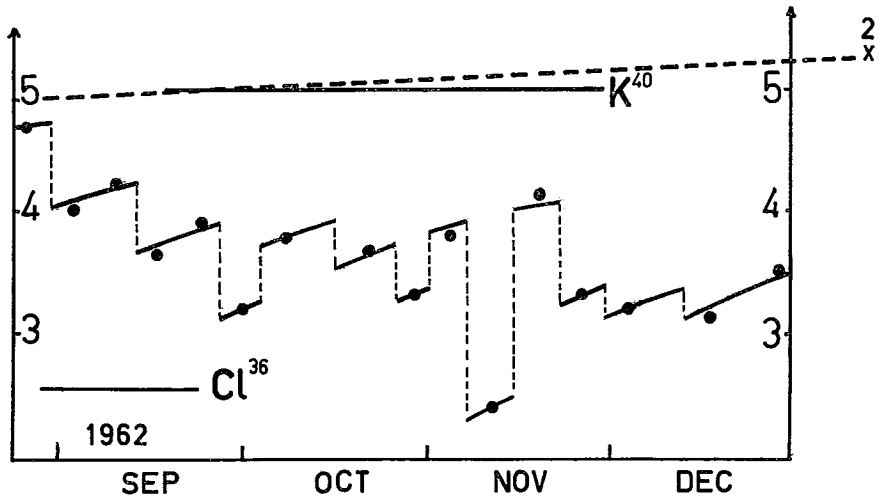on the 19th of November 1962.

Fig. 3. Energy indexes of Maarianhamina aerosol samples through which fragments
of reference curves have been drawn (compare with Fig. 1).

range fall-out. These samples, however, are indicated by significant differences between the 6 separate measurements mentioned above. After about a month of no nuclear tests, as the hot particles are rare, also the energy index is logical and can be used as a strong argument for each measurement.

The advantages of measuring with two different absorber values as described above compared with measurements made with only one absorver value will be summed up as follows:

a) Any routine measurement should be checked with at least one extra measurement that differs in principle from the first one. In this method the energy index usually has to be logical (see Fig. 3) and thus eliminates occasional errors.

b) The method gives comparable values of total β-activity and offers good correction factors for filter measurements where only thick window counters have been used. From Fig. 1 it can be seen that if approx. 3 weeks old fall-out had been measured only with a BZ-45 the correction factor would have been $5/2.5 = 2$, provided that the BZ-45 counting arrangement was standardized against K^{40}.

c) The energy index can also be used as an age index and can be measured with good accuracy from quite small samples. From a table of percentual contributions to fission product activity (1) even a rough calculation shows that the ratio of soft β-emitters to hard β-emitters should be expected to show a characteristic turn at an age of approx. 100 days, depending slightly on the absorbers in question. It should occur when the soft Nb^{95} percentually becomes dominating but only for a short period until the hard Pr^{144} again raises the ratio. Thus the energy index is not a singlevalued age index during this period unless one or two extra measurements are made.

d) The energy indexes of filter samples that have been taken shortly after known nuclear tests are interesting to compare with the same indexes of samples taken later (but measured at the same time).

e) The energy index is a quick and simple method of detecting unexpected components in the air, whereas if measurements with only one absorbator value is carried out nothing special would be detected even if pure γ-activity were in question.

REFERENCES

HUNTER, H. F. and N. E. BALLOU, 1951: Fission-product decay rates. Nucleonics 9, No. 5, C 2—C 7.