Abstract. A measurement system was assembled and tested for the absolute standardization of large area alpha and beta sources. Such sources are employed to calibrate a variety of contaminants. A window-less multi-wire proportional counter, donation of the “Laboratoire National Henri Becquerel” (LNHB, Saclay – France) was used, with pure methane as flowing gas. The needed electronics (high voltage, amplifier, discriminator, counter, clock, MCA) was a CANBERRA one. Point and extended sources of $^{241}$Am, $^{90}$Sr + $^{90}$Y and $^{204}$Tl were standardized. The variation of the counting rate with high voltage provided “plateaus” of (300–500) V with a slope of (0.1–1.5)% for 100 V. The efficiency of the counter for a point beta source and a central area of $(100 \times 150)$ mm$^2$, varied with less than 0.2%. To avoid spurious pulses, adequate threshold and working high voltage were chosen, and an imposed 10 $\mu$s dead-time was inserted in the counting channel. A procedure for the threshold correction was established. A relative compound uncertainty of maximum $\pm 2\%$ was obtained, a quite acceptable value for extended sources.

Key words: multi-wire counter, calibration, contaminometer, alpha source, beta source.

1. INTRODUCTION

In the Radionuclide Metrology Laboratory from IFIN-HH a measurement system was assembled and tested for the absolute standardization of large area alpha and beta sources. Such sources are employed to calibrate a variety of contaminants. The standardized quantity is the “Emission rate” of particles (flux of particles) in $2\pi$sr, expressed as particles/s in $2\pi$sr.

The activity of the sources, as requested by ISO 8769 [1], is known by the producer (if the preparation procedure is well controlled) or by special-not simple-methods [2–5].
A window-less multi-wire proportional counter (MWPC) with an associated PA was used, with pure methane as flowing gas; it represents a donation of the “Laboratoire National Henri Becquerel – LNHB” from Saclay, France. The usual dimensions of large area sources are $100 \times 150 \text{ mm}^2$; as radionuclide, $^{241}\text{Am}$, $^{90}\text{(Sr + Y)}$ and $^{204}\text{Tl}$ were preferred.

The method is absolute because, with the corrections for background, dead-time and threshold, the real number of particles emitted per second in $2\pi\text{sr}$ is obtained. In the laboratory, another MWPC exists, with a thin Mylar window, which was attested as secondary standard equipment [6]. The activity value is obtained by relative measurement.

2. EXPERIMENT

The counter is of DEXTRAY AB710 type ($250 \times 400 \times 30 \text{ mm}$) and the preamplifier PS 76-2B is produced by Eurysis Measures, France. The source is introduced in the counter with a shelter. The counter is shielded with 5 cm of Pb. The counter volume of $3000 \text{ cm}^3$ is fulfilled with pure methane in 1–1.5 hours.

The needed supplementary electronics (high-voltage amplifier, discriminator, counter, MCA) is a CANBERRA one. For data analyses a PC was used.

To avoid spurious pulses, adequate discrimination thresholds and working high voltages were chosen, and an imposed dead-time of $10 \mu\text{s}$ was inserted in the counting channel.

Alpha and beta spectra and the variation of counting rates with high voltage were studied. The variation of the efficiency of the counter for a point beta source, with the position of the source on the shelter (removal from the centre) was determined.

The background was subtracted in the usual way.

From the registered counting rate $r$, the corrected counting rate $R$ was obtained with the usual formula:

$$R = \frac{r}{1-r\theta} - F,$$

where $\theta$ is the imposed non-extended dead-time and $F$ is the background.


3. RESULTS

Alpha background is $0.1 \text{ cps}$ in the $(1600–2100) \text{ V}$ range, the MDA value (Minimum Detectable Activity), for $1000 \text{ s}$ counting time, is $0.1 \text{ Bq}$. For beta sources the background is $33 \text{ cps}$ and the MDA value is $1.5 \text{ Bq}$ (Fig. 1).
Both alpha and beta spectra present, for high voltages of 2000 V and 3300 V respectively, a minimum in the (0.2–0.4) V region; amplitudes lower than that are suspected to contain spurious pulses. So, the thresholds of registration were set at 0.2 V for alpha particles and at 0.4 V for beta particles and threshold corrections were made (Figs. 2–4).
Fig. 3 – DEXTRAY AB710 Multi-wire Proportional Counter. Point Source Spectrum of Sr-90 SEB 7-3646: HV = 3200 V; threshold = 0.4 V; amplification = 240; gas = CH₄.

Fig. 4 – DEXTRAY AB710 Multi-wire Proportional Counter. Extended Source Spectrum of Sr-90, SEB 7-4196, 100 × 150 mm: HV = 3200 V; Threshold = 0.4 V; Amplification = 240; Gas = CH₄.
The spectrum for secondary electrons produced by an external gamma source is presented in Fig. 5; though the ionization is produced too in the most “hidden” corners of the counter, the spectrum differs from that of an internal source.

![Fig. 5 – DEXTRAY AB710 Multi-wire Proportional Counter. Spectrum of secondary electrons by gamma irradiation with an external Co-60 Source: HV = 3200 V; threshold = 0.4 V; amplification = 240; gas = CH₄.](image)

The variation of alpha counting rate with high voltage provided, in the range (1600–2100) V, a “plateau” with a slope of only 0.4% for 100 V (Fig. 6). For beta sources, the plateau was situated at (3100–3400) V, with a slope of less than 0.1% for 100 V, for point sources, and less than 1.5% for 100 V, for extended sources (Fig. 7–9). High voltage values for routine work were chosen at 2000 V for alpha sources and 3300 V for beta sources, than is 100 V below the end of the plateau.

The alpha and beta counting rates for point sources varied with less than 0.2% on a centered area of 100 × 150 mm². So, one does not need an extension correction for extended sources up to 100 × 150 mm²! Nevertheless, the possible “non uniformity” of the source must be checked with other method.

The correction for the pulses lost below the threshold was made considering the shape of the spectra near the threshold (constant value or a trend to zero) [7].

The correction amounted to 0.4% for alpha sources and (0.2–2)% for point and extended beta sources. Half of these values were considered as type B (systematic) components of uncertainty.

An alternative procedure for considering the threshold correction is to estimate the growth of the counting rate between the working point on the plateau and the end of the plateau, using the determined slope. We preferred the first
method, though the correction values obtained by the second method were practically the same.

Fig. 6 – Alpha plateau with point source of Am-241, SEA 3-3, uncertainty ±1%.

Fig. 7 – Beta plateau with point source of Sr-90, SEB 7-3646, uncertainty ±1%.
The relative combined uncertainty was calculated as:
\[ u_c^2 = u_a^2 + u_b^2 + u_c^2 + u_d^2, \]  
(2)
where $u_r$ and $u_F$ are components of the type A (statistic) and $u_t$ (threshold correction) and $u_0$ are components of type B (systematic).

For $u_r$, a maximum value of $(1.5–2)\%$ was obtained, which is quite acceptable for extended sources.

Several sources, standardized with other systems, were measured; the obtained differences of the emission values were less then:

$$\sqrt{u_c^2 + u_s^2}, \quad (3)$$

where $u_c$ (absolute value) refers to the measurement and $u_s$ is the absolute combined uncertainty value written down in the source certificate.

4. CONCLUSIONS

An efficient system for the standardization of extended alpha and beta sources was realized.

It uses a large area multi-wire proportional counter without window and pure methane as flowing gas.

Sources of $^{241}$Am, $^{90}$(Sr + Y) and $^{204}$Tl, point and extended, were standardized.

The graphs of the counting rates versus high voltage provided plateaus of (300–500) V, with slopes of $(0.1–1.5)\%$ for 100 V.

The efficiency of the counter is practically constant on a centered area of $100 \times 150 \text{ mm}^2$.

A procedure for the threshold correction was established.

The obtained relative combined uncertainty, $u_c$, was of maximum $\pm 2\%$, which is quite acceptable for extended sources.

REFERENCES