A MULTI-ANODE PROPORTIONAL COUNTER FOR MEASURING ^{15}O-LABELLED GAS ACTIVITIES IN LABORATORY EXHAUST AIR

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AIMS: Proper ventilation is necessary to maintain safe and comfortable working conditions in any laboratory or hospital clinic. ^{15}O-labelled gases and [^{15}O]water are produced continuously during patient studies with PET. Often small amounts of the radioactivity will be lost into the exhaust air. Exhaled air in patient studies is one source of the airborne radioactive waste. The aim of this study is to develop an improved radioactivity detection system for measuring ^{15}O-labelled gas activities in the exhaust air of PET laboratories or PET scanner rooms.

METHODS: A common method for measuring short-lived positron emitters like ^{11}C, ^{15}O and ^{18}F in exhaust air is to use 511 keV photon detection. There are available several conventional NaI or BGO detection systems which can be used as radioactivity monitors in laboratory exhaust air. Small amounts of radioactivity are difficult to measure in a large diameter (0.7 – 1.0 m) ventilation tube. Coincidence methods can improve the geometry and minimize the background. Low count rates in the flowing exhaust air and short counting times (10-20 s), can limit the sensitivity of the measuring system. Another approach is to use a positron sensitive detector. A thin-window proportional counter is a very sensitive positron detector (Ref.), but its 511 keV photon sensitivity is low. Typically this type of detector has low background count rates also without lead shield. In our study we made first a cylindrical (diam. 65 mm, length 170 mm) single-anode proportional counter. The detector fill gas was argon-methane P10 (90%/10%). A beer can (thickness 110µm) was used as detector window. The detector was installed in the middle of a 1 meter long ventilation tube (diam. 0.7m). Both ends were closed with a plastic foil and a known amount of [^{15}O]oxygen gas was injected into the tube volume. The air was mixed with a fan during the measurements. Radioactivity was measured for 12 half-lives. The detector performance was tested with the help of ^{55}Fe and ^{57}Co sources.

The multi-anode (8 wires) planar proportional counter was constructed based on the experiences with the single-anode counter. The multi-anode detector dimensions are 565 mm x 460 mm x 50 mm. The active window area was increased up to 0.32 m^2. The aluminium window (thickness 90µm) is installed on both sides of the detector. The window is supported on a stainless steel grid (50 mm x 50 mm). Radioactivity measurements were done as described above.

RESULTS: The single-anode detector response was 3.4 cps/kBq and the detection limit in 20 s counting time was 1.5 kBq/m^3 (3δ). The background count rate was 8 cps. The multi-anode detector response was 30 cps/kBq and the detection limit in 20 s counting time was 450 Bq/m^3 (3δ). The background count rate was 60 cps. The detector responses were linear for low radioactivity levels with the same electronics.

CONCLUSION: A multi-anode proportional counter is a good device for measuring radioactivity in laboratory exhaust air. Radioactivity concentrations down to the MAC value 600 Bq/m^3 (MAC = Maximum Air Concentration) for oxygen-15 and other positron-emitting radionuclides in exhaust air can be measured with the above described system.

REFERENCE: S-J. Heselius, H.T. Sipila and D. Roeda: A multi-anode proportional counter for measuring [^{11}C]carbon dioxide in exhailed air, Phys. Med. Biol. 32 (1987) 1495-1500.