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# Retention efficacy and release of radioiodine in fume hoods

K. Schomäcker [a,*], T. Fischer [a], B. Zimmermanns [a], J. Bregulla [a], F. Sudbrock [a], O. Prante [b], A. Drzezga [a]

[a] Department of Nuclear Medicine, University Hospital of Cologne, Germany
[b] Department of Nuclear Medicine, University Hospital Erlangen, Germany

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ABSTRACT

Procedures to determine the release of hazardous gaseous substances including radioactive iodine are covered by different norms such as the European standard EN 14175 and the German national standard DIN 25466. The detection of sulphur hexafluoride ($SF_6$) is required to comply with the prescribed methodology. The detection limit of this test is $4.5 \cdot 10^{-7}$ mol/m$^3$ in exhaust air. This detection limit would represent a very high activity in the region of 0.27 TBq/m$^3$ leading to an unacceptable risk. We therefore developed a test using a filter system, consisting of a combination of filters capable of separating various chemical forms of airborne radioiodine. Air samples were collected directly in front of the fume hood and in the laboratory beside two different fume hoods of a similar construction with a final activated carbon filter for retention of radioiodine. Particular attention was therefore paid to air samples taken after passage over the filters.

Significant differences in the degree of retention of iodine were found between the two fume hoods investigated. In one test a malfunction of the fume hood was demonstrated. In this case $0.148 \times 10^{-3}$% of the total released activity per m$^3$ air was found 1 cm in front of the hood sash. A remarkably high fraction of the activity released in the fume hood ($1.3 \times 10^{-3}$%/m$^3$ air) was measured after the activated carbon filter. In the ambient air, values of up to $8.6 \times 10^{-6}$% pro m$^3$ laboratory air sampled were measured, despite a 6–8-fold air exchange.

The selected procedure is a factor of $10^{11}$ (Schomäcker et al., 2001) more sensitive than the standard recommended methods (EN 14175). The standard test prescribed by the DIN/EN failed to reveal any inadequacy in the protective function of the radionuclide hood with respect to radioiodine retention.



## 1. Introduction

Fume hood extraction units are installed in nuclear medical and radiopharmaceutical facilities in order to maintain a working environment with a low level of microbacterial contamination for the handling of unsealed, radioactive materials. These units should be suitable for the production of ready-to-use radioactive pharmaceuticals, in accordance with GMP (GMP = Good Manufacturing Practice) conditions. Those generally available are a combination of a laminar-flow cabinet and a radionuclide hood. Special construction and operating modifications guarantee protection of personnel from incorporation, contamination and external radiation exposure. Here the retention capability of the combined fume hood unit assures that no dangerous levels of airborne radionuclide are incorporated by the operator standing in front of the fume hood. This is particularly important in the case of radioactive iodine. The volatility of radioiodine depends on its chemical form. In order to prevent release of $^{131}$I-iodine, with its half-life of ca. 8 days, into the environment, radionuclide hoods are fitted with additional, activated carbon filters. This should guarantee a reliable decontamination of air leaving the fume hood unit.

To guarantee that the fume hood unit offers full protection, safety equipment must be regularly maintained and monitored to ensure that it functions effectively. The regulations for the design and testing of radionuclide hoods are laid-down in the form of DIN/EN standards. These DIN/EN standards can be national, European or international. They apply to the performance of standard technical tasks and frequently provide a basis for regulatory measures.

The behaviour of released radioactive substances and of gaseous $^{131}$I-iodine in particular is currently assessed in the respective DIN/

* Corresponding author. Department of Nuclear Medicine, University Hospital of Cologne, Kerpener Str. 62, 50937 Cologne, Germany.
*E-mail address:* klaus.schomaecker@uni-koeln.de (K. Schomäcker).

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EN standards as equivalent to non-radioactive chemically hazardous substances. Thus the German DIN standard for radionuclide hoods (DIN 25466) stipulates that the air technology type examination should follow recommendations set down in DIN EN 14175 (DIN EN 14175-1—DIN EN 14175-4). The regulations for type testing laid down in the standard EN 14175-3 (DIN EN 14175-3) in particular call for test measurements with the tracer gas sulphur hexafluoride. This requires a detection limit of at least $10^{-8}$ volume fractions (0.01 ppm). Assuming the gas density of $SF_6$ to be ca. 6 kg/$m^3$, this is the equivalent of a molar concentration of ca. $4 \cdot 10^{-7}$ mol/$m^3$ air. With regard to volatile radioiodide compounds, in the case of $^{131}$I this amount would correspond to a radioactivity concentration in the order of magnitude of Terabequerel per cubic meter. A theoretical exposure distributed over 1000 individuals with average thyroid retention of 55% to such a radioactivity of $^{131}$I would lead to an effective dose of ca. 6 Sv.

For this reason, the current test specifications, based on DIN-standards, are unsatisfactory. Below is a proposed method of high sensitivity for measurement of radioiodine concentrations in the air. This offers a suitable procedure for testing the protective function of radionuclide extraction units with regard to protection of personnel (retention of radioiodine in the area around the fume hood) and environmental protection (decontamination of exhaust air from the radionuclide hood).

## 2. Materials and methods

### 2.1. The fume hoods

The fume hoods investigated in this study are shielded hoods for manipulations at medium activity, with frontal sliding shield and laminar flow. The workstation should be suitable for the breakdown of air-hanging radioisotopes coming from the manipulation of liquid or volatile gaseous substances. The interior is made of stainless steel (AISI 304). An integrated ventilator draws the process air from the working area through an activated carbon filter combination within a separate filter cabinet that is also made of stainless steel. The bag change technology, which is based on research from the field of nuclear technology, guarantees a safe filter change (according to the manufacturer).

### 2.2. Immission in the laboratory

#### 2.2.1. Description of the measuring equipment

For the determination of $^{131}$I-iodine concentrations in air we developed a test using a filter system (Figs. 1–3) for selective adsorption of chemically different radioiodine species as described by Schomäcker et al. (2001, 2011). This filter system was mounted in two radionuclide laboratories in separate locations within the area around the radionuclide hood at various measuring positions.

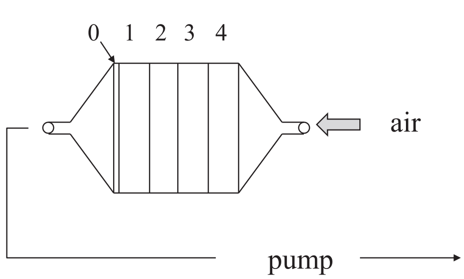


**Fig. 1.** Sketch of the air sampling system. 0: GF50 = aerosole filtre, 1: BE 110 = cadmium iodide, 2: BE 110 = cadmium iodide, 3: Silverzeolithe filtre, 4: TEDA-coated charcoal.

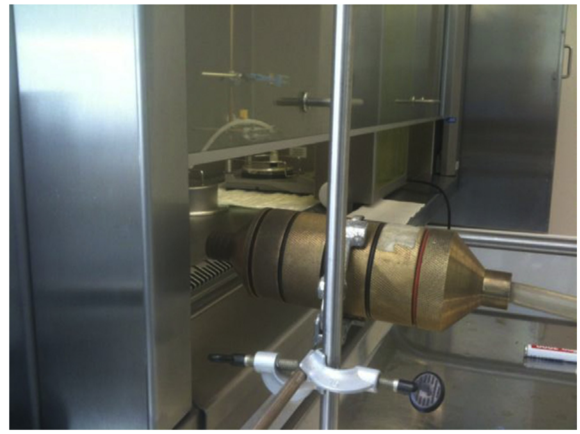

**Fig. 2.** Measurement of the containment capability of the fume hoods. For air sample collection the filter system was positioned to the left of the fume hood at a distance of 1 cm from the front sash.

**Fig. 3.** Test of the decontamination capacity of the activated carbon filter combination in the filter unit to the right of the fume hood via a removal device (tubing joint) was fitted.

The air was drawn in by a portable constant flow air-sampler Model AVS-28 A from the company SAIC/RADeCO (USA) through a filter system consisting of an aluminium mounting bracket with 5 tightly packed individual filters. The filters were serially arranged in the following order (Fig. 1): one circular glass fibre filter GF50 (Schleicher & Schuell), two BE-110 cadmium iodide filters (SAIC), one GY-130 silver zeolite filter (SAIC) and one CP-100 filter (TEDA-impregnated activated carbon, SAIC, USA). The diameter of the filters was 5.77 cm, with a thickness of 2.54 cm (except for the round glass-fibre filter). The portable constant flow air-sampler and the filters were supplied by the company "Technisches Büro Schütz", Rimbach, Germany. The listed adsorption materials have been used for many years to contain iodine released during accidents in nuclear power stations. The arrangement of filters used here, or similar combinations of such filters, often serve in nuclear reactor operations or in hot cells to establish the chemical composition of the iodine-radioactivity contained in the exhaust air (Emel et al., 1977; Giraud, 1985; Lee et al., 1991; Wilhelm, 1977, 1982).