^{133}Xe Contamination Found in Internal Bacteria Filter of Xenon Ventilation System

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Objective: We report on ^{133}Xe contamination found in the reusable internal bacteria filter of our xenon ventilation system.

Methods: Internal bacteria filters (n = 6) were evaluated after approximately 1 mo of normal use. The ventilation system was evacuated twice to eliminate ^{133}Xe in the system before removal of the filter. Upon removal, the filter was monitored using a survey meter with an energy-compensated probe and was imaged on a scintillation camera. The filter was monitored and imaged over several days and was stored in a fume hood.

Results: Estimated ^{133}Xe activity in each filter immediately after removal ranged from 132 to 2,035 kBq (3.6–55.0 μCi), based on imaging. Initial surface radiation levels ranged from 0.4 to 4.5 μSv/h (0.04–0.45 mrem/h). The ^{133}Xe activity did not readily leave the filter over time (i.e., time to reach half the counts of the initial decay-corrected image ranged from <6 to >72 h). The majority of the image counts (~70%) were seen in 2 distinctive areas in the filter. They corresponded to sites where the manufacturer used polyurethane adhesive to attach the fiberglass filter medium to the filter housing.

Conclusion: ^{133}Xe contamination within the reusable internal bacteria filter of our ventilation system was easily detected by a survey meter and imaging. Although initial activities and surface radiation levels were low, radiation safety practices would dictate that a ^{133}Xe-contaminated bacteria filter be stored preferably in a fume hood until it cannot be distinguished from background before autoclaving or disposal.

Key Words: ^{133}Xe; radioactive contamination; radiation monitoring

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As a part of routine monthly maintenance on our xenon ventilation system, we replace its internal bacteria filter (model 1549; A-M Systems, Inc.), which is reused after steam autoclaving. After removal of a bacteria filter that was going to be discarded (i.e., according to the manufacturer's instructions, the filter can be autoclaved up to 25 times but should be discarded after 1 y of use), monitoring with a survey meter detected radioactivity. We report on ^{133}Xe contamination found in the reusable internal bacteria filter of our xenon ventilation system.

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MATERIALS AND METHODS

Each internal bacteria filter (n = 6) (Fig. 1) was evaluated after approximately 1 mo of normal use. The xenon ventilation system (Ventil-Con 3; RADX) was evacuated twice to eliminate ^{133}Xe in the system before removal of the bacteria filter. Upon removal, the filter was immediately placed in a resealable plastic bag and monitored using a survey meter equipped with an energy-compensated probe. The maximum surface radiation level was recorded. The filter was then imaged for 5 min using a scintillation camera equipped with a low-energy all-purpose collimator and 20% energy window centered around 81 keV. The bacteria filter was removed from its resealable plastic bag and stored in a fume hood for several days. It was periodically monitored and imaged during that time. A used ^{133}Xe vial was assayed in a dose calibrator and imaged on the scintillation camera to estimate the ^{133}Xe activity in the bacteria filter. Background images were obtained for all sets of images.

Based on imaging, the polyurethane adhesive used by the manufacturer to attach the fiberglass filter medium to the filter housing was thought to be the primary cause of the ^{133}Xe retention. To confirm this suspicion, a small sample (~4 × 5 × 15 mm) of the adhesive from a filter was placed in a sealed vial with ^{133}Xe for several days. Upon removal from the vial, the adhesive sample was imaged over several days.

We also evaluated if ^{133}Xe activity was found in the CO_2 and moisture absorbers (i.e., soda lime granules and silica gel, respectively, n = 2 for both) on their removal from the ventilation system. After the bacteria filter was changed, each absorber was removed and placed in separate resealable plastic bags. The bags were monitored using a survey meter, and then, like the filter, they were imaged on a scintillation camera. The absorbers were stored in the fume hood with the plastic bag opened for approximately 7 h if ^{133}Xe activity was detected. At that time, they were monitored and imaged.

RESULTS

Estimated ^{133}Xe activity in each bacteria filter immediately after removal ranged from 132 to 2,035 kBq (3.6–55.0 μCi),

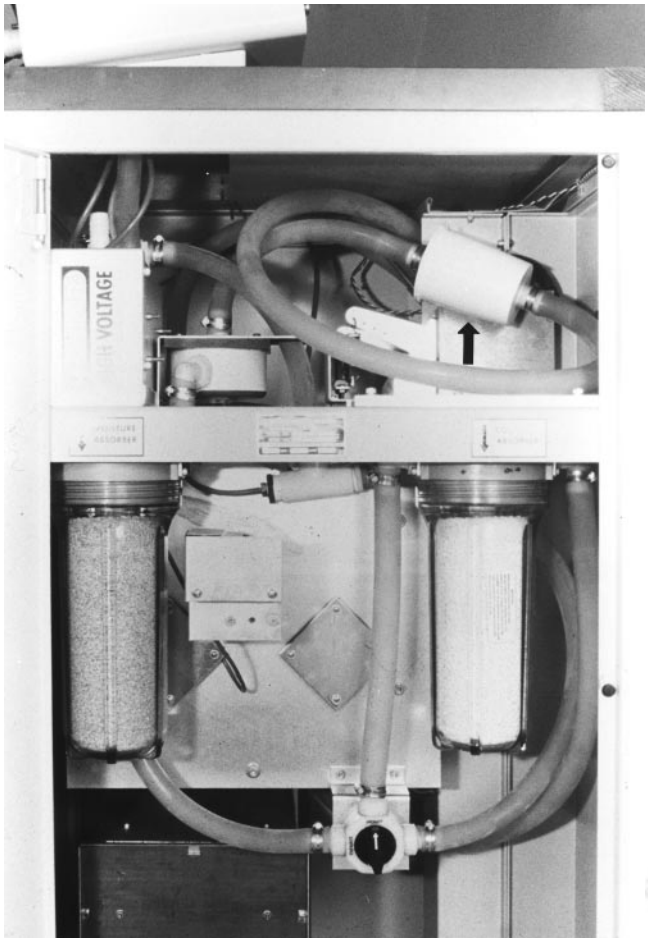

FIGURE 1. Bacteria filter (arrow) (15 cm from filter inlet to filter outlet, 9-cm maximum diameter) inside xenon ventilation system. CO_2 absorber is located in canister directly below filter. Filter and CO_2 absorber are in constant contact with ^{133}Xe in ventilation system. Moisture absorber is located in canister directly across from CO_2 absorber canister. Moisture absorber comes into brief contact with ^{133}Xe only when system is evacuated or during washout phase of ventilation study. During that time, ^{133}Xe is trapped in internal shielded xenon filter (i.e., activated charcoal).

based on imaging. The higher the estimated ^{133}Xe concentration (MBq/L) of the ventilation system was before evacuation, the higher was the initial filter activity. Initial maximum surface-radiation levels ranged from 0.4 to 4.5 μSv/h (0.04–0.45 mrem/h), which correlated well with the estimated activity (Fig. 2). Background levels were 0.1 μSv/h (0.01 mrem/h). The ^{133}Xe activity did readily leave the filter over time (i.e., time to reach half the counts of the initial decay-corrected image ranged from <6 to >72 h) (Fig. 3).

The majority of the image counts (~70%) were seen in 2 distinctive areas in the bacteria filter (Fig. 4). They corresponded to sites where the manufacturer used polyurethane adhesive to attach the fiberglass filter medium to the polypropylene filter housing (Fig. 5). To confirm that the adhesive was the primary cause of the ^{133}Xe retention, a sample of the adhesive from a filter was placed in a sealed vial with ^{133}Xe for several days. Imaging of the adhesive on removal from the vial demonstrated that the adhesive retained ^{133}Xe activity, which was released slowly over time, as had been the case with the internal bacteria filters.

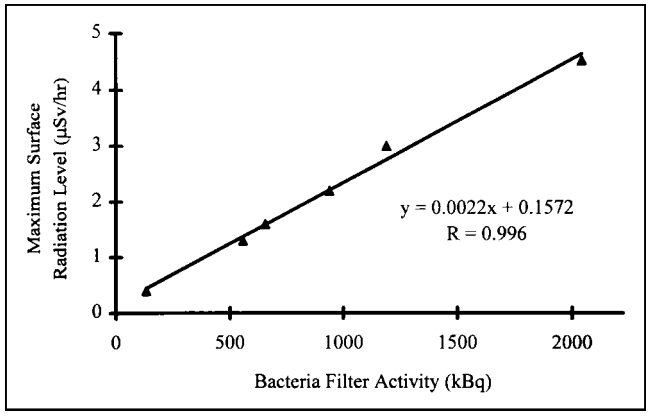

FIGURE 2. Linear regression analysis between maximum surface-radiation level and estimated ^{133}Xe activity in each bacteria filter immediately after removal from xenon ventilation system.

One bacteria filter had increased initial ^{133}Xe activity throughout. The increase was probably due to incomplete evacuation of the ^{133}Xe activity from the xenon ventilation system before removal. This would explain its quicker release of ^{133}Xe activity (○ line in Fig. 3) when compared with the other filters.

The moisture absorber showed no detectable ^{133}Xe activity on removal, whereas the CO_2 absorber did. The 2 CO_2 absorbers had estimated ^{133}Xe activities of 157.7 and 308.8 kBq (4.3 and 8.3 μCi), with low maximum surface-radiation levels of 0.3 and 0.4 μSv/h (0.03 and 0.04 mrem/h), respectively. No detectable ^{133}Xe activity in the CO_2 absorber could be found after storage in the fume hood for 7 h.

DISCUSSION

Normally, we think of radioxenon contamination as resulting from a xenon spill (e.g., vial breaks or patient removes mask during ventilation study). We have shown that ^{133}Xe contamination is present in the reusable internal

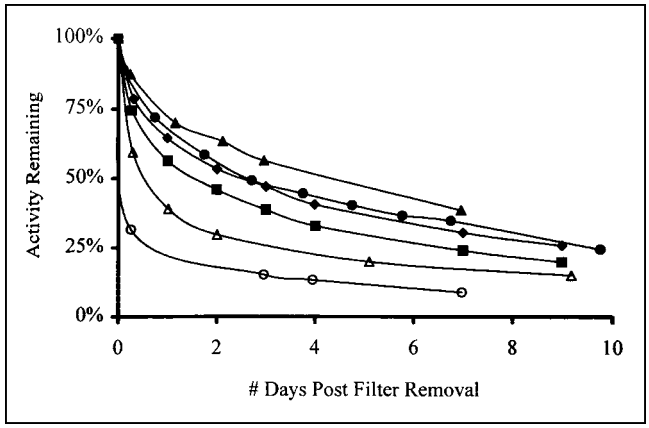

FIGURE 3. Percentage of activity remaining in bacteria filter based on initial decay-corrected scintillation camera counts versus time after filter removal.

bacteria filter and CO_2 absorber of our ventilation system. One would not expect to see this type of contamination—of an inert radioactive gas—in a bacteria filter or CO_2 absorber. Because the filter is internal, there is a constant presence of ^{133}Xe in the filter (and the CO_2 absorber) if the ventilation system has activity loaded (i.e., does not include activity in the xenon trap), thus allowing time for the ^{133}Xe to adsorb to the plastic contents of the bacteria filter (i.e., primarily to the polyurethane adhesive) and to the CO_2 absorber. Radioxenon adsorption to plastic syringes (*1*,*2*) and to rubber and plastic stoppers and components (*1*–*5*) has been reported. Radioxenon contamination of polystyrene packing materials from ^{133}Xe shipments (*5*–*7*), plastic packaging jackets that house shielded ^{133}Xe vials (*6*), and polyurethane packing materials (*8*) and activated carbon absorbent packets (*9*) from ^{131}I capsule shipments (i.e., ^{131m}Xe contamination) has been reported.

CONCLUSION

^{133}Xe contamination within the reusable internal bacteria filter and CO_2 absorber of our ventilation system was easily detected by survey meters and imaging. Although initial activities and surface radiation levels were low, radiation safety practices would dictate that a ^{133}Xe-contaminated bacteria filter and CO_2 absorber be stored preferably in a fume hood until it cannot be distinguished from background before autoclaving or disposal.

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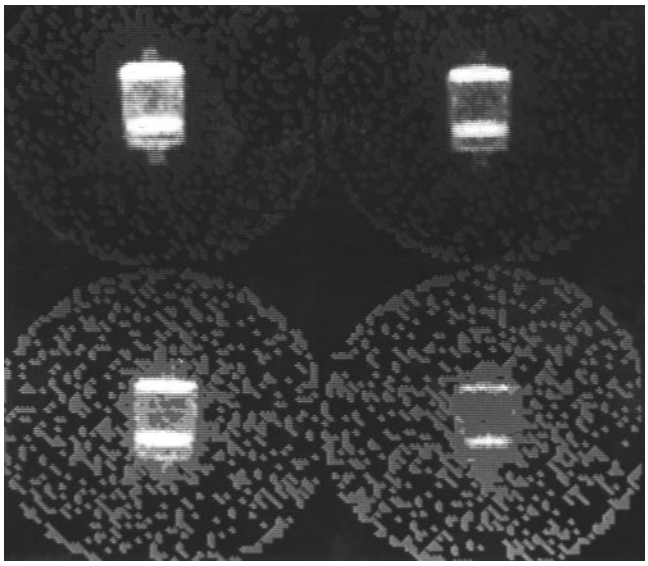

FIGURE 4. Images of typical bacteria filter after removal from xenon ventilation system. Top left is immediately after removal. Top right is 0.3 d after removal, with 75% of ^{133}Xe activity remaining based on decay correction. Respective left and right bottom images are 3 and 7 d after removal, with 39% and 24% of ^{133}Xe activity remaining based on decay correction. Two hottest bands of activity correspond to 2 polyurethane adhesive areas in filter.

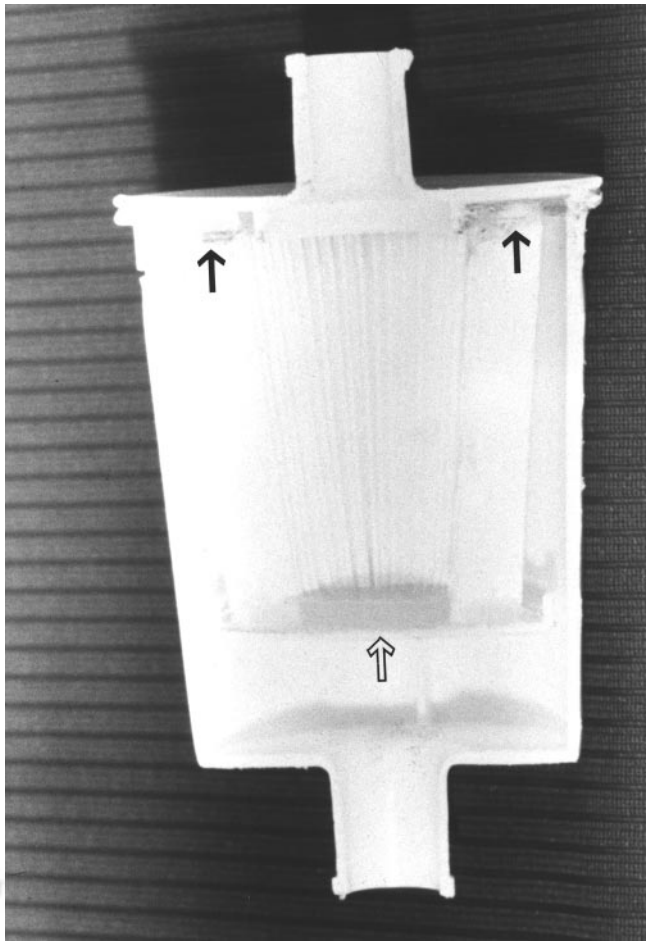

FIGURE 5. Cross-section of bacteria filter. Polyurethane adhesive area (open arrow) toward filter inlet is circular, with 6-cm diameter and 3- to 5-mm thickness. Other polyurethane adhesive area (solid arrows), toward filter outlet, is doughnut shaped with 4-cm inner diameter, 7.5-cm outer diameter, and 4- to 5-mm thickness. Fiberglass filter medium is between and attached to 2 adhesive areas so as to secure it to polypropylene filter housing.

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