Radioxenon Packaging Contamination

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Xenon-133 in multiple unit-dose vials is a commonly employed radionuclide in nuclear medicine. Because it is an inert gas, shipments of radioxenon for nuclear medicine departments are not required to be checked for contamination. An evaluation of 30 shipments containing ^{133}Xe vials revealed consistent contamination of the inner plastic packaging jackets. Surveys were performed using a Geiger-Muller survey meter, a dose calibrator, and a scintillation camera. Study of the xenon removal from the jackets indicated storage in a fume hood until the following day reduced the contaminated materials to background levels. The dose calibrator was found to be a quick and sensitive survey instrument for determining contamination in these plastic jackets.

A standard practice in nuclear medicine laboratories is to survey radioactive packages for contamination upon their receipt. This practice includes checking the packaging materials for measurable amounts of contamination prior to disposal. This survey may be performed by counting a wipe smear or by directly measuring the packaging with a suitable survey instrument such as a Geiger-Muller (G-M) detector. Negative survey results permit the disposal of the packaging materials after properly removing or defacing any radioactive material labels.

Regarding the receipt of radioactive gases such as ^{133}Xe by a nuclear medicine laboratory, the Nuclear Regulatory Commission (NRC) has exempted packages from contamination survey requirements (*1*). Following external and surface monitoring, proper handling procedures require that radioxenon packages be opened and the vials stored in a properly ventilated area, such as a fume hood (*2*). However, because of xenon's gaseous state, it is assumed that contamination of the packaging is not a concern.

Our routine procedure is to survey all packaging material with a G-M detector before disposal, including those packages which contained radioactive gases. If no detectable contamination is present, the materials are disposed in the general trash. Performance of these surveys on the packaging from ^{133}Xe gas vial shipments consistently indicated that the clear plastic tubes, or jackets (Fig. 1), containing the shielded xenon were contaminated. Investigation of the contamination with a multichannel analyzer confirmed the presence of ^{133}Xe. The styrofoam packaging which holds the xenon jackets inside the shipping container was also occasionally contaminated. An evaluation of this contamination and a solution to the problem are presented.

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MATERIALS AND METHODS

The plastic jackets from 30 individual shipments of ^{133}Xe unit dose vials* were measured with a G-M detector, a dose calibrator, and a scintillation camera. A typical shipment consisted of 1–3 plastic jackets which held up to five unit-dose vials of ^{133}Xe calibrated to contain 10, 20, or 50 mCi. Typically, the jackets were assayed 5 days prior to the date of calibration.

The jackets from all 30 shipments were measured immediately after removing the lead shields containing the xenon vials and recapping the jackets. Images were obtained for several of the different capped jackets with a scintillation camera. The jackets from 15 of the shipments were stored in a fume hood with the caps off for at least 4 hr. The jackets were then remeasured with the same three devices. All measurements were background corrected. The camera measurements were based on counts obtained from a 5-min acquisition of the jackets and background. The net counts/min (cpm) were recorded for the G-M and scintillation camera detectors; the net activity in these measurements was recorded for the dose calibrator measurements.

The 30 initial measurements from the scintillation camera were correlated with those from the dose calibrator and G-M detector by linear regression.

Immediately after unpacking its xenon, a single representive capped jacket was imaged for 2 min with a scintillation camera interfaced to an image processing computer. The jacket had contained five 50 mCi vials. It was placed on its side parallel to the floor during image acquisition. Removing only the cap, serial 1-min images were acquired by the computer. A time-activity curve of the net jacket activity and a functional image of the time to reach minimum activity were generated. The only air flow in the imaging room was provided by a mechanical ventilation system for a room under negative pressure with the exhaust vent located near floor level. The room exhaust is directly vented outside the building.

RESULTS

The net measurements from the first 15 shipments are arranged in Table 1 according to vial activity at calibration time. Typically there were five 10 mCi or 20 mCi vials and seven 50 mCi vials per shipment. The degree of contamination seems to increase proportionally with the total activity of the vials. However, after 4.5–7.5 hr, the measured activity levels were essentially equal to background in all cases regardless of the activity originally contained within the jackets.

For the total 30 shipments, these initial measurements from

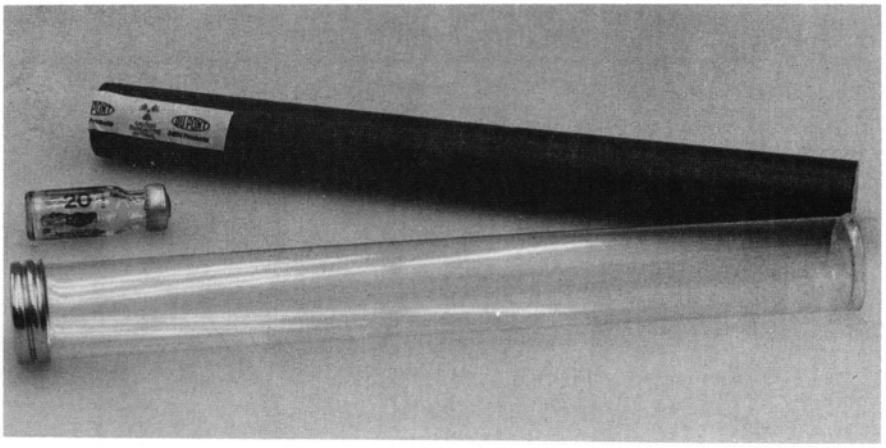

FIG. 1. A representative plastic shipping jacket (bottom) used to enclose the lead shield (top) containing the xenon vials (middle).

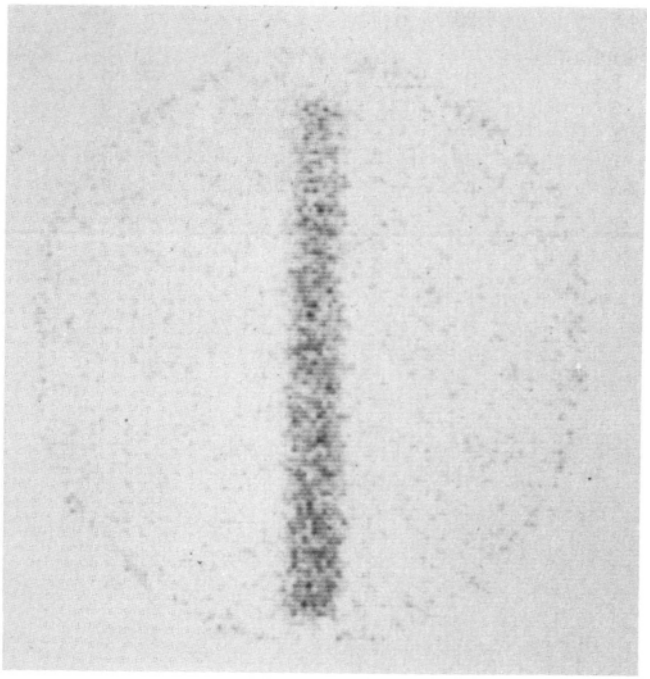

FIG. 2. Digital 2-min image of the radioactive contamination distributed in a capped jacket.

the scintillation camera correlated extremely well with the dose calibrator; the coefficient of determination (r^2) was 0.95. The correlation between the camera and the G-M detector measurements was good with an r^2 of 0.74. Detector geometry and efficiency factors permitted more sensitive measurements with the scintillation camera and the dose calibrator.

Figure 2 shows a 2-min computer image of the distribution of radioactive contamination throughout the representative jacket. The contamination is evenly distributed and is typical of that found in other jackets. The washout of the xenon from the tube when the cap was removed is illustrated in the time as compared to activity curve in figure 3. The effective washout half-time for these measurements was 22.5 min.

Figure 4 is a functional image of the time to reach minimum activity also generated from the 60 serial washout images. The open end of the jacket is at the top of the image. The darkest intensities correspond to the spatial locations that took the longest time to wash out. As Figure 4 illustrates, the xenon flowed through the tube opening and did not remain attached to the plastic.

DISCUSSION AND CONCLUSIONS

Radioactive packages delivered to a nuclear medicine laboratory must be handled in a manner that minimizes unnecessary exposure to personnel and contamination. Analysis of the data in Table 1 reveals that the amount of contamination in the jackets is $< 1\%$ of the total activity. A conversation with a representative of the radiopharmaceutical manufacturer revealed that leakage from the xenon vials of 1–2% of the total activity can be expected. Although the xenon appeared trapped inside the plastic jacket, it was not bound to the plastic as evidenced by the rapid diffusion of the xenon from the jacket. This factor is in agreement with previous studies which have shown that xenon readily adheres to rubber but not to certain other surfaces such as glass (*3,4*).

In monitoring the packages, the G-M detector provided a good means of determining the presence of contamination but was not as sensitive as the dose calibrator or scintillation camera. The camera and the dose calibrator were equivalent

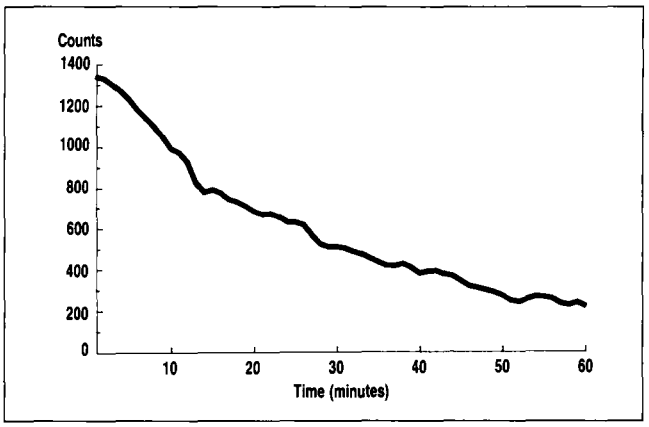

FIG. 3. Time-activity curve representative of the washout of xenon from an opened jacket.

TABLE 1. Radioactive ^{133}Xe Contamination Measurements

Upon Receipt				Later		
Scintillation Camera (cpm)	Dose Calibrator (μCi)	G-M Detector (cpm)	Time (hr)*	Scintillation Camera (cpm)	Dose Calibrator (μCi)	G-M Detector (cpm)
			10 mCi Vials/50 mCi total†			
140	1.5	30	6	34	0	0
576	5.7	30	7	12	0	0
616	5.2	75	7.5	0	0	0
893	6.5	50	4.5	21	0	0
			20 mCi Vials/100 mCi total†			
95	0.7	30	7.5	0	0	0
221	2.1	40	6	13	0	0
529	4.4	100	6	0	0	0
759	6.9	175	7.5	0	0	0
870	8.6	100	7	26	0	0
1,751	13.2	110	4.5	35	0	0
			50 mCi Vials/350 mCi total†			
823	6.5	100	6	37	0	0
1,329	11.0	200	5	176	0	0
2,705	20.2	150	4.5	70	0.1	0
3,274	30.0	500	7	36	0	0
3,490	24.5	500	7.5	60	0.2	0

*Time after initial measurements.
†Approximate total activity at time of calibration.

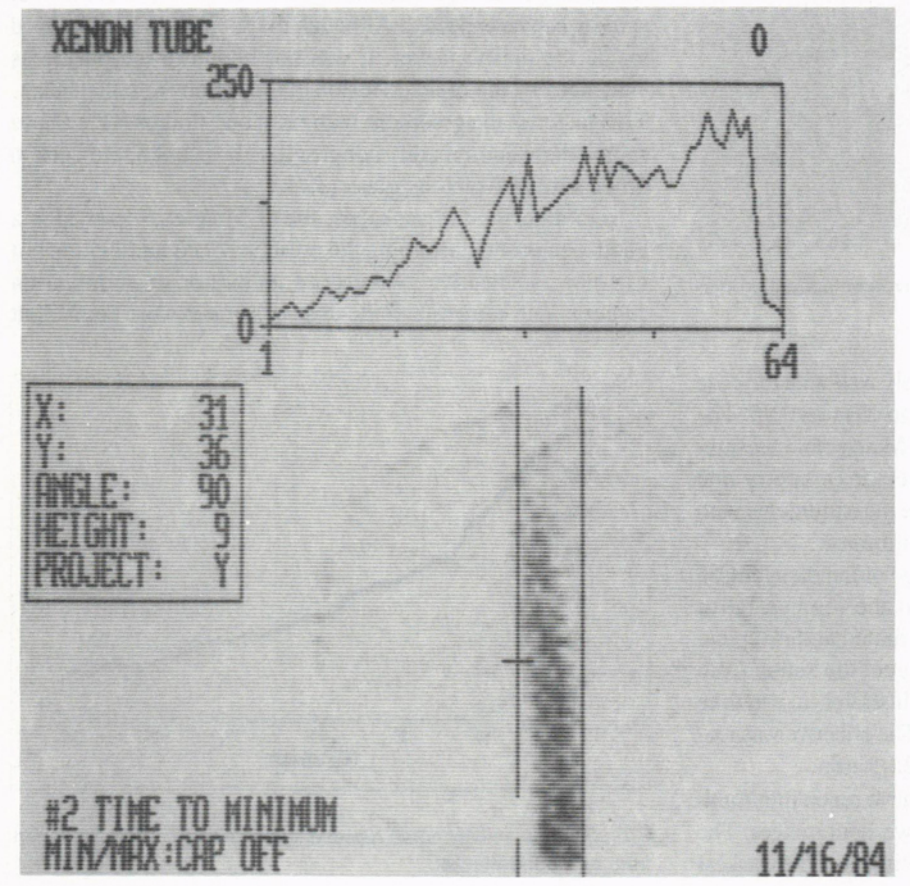

FIG. 4. Functional image of the time-to-reach minimum activity and its profile curve. The slowest areas to wash out have the largest profile values and correspond to the darkest intensities.

for detecting contamination, but the camera is an impractical device for this routine purpose. However, the availability of a dose calibrator makes it an ideal instrument for quickly determining the presence of xenon contamination in the jackets before disposal in the trash. The G-M detector is most useful for evaluating contamination of those articles which are too large for the dose calibrator.

The consistent presence of measurable ^{133}Xe contamination warrants that the receipt of radioxenon shipments include a routine survey and procedures for handling of this contaminated waste. All packages should be opened in a properly functioning fume hood. Following removal of the shielded xenon from the plastic tubes or jackets, the jackets should be stored in the fume hood with the caps removed until the next day. All other packaging materials should be surveyed to determine the presence of contamination. If contaminated, these articles should also be placed in the fume hood. By waiting until the next day, it can be assured that the xenon has been vented, and the contaminated articles are at background levels for disposal. Prudent judgement dictates that all articles be resurveyed prior to disposal in the general trash.

FOOTNOTE

*Dupont NEN Medical Products, North Billerica, MA.

ACKNOWLEDGMENTS

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