

ATTACHMENT N

ITEM 24 MONITORING, CALCULATING AND CONTROLLING AIR CONCENTRATIONS

PREFACE:

It is assumed that the facility where radioactive gas will be used is under a dedicated air handling system. This means that the air coming into the restricted area empties directly to the outside and not into a return system. It is further understood that some nuclear medicine departments will be built into an existing facility that does not have exhaust capability. In those cases this limitation should be brought to the attention of the Agency and that the **use of aerosols instead of gases should be considered.**

GENERAL PROCEDURES WHEN USING A RADIOACTIVE GAS

1. Noble gases such as Xenon in the air present an external source of radiation exposure that must be calculated. Many commercially available dosimeters and survey instruments are not capable of accurately measuring worker doses from immersion in noble gases.
2. If you will collect spent gas in a shielded trap with an effluent air contamination monitor and will follow the monitor manufacturer's instructions for checking its accuracy and constancy, initial the appropriate statement on the signature page of this attachment.
3. If you will collect spent gas in a shielded trap and will follow the model procedure shown below for checking trap effluent, initial the appropriate statement on the signature page of this attachment.
4. If you are not monitoring trap effluent or if you exhaust spent gas to the atmosphere, you must estimate worker dose by calculation. If you will follow the model procedures below for calculating worker dose from noble gases, initial the appropriate statement on the signature page of these model procedures.
5. If none of the above apply, you may develop your own procedure for review. If you do so, you should consider all the above information. Initial the appropriate statement on the signature page of this attachment.
6. If neither of the above apply, you may develop your own procedure for review. If you do so, you should consider all the above information. Initial the appropriate statement on the signature page of this attachment.
7. Where appropriate, attach copies of calculations performed.

I. MODEL PROCEDURE AND WORK SHEET FOR CALCULATING WORKER DOSE FROM CONCENTRATIONS OF RADIOACTIVE GASES IN WORK AREAS (Restricted Area)

1. Collect the following data:

Estimated number of studies per week (N):

Activity to be administered per study, in microcuries (Y):

Estimated activity lost to the work areas per study (assume 20 %) (f):

Measured airflow supply by each vent in the imaging room (if different during heating and cooling seasons, use the lesser value): (S):

Measured airflow exhaust by each vent in the imaging room (exhaust should be vented and not recirculated within the facility)(E):

Maximum permissible air concentrations in restricted and unrestricted areas. For Xe-133, the maximum permissible values are 1×10^{-4} microcuries/ml in restricted areas and 5×10^{-7} microcuries/ml in unrestricted areas (See Schedule B Article 4). (C):

2. Perform the following calculations:

Sum all exhaust rates and all supply rates. For negative pressure, the exhaust rate must be larger than the supply rate, in milliliters ($R=E-S$):

Estimate the average concentration in restricted areas.

Total activity released to the restricted area: ($A=Y \times N \times f$):

Average concentration: (A / V):
(V = Air volume of room in ml)

The total activity released to an unrestricted (activity used each week multiplied by the estimated fractional loss per study) divided by the total air exhausted (sum of all exhaust rates multiplied by the length of the work week) must be less than the applicable maximum permissible value for a restricted area.(See Schedule B, Article 4)

If the concentration is greater than the applicable maximum permissible value for a restricted area, plan for fewer studies and do the calculation again; and you may use the following example problem and table to determine your allowable patient workload by comparing required airflow and release amounts.

3. EXAMPLE PROBLEM

A nuclear medicine lab plans to use 10 mCi Xe-133 per patient and will perform a maximum of 10 studies per week. What ventilation rate is required to ensure compliance?

Maximum activity lost per week:

$$A = \frac{10 \text{ mCi}}{\text{patient}} \times \frac{10 \text{ patients}}{\text{week}} \times \frac{1 \times 10^3 \text{ microcurie}}{\text{millicurie}} \times 0.20$$

$$A = \frac{2 \times 10^4 \text{ millicurie}}{\text{week}} \times \frac{1}{1 \times 10^{-5} \frac{\text{microcurie}}{\text{ml}}}$$

$$A = 2.0 \times 10^9 \frac{\text{ml}}{\text{week}}$$

The required ventilation rate is

$$\frac{2.0 \times 10^9 \frac{\text{ml}}{\text{week}}}{40 \frac{\text{hr}}{\text{week}}} \div \frac{1.7 \times 10^6 \frac{\text{ml}}{\text{hr}}}{\frac{\text{cubic feet}}{\text{minute}}} = 30 \frac{\text{cubic feet}}{\text{minute}}$$

The answer shows that, in order to meet the requirements of AAC R12-1-408 the imaging room (RESTRICTED AREA) must have a ventilation rate of at least 30 cubic feet/min with no return of the contaminated air. Where practical, the ventilation rate should be greater than that shown necessary by the calculations. **Consider every alternative in order to maintain the air concentration of Xe-133 as low as reasonably achievable.**

The following table gives some examples of the amount of Xe-133 that can be released per week without exceeding the permissible levels for Xe-133 in restricted areas.

<u>Ventilation Rate</u> <u>(ft³/min)</u>	<u>Maximum Xe-133 Released</u> <u>per 40-Hour Week (mCi)</u>
100	67.9
500	339.7
1000	679.4

II. MODEL PROCEDURE FOR CALCULATING AIRBORNE EFFLUENT CONCENTRATION (Unrestricted Area)

1. Collect the following:

Activity released to unrestricted area in one year in microcuries (A): _____

Total volume of air exhausted over one year in milliliters ("on" time x airflow rate) (V): _____

2. Calculate the average concentration: $C = A/V$: _____

3. C must be less than or equal to the applicable maximum permissible value for an unrestricted area. If this is not the case, plan for fewer studies and do the calculation again. Alternatively, you may consider collection and decay-in-storage for waste, or restriction of access to the release point and calculation of concentration at the boundary of the restricted area. (See Schedule B, Article 4).

4. **EXAMPLE PROBLEM**

A nuclear medicine lab plans to use 10 mCi per patient and will perform a maximum of 10 studies per week. A fume hood is available for disposal of Xe-133 and has a measured airflow of 168 ft/min with an opening of 8 square feet. What is the average concentration of Xe-133 at the point of release from the fume hood exhaust? (**NOTE:** All xenon that has been released, e.g., collection bags, filters, must be considered.)

$$A = \frac{10 \text{ patients}}{\text{week}} \times \frac{10 \text{ mCi}}{\text{patient}} \times \frac{10^3 \text{ microcurie}}{\text{mCi}} \times \frac{52 \text{ weeks}}{\text{yr}}$$

$$A = 5.2 \times 10^6 \text{ microcurie/yr}$$

$$V = \frac{168 \text{ ft}}{\text{Min}} \times 8 \text{ ft}^2 \times \frac{1.49 \times 10^{10} \text{ ml/yr}}{\text{cubic feet/min}}$$

$$V = 2.0 \times 10^{13} \text{ ml/yr}$$

$$C = \frac{5.2 \times 10^6 \text{ microcurie/yr}}{2.0 \times 10^{13} \text{ ml/yr}}$$

$$C = 2.6 \times 10^{-7} \text{ microcurie/ml}$$

The following table gives some examples of the amount of Xe-133 that can be released per week without exceeding an average concentration of 5×10^{-7} microcurie/ml.

Exhaust Rate (ft^3/min)	Average Release of Xe-133 per week (mCi)
100	8.6
500	42.8
1000	85.6
1500	128.4

III. MODEL PROCEDURE FOR MONITORING OR CHECKING TRAP EFFLUENT

Charcoal traps can significantly reduce air contamination. They can also become saturated or be spoiled by improper use, humidity, chemicals, or inadequate maintenance.

1. If the trap effluent is monitored by a radiation detector designed to monitor effluent gas, check the detector according to the manufacturer's instructions and keep a record of the checks.
2. If you do not monitor the trap effluent, check it on receipt and either once each month or after every 10 patient studies, whichever comes first. Collect the effluent from the trap during one patient study in a plastic bag and then monitor the activity in the bag by holding the bag against a camera, with the camera adjusted to detect the noble gas, and comparing its counts per minute (cpm) to background cpm with no other radioactivity in the area. Keep a record of the date, background cpm, and bag cpm.
3. The RSO will establish an action level based on cpm or a multiple of background cpm. If you measure a significant increase in the bag cpm, the trap is breaking down and must be replaced.
4. Follow the trap manufacturer's instructions for replacing the trap.

IV. MODEL PROCEDURE FOR PUBLIC DOSE FROM AIRBORNE EFFLUENT

1. Effluent release presents a potential source of dose to the public. Usually a calculation of concentration at the release point is done and compared to the appropriate value of Table II of Schedule B to Article 4.
2. If you are not directly venting gases to the atmosphere, initial the appropriate statement on the signature page of this attachment.
3. If you are going to vent gases to the atmosphere, you must estimate effluent concentrations by calculation. If you will follow the model procedure shown in Section II above, initial the appropriate statement on the signature page of this attachment.
4. If neither of the above apply, you may develop your own procedure for review. If so, you should consider all the above information.

V. EMERGENCY PROCEDURES AND SPILLED GAS CLEARANCE TIME

Should there occur an accidental release of Xenon-133 into either the imaging room or the hot lab, the nuclear medicine technologists would immediately remove themselves and the patient, if feasible or applicable, from the imaging room or hot lab. The room will remain vacant until such a time as the ventilation would dilute the concentration of released Xenon-133 to levels below the MPC for restricted areas, i.e., 1×10^{-4} microcuries/ml.

Because normal room ventilation is usually not sufficient to ensure timely clearance of spilled gas, the calculations described below, should be done to determine for how long a room should be cleared in case of a gas spill. This clearance time should be posted in the room.

If you will calculate spilled gas clearance times according to the model procedure below, initial the appropriate statement on the signature page of these model procedures. If you develop your own procedure, you should consider all the above information.

VI. MODEL PROCEDURE FOR CALCULATING SPILLED GAS CLEARANCE TIME

1. Collect the following data:

Highest activity of gas in a single container, in microcuries: A:

Sum of airflow supply from each vent in the room, in ml/min (if different during heating and cooling seasons, use the lesser value): S:

The total room air exhaust determined by measuring, in ml/min, the airflow to each exhaust vent in the room. (The exhaust should be vented and not recirculated within the facility.) This may be either the normal air exhaust or a specially installed gas exhaust system: Q:

C, the maximum permissible air concentrations (MPC) in restricted and unrestricted areas. For Xenon-133, the MPC values are 1×10^{-4} microcuries/ml in restricted areas and 5×10^{-7} microcuries/ml in unrestricted areas. For other gases, see Schedule B to Article 4. C:

The volume of the room in ml: V:

2. For each room calculate the following:

Determine the net airflow in the room ($Q - S$). The value must be positive to ensure the room is at negative pressure.

The evacuation time is calculated by: $t = ((-V)/Q) \times \ln(C \times (V/A))$

**INITIAL ALL STATEMENTS WHICH APPLY TO THE FACILITY
AND SIGN AND DATE FORM AT BOTTOM.**

PREFACE:

If you plan to use aerosols, note the following:

- Aerosol should not be collected in an unshielded trap,
 - An air contamination monitor should be used with reusable traps,
 - And the manufacturer's instructions for checking for accuracy and constancy should be followed.
- Initial the appropriate statements on this page, otherwise initial the appropriate statements for use of noble gases.

WORKER DOSE FROM NOBLE GASES

- _____ Noble gas will be collected in a shielded trap and monitor the trap effluent with an air contamination monitor that we will check regularly according to the manufacturer's instructions.
- _____ Noble gas will be collected in a shielded container and will establish and implement the model procedure for checking trap effluent published in Section III of these model procedures.
- _____ The model procedure listed in Section I for calculating worker dose from noble gases will be followed.
- _____ A procedure for monitoring worker dose due to submersion in noble gases that has been developed and is appended.

WORKER DOSE FROM AEROSOLS

- _____ Spent aerosol will be collected in a shielded trap and monitor the trap effluent with an air contamination monitor that we will check regularly according to the manufacturer's instructions.
- _____ Our procedures are attached for Agency review..
- _____ Aerosols will not be used at this facility.

AIRBORNE EFFLUENT

- _____ Aerosols and gases will not be vented directly to the atmosphere and therefore no effluent estimation is necessary.
- _____ A procedure for monitoring airborne effluent concentration is attached.

SPILLED GAS CLEARANCE TIME

- _____ Spilled gas clearance times will be calculated according to the model procedure listed in Section V.
- _____ A procedure has been developed for calculating spilled gas clearance times that is appended. procedures attached.
- _____ If need be, doses will be calculated in accordance with R12-1-409.

SIGNATURE

DATE

UNIT DOSAGE RECEIPT AND USE LOG FOR _____ AS _____

DATE REC'D	SUPPLIER	LOT	DOSAGE mCi	LABEL TIME	DATE DISPENSED	TIME	MEASURE mCi	PATIENT	ID NUMBER	INIT