Safe Delivery and Administration of O-15 Gas

Purpose:

This document is written to detail safe work practices for the delivery and administration of radioactive oxygen-15 gas to the PET/MRI suite for large animal studies. Administering O-15 gas to humans is not permitted.

Policy:

This document details a step-by-step procedure to follow for the safe use of radioactive gas in the PET/MRI suite for animal experiments. This document must be read by all staff associated with the experiment. Any questions can be directed to the RSO (Charis Johnson-Antaran). A log sheet is included at the end to document staff who have read & understand this document. Staff must sign this log sheet before they can be approved by the RSO to work on the experiment. The RSO will keep this log sheet on file.

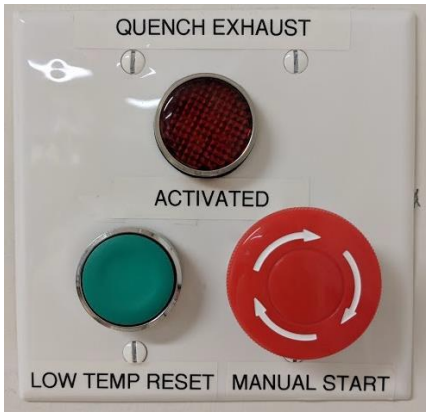
Responsibility:

PET/MRI technologists, Animal Health technicians, Principle Investigators and/or students.

Steps:

Pre O-15 gas delivery:

1. Assign a PAD (personal alarming dosimeter) to a staff member in the PET/MRI suite (PET/MRI technologist or Animal Health Technician). Record the starting value. DO NOT BRING THE PAD INTO THE PET/MRI EXAM ROOM.
2. Bring the Ludlum Model 3 Survey Meter (serial no. 125118) or the Ludlum Model 2401-P Survey Meter (serial no. 304174) from the Nuc Med Hot Lab to the PET/MRI Control Room (B5-233c) in case internal contamination monitoring is necessary.
3. Post “Danger RADIOACTIVE, Do Not Enter” signs on the door to the PET/MRI Equipment Room (B5-233f) and the door to the PET/MRI Exam Room (B5-233d).
4. Turn on PET/MRI Exam Room exhaust fan by pressing red button labelled “MANUAL START” (see picture below).
    a. Ensure that the room pressure in the PET/MRI Exam Room has changed from positive to negative by testing the airflow at the wave guides (place a piece of paper directly up against the wave guide)



5. Before the research animal arrives, prepare the room and set up ventilator equipment and tubing.
6. Vent the exhaust tank in the PET/MRI Equipment Room to ensure its pressure is close to zero. This is necessary as each O-15 run will increase the pressure by 66 psi.
    a. Ensure that the vent tubing connected to the manual exhaust valve is running through a waveguide into the PET/MRI Exam Room.
7. Close the manual exhaust vent when complete.
8. When the research animal arrives, position in the scanner.

Receipt and Administration of O-15 gas:

9. When the research animal is ready to be scanned,
    a. Turn on the compressor using the 30-minute button on the timer.
    b. Set the flow meter to 30 l/min, document time ON.
10. Lock the PET/MRI Equipment Room door.
11. Lock the PET/MRI Exam Room door.
12. Begin PET/MRI scanning
13. Phone cyclotron staff. Tell them that you are ready for radioactive gas delivery, stay on the line to confirm "go time" (actual time of gas delivery)
    a. Start a 25 minute timer at "go time".
14. **Access to the PET/MRI Exam Room and PET/MRI Equipment Room door is not permitted for 25 minutes after delivery of O-15 gas.**
15. Complete PET/MRI scanning.

Post O-15 Gas Administration:

16. After the 25 min delay, unlock the PET/MRI Equipment Room and manually vent the exhaust tank into the PET/MRI suite via the connected tubing. Ensure the tank pressure is close to zero.
17. Close the manual exhaust vent when complete.
18. Unlock the PET/MRI Exam Room doors.
19. Repeat steps 8-18 for each additional O-15 gas delivery. The exhaust tank must be vented after every O-15 gas delivery.
20. At the end of the experiment:
    a. turn off PET/MRI Exam Room exhaust fan.
    b. Record the final PAD reading.

Procedures for Unusual incidences:

Suspected Inhalation of Radioactive Gas (Internal Contamination Monitoring)

Suspected inhalation results from being near/around radioactive gas during its accidental release. The very short half-life of O-15 requires immediate use of the contamination meter during suspected unusual incidences. The contamination meter must be brought to the imaging suite prior to every O-15 gas experiment to facilitate immediate measurement of suspected internal contamination.

If inhalation of O-15 gas is suspected for any reason:

1. Calculate the estimated effective radiation dose received by staff using the following steps based on established equivalent Count Rates below (Table 1).
2. The RSO will issue an incidence report involving radioactive gas inhalation that results in an estimated lung effective radiation dose of equal to or greater than 50 µSv to the CNSC. An incidence report will also be filed with St. Joseph's Occupational Health Unit.
3. Upon request from the affected staff, the RSO will seek advice (e.g. from Medical Radiation Physicists, Nuclear Medicine Physician) to help complete a report indicating potential health risk (e.g. risk of getting additional cancers) resulting from the exposure

In an emergency situation of a fire in the PET/MRI Exam Room, magnet quench or a person pinned to the magnet, staff must follow regular emergency procedures and monitor for internal contamination as soon as possible after the incident.

Table 1-Steps to Determine Amount of Gas Inhaled and Estimated Effective Radiation Dose based on Equivalent Count Rates

Establishing Count Rate for Contamination Meter Placed Close to the Lungs*	**STEP 1: Calculate Amount of Radioactive Gas Inhaled (in MBq)** . Apply correction based on the contamination meter used:
Ludlum 2401-P → *Phantom Source = 1.00 MBq* *Count Rate = 2917 CPM*	**Ludlum 2401-P** = Recorded count rate with pancake detector close to the lungs / 2917
Ludlum Model 3 *Phantom Source = 1.00 MBq* *Count Rate = 1390 CPM*	**Ludlum Model 3** = Recorded count rate with pancake detector close to the lungs / 1390
	STEP 2: Decay Correction Record **Time of Incident** and **Time of Measurement** (with Contamination Meter). Calculated Elapsed Time, T (in **seconds**). $= \exp (T \times 0.00564\ s^{-1})$ E.g. If T = 123 s, the decay correction = 2.
	STEP 3: Calculate Effective Radiation Dose (in mSv) = (Step 1 value) x (Step 2 value) x 16 (biodistribution & extraction factor)[a] x 4.45E-4 (dose coefficient for inhalation of oxygen, mSv/MBq)[b]

*Count rate was determined using a 1.05 MBq ^{18}F point source placed in the centre of the air compartment of a torso phantom. Contamination meter was placed outside the phantom directly above the point source and allowed to stabilize. Background was subtracted from recorded count rate and measured activity was decay corrected.

[a] Steady state biodistribution of $^{15}O_2$ in lung determined by summing the vascular/metabolic activity in the lung + alveolar lung gas + dead space space / total cumulated activity in a steady state (Bigler 1983). This yields correction factor of 4, assuming we're measuring total lung activity with the contamination meter. An additional correction factor 4 is included to account for the fact that ~25% of oxygen is absorbed in the lung prior to exhalation. 4 x 4 = 16.

Bigler RE, Sgouros G. Biological analysis and dosimetry for 15O-labeled O2, CO2, and CO gases administered continuously by inhalation. J. Nucl. Med. 1983;24:431–437.

[b] Effective dose coefficient for inhalation of $^{15}O_2$ found in Table 3 of (Eckerman & Leggett 2006).

Eckerman KF and Leggett RW. Dose Coefficients and Derived Air Concentrations for Accelerator – Produced Radioactive Material. 2016 Report ORDOS/2006/01 for Oakridge National Laboratory.

Appendix- Approval of staff for work with O-15 Gas

Signing this log indicates that you have read through and understand the online Learning Edge Module "Radiation Safety: Oxygen-15 Gas" and the "Safe Delivery and Administration of O-15 Gas" procedures. You agree to follow all steps in the "Safe Delivery and Administration of O-15 Gas" procedure to ensure the safe use of O-15 gas.

Name	Signature	Date	RSO approval