Authorized User / Radiation Safety Officer Training for Veterinary Users

Module 9: Practical Use of ^{131}I Radioiodine for Feline Hyperthyroidism Treatment

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Introduction

- This module begins with a review of basic radiation safety regulations and practices.
- It then focuses specifically on the use of radioiodine (^{131}I):
  - Pet owner interview
  - Ordering
  - Receiving
  - Measuring
  - Treatment Procedure
  - Disposal
  - Patient release

- Recommended Reading:
  - Pet Owner Interview Checklist
  - Pet Owner Precautions and Release Instructions
  - Policy and Procedures manual, with template recordkeeping forms

Outline

- Properties of ^{131}I Sodium Iodide
- Potential Risks from ^{131}I contamination
- Instrumentation to detect and measure ^{131}I
- Wipe Test measurement
- Performing ^{131}I thyroid bioassay
- Hot Lab Setup
- Procedure Overview
- Treatment Workflow for Feline Hyperthyroidism
    - Selecting ^{131}I treatment dosage
    - Pre-Screening Interview
    - Written Directive
    - Ordering and Receiving Radioiodine
    - Check-in procedure
    - Treatment Procedure
    - In-house activities
    - Release Criteria
    - Release Instructions for Owners
    - Radioactive Waste Management
    - Radiation Safety Practices and Records
- Quiz (do note that some of the quiz questions deal with material that was explained in previous modules)

What Is a Radioactive Materials License?

- The US regulates the safe use of radioactive materials through the Nuclear Regulatory Commission (NRC) and Agreement States.
- A radioactive materials (RAM) license is the document that authorizes an entity to procure, possess, and manipulate sealed or unsealed radioactive materials.
- Specific regulations and procedures must be followed when handling radioactive materials, and the licensee is required to develop and maintain an approved radiation protection program.
- There are two specific roles identified on a radioactive materials license:
  - **Radiation Safety Officer (RSO)**
  - **Authorized User (AU)**

  The RSO and AU can be the same person.
- For more information, refer to supplemental reading: NUREG 1556 Volume 7.

Authorized Users (AU) and Radiation Safety Officer (RSO)

- **Authorized User:** Licensed veterinarian who is listed on a RAM license and is trained in the safe handling and use of unsealed and sealed radioactive materials. Qualified training includes one or more of the following:
  - Fellowship in radiology and / or nuclear medicine
  - Training course specific to the safe use of radioactive material
  - Preceptor attestation by an AU approved for the type of use requested
    - Authorized Users can also supervise other employees with specific, documented training. For example, a technologist could be trained to receive and check-in packages containing radioactivity, prepare a dose, and assist in injections. The technologist would be a **Supervised Individual (SI).**
- **Radiation Safety Officer:** Typically an AU or contracted consulting health or medical physicist who is trained in the state/federal regulations for the safe use of radioactive materials.
  - Responsible for the licensee's safe use of radioactive materials
  - Ensures the program is kept ALARA (staff and public radiation exposure is maintained "as low as reasonably achievable")
  - Serves as liaison with regulators

Flowchart of establishing ^{131}I treatment program

Express interest in treatment of feline hyperthyroidism using radioiodine

Register with F.X Masse Associates for training

Complete training modules 1-9, and obtain certification

Pick out a Radiation Safety Officer, Authorized User(s), location of use, and generate a floor plan

Get license application prepared (with F.X Masse Assoc.), and mail it with attachments, to your State's regulators. A license application fee may be involved.

Answer questions from application reviewers; the waiting time for license issuance can be weeks to months.

While waiting for license, get prep work done: Establish hot lab, signage, equipment, dosimetry badges and rings, and other paraphernalia. Personnel receiving and checking-in packages need specific training. **DOT/Hazmat training** to be done optionally.

If necessary, arrange for hands-on **onboarding** training of AUs and SIs with consultants or RSO. This could involve practice runs using a non- radioactive practice solution (dye) injected into animal tissue (chicken breast). Performance evaluations and re-iterations done as necessary.

Once the license is issued, make arrangements with radioisotope supplier or drug manufacturer to ship doses.

If necessary, do **practice run**(s) on animal tissue with radioactive material. This will also help you get acquainted with package receipt, check-in and security procedures, aside from refining and fine tuning injection technique, area surveys and wipe tests, handling a possible spill, and decay-in-storage. Performance evaluations and re-iterations done as necessary.

Arrange for **initial treatment**(s), after picking out suitable candidate, owner interview, etc.

On the day(s) prior to treatment: receive, check-in and secure the radioisotope treatment package

Initial treatment may be done in the presence of the RSO or a trained expert. It may happen that **onboarding, practice tun** and **initial treatment** are done very close together (maybe a day apart). Additional hands-on training for more patients may be arranged as required, until the RSO or drug manufacturer determines proficiency of personnel.

Applying for a Radioactive Materials License

- A Radioactive Materials (RAM) License is issued by the relevant government authority in an Agreement State (such as Radiation Control Program, which may be part of the Department of Public Health) or the NRC, depending on what state you are located in.

- F.X. Masse Associates will assist in preparing the license application. At a minimum, the following information must be available when the application is submitted:
    a. Name of proposed RSO, with qualifications
    b. Name of Authorized User(s), with qualifications and documentation of training
    c. Floor plan of facility, clearly showing secure (lockable) area for RAM storage, areas of use, locations of animal cages, etc.
    d. Procedural details of how RAM will be obtained, checked-in, processed, used, and wastes disposed of.
    e. Additional documentation – these can vary by state.

- You will likely be billed by the regulatory agency to process your application. More than one regulatory reviewer may be involved in granting approval. There will likely be a series of additional questions to be answered. The processing time for the application can vary from a few weeks to a few months.

- A pre-licensure inspection may also take place, wherein the regulators will tour the facility, interview the AUs proposed on the license application, in order to establish the legitimacy of the applicant before they issue the RAM license.

- Once the licensing process is underway, you may procure all the required items to run the program.

- Once the license is issued, you will have to pay an annual fee to the regulatory agency: This varies by state, and can range from $500 to $5000. The average cost is about $3000.

License Conditions

- A Radioactive Materials (RAM) License will specify the name of the licensed facility, physical address, license number and its expiration date, permitted radioisotopes, their chemical / physical forms and their possession limits, permitted address(es) of usage, names of RSO and AU(s), as well as numerous license conditions.

- License conditions may pertain to:
  - How the doses will be received
  - How radioactivity will be transported (DOT regulations)
  - How wastes will be managed (decay in storage)
  - Personal dosimetry requirements for RAM users (badges and rings)
  - Dose calibrator requirements (if any)
  - Calibration frequency of survey meters
  - Area survey for ambient dose rate and removable contamination
  - Animal release criteria
  - Annual review of radiation safety program by the RSO
  - Any additional conditions imposed by the regulator

Occupational Dose Limits

Members of the general Public (including pet owners, family, caregivers, bystanders)	Unrestricted areas: Not to exceed 2 mrem in 1 hr				
	Individuals: Not to exceed 100 mrem in 1 year (if exceeded for employees: require annual training commensurate with exposure)				
Adult Radiation Workers		**ODL**		**ALARA (10% of ODL)**	
		mrem/y	mSv/y	mrem/y	mSv/y
	Whole body (DDE) (head, neck, trunk, arms above elbows, legs above knees)	5,000	50	500	5
	Extremities, skin, organs (SDE)	50,000	5000	5,000	50
	Lens of the eye (LDE) (arms below elbows, legs below knees)	15,000	1,500	1,500	15
Minors (below 18 yrs of age)	10% of the OLDs for adults (i.e., ALARA for adults = ODL for minors)				
Declared Pregnant Workers (likely to exceed 100 mrem/yr)	Fetal dose not to exceed 500 mrem over the gestation period, and Dose in any single month not to exceed 50 mrem (the 2nd condition is an NCRP recommendation)				

Properties of Radioiodine: Sodium Iodide ($Na^{131}I$)

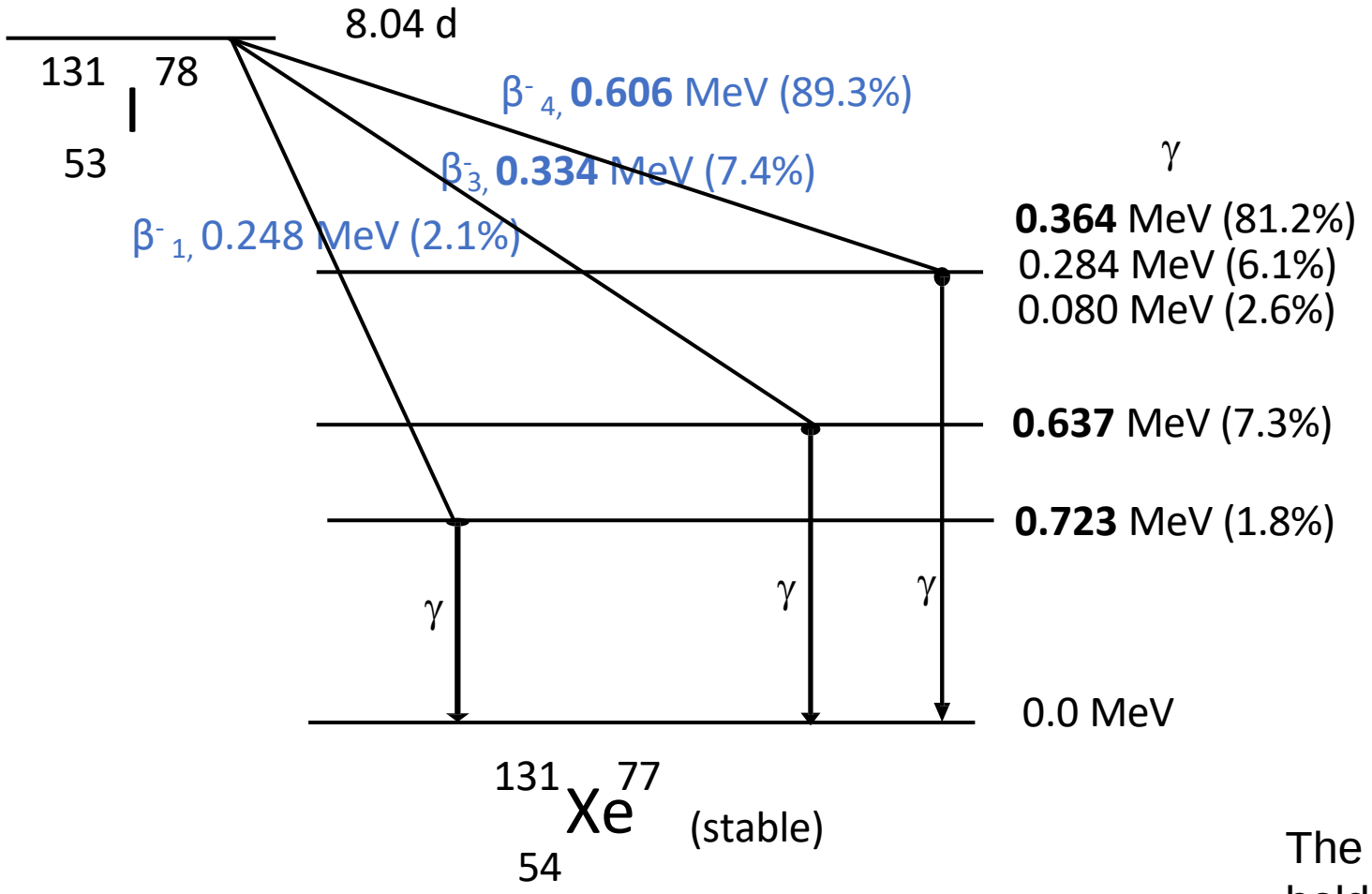
- For veterinary uses, ^{131}I is administered in the liquid form of Sodium Iodide, for subcutaneous injection. For human use, the predominant mode of administration is as capsules, except in cases where a patient is unable to swallow the capsule, in which case liquid NaI is injected.

- ^{131}I decays primarily by high energy beta-minus (β-) emissions of 6 energies, 3 of which are significant. It also emits gamma photons of 14 energies, of which 5 are significant, as well as conversion electrons of 8 energies. A simplified decay scheme is shown on the next page. The prominent emissions, with maximum and average beta energies are:

Type of Emission	Energy (MeV)		Probability of emission
	Maximum	Average	
Beta	0.606	0.192	89.3%
Beta	0.334	0.097	7.4 %
Beta	0.248	0.069	2.1 %
Gamma	0.364		81.2 %
Gamma	0.637		7.3 %
Gamma	0.723		1.8 %

(MeV x 1000 = keV)

Properties of ^{131}I Sodium Iodide ($Na^{131}I$) *(continued)*



^{131}I decay scheme (simplified)

Emission of 606 keV beta particle with 89.3% yield decreases the energy of the parent nuclide to 364 keV, which is emitted as multiple gamma photon, of energies 364, 284 and 80 keV. These are the major beta and gamma emissions of ^{131}I.

Emission of 334 keV beta particle with 7.4% yield decreases the energy of the parent nuclide to 637 keV, which is emitted as a gamma photons with 7.3% yield

Emission of 248 keV beta particle with 2.1% yield decreases the energy of the parent nuclide to 723 keV, which is emitted as a gamma photon with a yield of 1.8%.

The most prominent emissions are shown in bold. A more elaborate list is provided on the next page

Properties of ^{131}I Sodium Iodide (Na^{131}I) *(continued)*

Radiations	$E(\beta)_{max}$ (MeV)	y(i) (Bq-s)$^{-1}$	E(i) (MeV)
β- 1	0.248	2.08×10^{-02}	6.936×10^{-02a}
β- 2	0.303	6.45×10^{-03}	8.694×10^{-02a}
β- 3	0.334	7.23×10^{-02}	9.662×10^{-02a}
β- 4	0.606	8.96×10^{-01}	1.916×10^{-01a}
β- 6	0.807	3.90×10^{-03}	2.832×10^{-01a}
γ 1		2.62×10^{-02}	8.019×10^{-02}
ce-K, γ 1		3.14×10^{-02}	4.562×10^{-02}
ce-L, γ 1		4.45×10^{-03}	7.473×10^{-02b}
γ 3		2.69×10^{-03}	1.772×10^{-01}
γ 6		6.12×10^{-02}	2.843×10^{-01}
ce-K, γ 6		2.50×10^{-03}	2.497×10^{-01}
γ 11		2.73×10^{-03}	3.258×10^{-01}
γ 13		8.15×10^{-01}	3.645×10^{-01}
ce-K, γ 13		1.56×10^{-02}	3.299×10^{-01}
ce-L, γ 13		2.44×10^{-03}	3.590×10^{-01b}
γ 15		3.59×10^{-03}	5.030×10^{-01}
γ 16		7.16×10^{-02}	6.370×10^{-01}
γ 17		2.17×10^{-03}	6.427×10^{-01}
γ 18		1.77×10^{-02}	7.229×10^{-01}
Kα1 X-ray		2.68×10^{-02}	2.978×10^{-02}
Kα2 X-ray		1.45×10^{-02}	2.946×10^{-02}
Auger-L		5.62×10^{-02}	3.430×10^{-03a}

Emissions of ^{131}I.

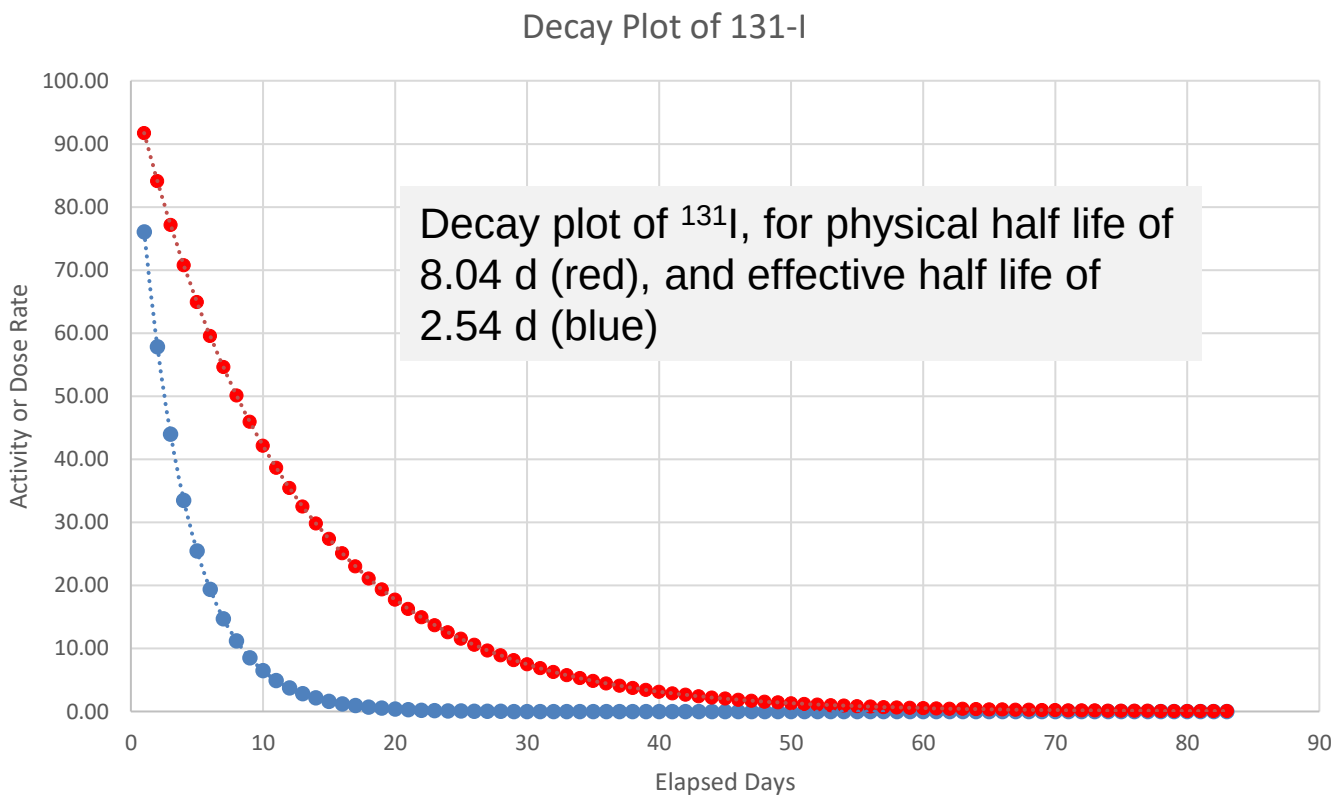
Source: Johnson, T.E, and B.K. Birky, 2012. Health Physics and Radiological Health, 4th ed. Lippincott Williams and Wilkins.

Properties of ^{131}I Sodium Iodide ($Na^{131}I$) *(continued)*

- The physical half life of ^{131}I is **8.04 days.**
- In Hyperthyroid cats, its effective half life has been estimated by different researchers as **2.3** or **2.54 days**.
- The high energy beta particles from ^{131}I can travel **1.65 meters (5.4 feet) in air**, **2 mm in water**, and **0.5 to 2 mm** (average **0.8 mm) in thyroid tissue**. The mechanism of action is bombardment of hyperthyroid cells by these beta particles, causing cell death and thereby rendering the cat euthyroid or hypothyroid.
- The dose rate over an unshielded 1 mCi dose of ^{131}I is **2200 mR/h** at 1 cm; this value is its gamma exposure rate constant (Γ) . Its beta and gamma emissions can present an external hazard to the skin and eyes. Accidental uptake of ^{131}I can present a significant internal hazard, with the thyroid being the critical organ affected.
- The appropriate shielding for ^{131}I is lead. Steel provides shielding as well. Low density materials such as plastic, acrylic, plexiglass or wood do not provide any shielding value.
- HVL of lead for gamma emissions of ^{131}I is **0.23 cm,** and linear attenuation constant (μ) is **3.01 cm^{-1}.**
- Stochastic ALI (Allowed Limit of Intake) of ^{131}I is 90 µCi for oral ingestion, and 200 µCi for inhalation
- Non-stochastic ALI of ^{131}I is 30 µCi, with Thyroid as critical organ
- The DAC (Derived Air Concentration) for ^{131}I is 2 x 10^{-8} µCi/ml

Properties of ^{131}I *(continued)*

Decay Chart for I-131 (Tp = 8.04 d)					
Days	Decay factor	Days	Decay factor	Days	Decay factor
1	0.917	11	0.387	21	0.164
2	0.842	12	0.355	22	0.150
3	0.772	13	0.326	23	0.138
4	0.708	14	0.299	24	0.126
5	0.650	15	0.274	25	0.116
6	0.596	16	0.252	26	0.106
7	0.547	17	0.231	27	0.098
8	0.502	18	0.212	28	0.089
9	0.460	19	0.194	29	0.082
10	0.422	20	0.178	30	0.075



Useful Conversion Factors

1 mCi = 37 MBq = 0.37 GBq 1 MBq = 27 µCi = 0.027 mCi

1 mR/h = 0.88 mrem/h 1 mrem/h = 1.136 mR/h

Specific Interaction Properties of Radioiodine: Sodium Iodide ($Na^{131}I$)

- The thyroid gland synthesizes the hormones thyroxine or tetra-iodo-thyronine (T_4) and tri-iodo-thyronine (T_3). Both these molecules which are derivatives of the amino acid tyrosine, contain iodine atoms: the former has 4, and the latter, 3 iodine moieties. The iodine required for this synthesis is transported into the thyrocytes by the sodium / iodide symporter from the blood, and subsequently enters the iodide cycle: a series of transport, oxidation and coupling steps. Excessive thyroid hormone secretion results in hyperthyroidism, a condition characterized by elevated basal metabolic rate – which in turn results in food being burned up faster, generate more body heat, and hyperactivity.

- The thyroid cannot differentiate between stable iodine and radioactive iodine when presented as sodium iodide. When $Na^{131}I$ is administered to a hyperthyroid cat, it is taken up actively, to be utilized to synthesize hormones. The concentration of iodine in the thyroid gland is 500 times that in the blood. The cell-killing action of ^{131}I is derived from its beta emission, while the local irradiation (radiation dose) comes 90% from beta, and 10% from gamma photons. The beta particles penetrate 0.5 to 2 mm into the thyroid follicles, causing the cells to undergo pyknosis (irreversible condensation of chromatin in the nucleus), necrosis, and fibrosis of the gland. The process can take several weeks to achieve fibrosis.

- The gamma emission of ^{131}I makes it suitable for nuclear medicine imaging using a planar or SPECT gamma camera.

Potential Risks from ^{131}I contamination

- Due to its accumulation in the thyroid, ^{131}I contamination presents a unique organ-based risk for radiation workers. The occupational risk is thyroid cancer.

- The thyroid cancer risk is higher for children: compared to adults, the risks increase by a factor of 2 for every 5 year's decrease in age below 15 years. The unborn fetus is extremely vulnerable to ^{131}I accumulation, and may undergo thyroid ablation if exposed *in utero*.

- Due to these reasons, pregnant women (irrespective of whether they are declared pregnant workers or not), are conventionally excluded from handling liquid ^{131}I. This includes Authorized Users and Supervised Individuals, and is applicable for all operations involving radioiodine treatment: injection, handling doses, caring for treated cats, and handling wastes.

- For the same reasons, once the cat is released, pregnant women and children (under 18 yrs for a safe margin) are instructed not to touch, or care for the cat for 2 weeks.

- Beyond 2 weeks, any remaining risks are negligible.

Instrumentation to detect and measure ^{131}I

- A Ludlum Model 3 (or a Ludlum 14C) base unit with two probe holders – one for the 44-3, and one for a 44-9 pancake probe with a flattening filter, is the recommended setup for ^{131}I. The 44-9 probe is well suited for package surveys, ambient dose rate surveys and wipe tests for removable contamination. When fitted with the flattening filter, it can be used for cat release survey measurements. A critical aspect of the use of ^{131}I radioiodine is the performance of thyroid bioassays, for which a 44-3 NaI gamma scintillation probe is ideal.

Wipe Test measurement: Ludlum 44-9 (^{131}I)

- Turn on the meter and perform a battery check and verify check source reading.
- Place the pancake probe on a clean lead brick to obtain background reading in mR/h (typically 0.02 to 0.05 mR/h, on the x0.1 scale).
- Wipe an area of 100 cm^2 (about the size of a postcard).
- Place the wipe on the lead brick with the “dirty” side up.
- Place the probe directly over the wipe. Place a counterweight on the probe if necessary, to hold it steady.
- Allow the unit to settle and take a gross reading/measurement, on the SLOW toggle switch. Watch the needle over 30 sec, to obtain the average value in mR/h.
- Each division on the x0.1 scale above background represents 200 dpm for ^{131}I
- Ten divisions on the x0.1 scale above background represent 2000 dpm for ^{131}I
- This method bypasses the need to obtain cpm values and divide by efficiency to obtain dpm.

For a background of 0.03 mR/h in this example, 0.04 mR/h is the trigger for unrestricted areas (200 dpm), and 0.13 mR/h is the trigger for restricted areas (2000 dpm). Contamination levels exceeding triggers require cleanup.

Performing ^{131}I thyroid bioassay using a Ludlum 44-3 Scintillation Probe

- In humans, ^{131}I will accumulate in the thyroid following such contamination in 48-72 hours. A bioassay should be capable of detecting trace amounts (nCi, or nanocurie quantities) of ^{131}I in the thyroid.

- During annual calibration, the response of an NaI probe to ^{125}I and ^{131}I are measured for a human thyroid geometry, and a calibration provided on the calibration sticker as cpm/nCi.

- Measurements are done in a low-background area, away from sources of ^{131}I. A background measurement is done by holding the probe against the inner thigh, and observing the reading in cpm for 30 seconds. The thyroid measurement is then done by holding the probe against the crook of the neck, between the sternocliedomsatoid (SCM) muscles, and observing the reading over 30 seconds.

- Example calculation: if background (thigh) reading is 120 cpm, the thyroid reading is 500 cpm, and calibration value on the meter is 23 cpm/nCi: Net reading = 500 – 120 = 380 cpm. Bioassay = 380 cm ÷ 23 cpm/nCi = **17 nCi**.

- In the event that a facility cannot get its base unit and 44-3 probe calibrated for thyroid ^{131}I measurements, there are other alternatives, such as a dedicated thyroid counter, or connecting the 44-3 to a Ludlum model 2200 scaler.

Thyroid Bioassay for ^{131}I handlers

- The purpose of a thyroid bioassay is to assess whether internal contamination of a radiation worker has happened during the handling of a liquid ^{131}I dose. Inhalation, ingestion and uptake through the skin are pathways for contamination, and can occur accidentally while preparing dose or injecting at cat, or while cleaning up a spill.

- Thyroid bioassays are required for anyone who handles a ^{131}I dose, or cares for a treated cat (with potential for skin injury from being scratched) , or cleans up a spill: in short, for anyone who has potential contact with liquid ^{131}I.

- The guidance document for radioiodine bioassays is **NRC Reg Guide 8.20**, Rev 2, 2014, APPLICATIONS OF BIOASSAY FOR RADIOIODINE, which supersedes Revision 1, 1979, APPLICATIONS OF BIOASSAY FOR I-125 AND I-131. The 2014 version is included in supplementary material. [Note that on Table 1 of that document, the non-stochastic ALI for ^{131}I is quoted wrongly as 50 µCi instead of 90 µCi.]

- RG 8.20 quotes handling 1 mCi of volatile ^{131}I as the level that requires a bioassay. A baseline bioassay is recommended before starting work with ^{131}I. Guidance on medical consultation is provided in NCRP Report 161

- The **PAL** (Predetermined Action Levels) for ^{131}I are:

  If the activity exceeds **1 µCi** (1000 nCi): Investigate the operations involved; repeat the bioassay within 24 hours.
  If the activity exceeds **5 µCi** (5000 nCi): In addition to the above actions, seek medical attention.

- For a NaI probe with a calibration factor of 25 cpm/nCi (for example), the net cpm on the thyroid would have to be 25,000 cpm to hit PAL-1, and 125,000 cpm to hit PAL-2

Hot Lab Setup for ^{131}I

- A radiation "hot lab" is where radioactive materials are prepared for diagnosis and therapy.
- It must have a secure (lockable) area for storing the material, and entry is restricted to trained radiation workers.
- The hot lab is a **Restricted (Controlled) Area**: Absolutely no food or beverage consumption or storage, or application of cosmetics is allowed. Only trained Radiation Workers are allowed entry.
- A hot lab that handles gamma emitters should include the following equipment:
  - 'L" Block shield made of lead with leaded glass window
  - Syringe shield – Lead or Tungsten, with leaded window
  - Shielded waste storage container (lead lined); this may be placed in a different lockable room
  - Appropriate survey meters: Two Ludlum Model 3 (or model 14C) meters with 44-3 NaI probe and 44-9 pancake probe with energy flattening filters

    One meter will serve as a backup in case the primary meter becomes non-functional, needs repair, or is taken for annual calibration.
  - Plastic or steel tray(s) to contain potential radioactive spills
  - Spill Kit to clean up radioactive spills
  - Dose calibrator, with calibration sources for its QC (optional for Veterinary use)
  - For the most part, localized shielding is used for radioactivity in a hot lab; therefore, the use of leaded dose containers and syringe shields are critical to shielding. For ^{131}I treatment, the walls or floors likely need added lead shielding, the thickness of which will exceed the $1/16^{th}$ inch typically used in x-ray rooms.
- A technician working in hot lab should always wear disposable gloves, a lab coat, a ring dosimeter, and a whole-body dosimeter to monitor any occupational radiation dose received while working with radioactivity.

Hot Lab Signage and Documentation Requirements

The following signage is required to be posted in a hot lab:

1. Notice to Workers: post on the wall or bulletin board [(1)]
2. A notice card indicating where your printed hard-copy of current license, license conditions and regulations (10CFR35 or state-equivalent) is kept
3. Contact information for the Authorized User and Radiation Safety Officer (post in a conspicuous location)
4. "Caution Radioactive Material" signs on the door of the hot lab, on the sealed source container, and on the shielded waste container. The universal sign for radioactivity is the **trefoil symbol**

Caution Signs and their meanings:

CAUTION RADIOACTIVE MATERIALS - dose rate less than 5 mrem in 1 h @ 30 cm from shielded source
CAUTION RADIATION AREA - dose rate greater than 5 mrem in 1 h @ 30 cm from shielded source
CAUTION HIGH RADIATION AREA - dose rate greater than 100 mrem in 1 h @ 30 cm from shielded source
VERY HIGH RADIATION AREA - dose rate greater than 100 rad in 1 h @ 100 cm from shielded source

- For veterinary nuclear medicine, the following information must be documented and kept on file:
  - Patient name and ID, name of drug , prescribed dose, determined dose, date and time of dose determination, and name of the technician.
  - Regulatory records such as daily closeout surveys, weekly wipe tests, annual training records, individual patient records, and dosimetry results
  - It is important to maintain the required documentation in a concise, organized manner to make your regulatory inspections as transparent and easy as possible.

(1): This is the NRC form for non-agreement states: https://www.nrc.gov/reading-rm/doc-collections/forms/nrc3info.html
Agreement states have their own versions of the Notice to Workers posting.

Procedure Overview for ^{131}I

- ^{131}I NaI is generally supplied as a unit dose, customized for a patient, and generally does not need additional preparation. The dose must be maintained at room temperature. Freezing the dose increase volatility, creating airborne radioactive contamination. Opening the syringe pig and placing the dose in a syringe shield is done behind the lead L-shield. The dose is transported to the injection table in a leaded container.

- Most facilities use a unit dose without adjusting its activity. A dose calibrator is not necessary in such cases. The activity specified by the manufacturer for the particular date and time can be re-calculated by decay correction.

- If manipulation of doses (decreasing the activity in a syringe, or increasing its activity by combining unused doses) is intended, then a dose calibrator is required. This also triggers the requirement for dose calibrator QC with sealed sauces of ^{57}Co and / or ^{137}Cs.

- A syringe holder is a small lead container which temporarily holds a prepared syringe. The technologist carries the syringe in the syringe holder to the patient for injection to avoid unnecessary radiation exposure during the process.

- After the radioactive medicine is injected into the patient, the syringe is transferred into a shielded waste storage container to “decay in storage” until the radioactivity decays to background level, when it can be disposed of as regular trash. Alternatively, it can be returned to the manufacturer if DOT requirements are met.

- After the procedure, a GM survey meter is used to check whether there is any radioactive contamination in the facility.

Treatment Workflow for Feline Hyperthyroidism using ^{131}I

- Consultation with pet owner on health issues. Select radioisotope therapy if appropriate (including physical exam / blood work, etc).
- Interview pet owner to determine if they can comply with instructions post-release. Proceed ONLY if you have firm and reasonable assurance that instructions will be followed.
- Explain restrictions depending on radioisotope. Examples:
  - The Pet will be released only after 4 days; and may be held for more days
  - Close contact with pet only for xx minutes per day per person, for xx days
  - No co-sleeping allowed for xx days
  - Pregnant women and children may not be allowed to be close to pet for xx days
  - Flushable kitty litter may have to be used. Will the home's septic system allow it?
  - Urine / feces may have to be collected and stored for xx days
  - If the pet passes away during xx days / weeks, its body will have to be brought back to the faculty and frozen for xx months

  DO NOT PROCEED WITH THE TEATMENT IF YOU HAVE <u>ANY DOUBTS</u> ABOUT OWNER COMPLIANCE.
- Determine radioisotope dosage in mCi. Order from radiopharmacy, and prepare for treatment.
- Receive the dose; perform check-in procedures per DOT regulations.
- After treatment, perform area surveys for daily closeout; decontaminate spills to within trigger levels.
- Monitor pets in holding, in the restricted area.
- Perform bioassay on all required personnel, if applicable.
- Measure radiation dose from pet to determine if it can be released, after required holding time. NO VISITAITON IS PERMITTED DURING THE HOLDING TIME
- Have pet owner sign off on instructions and restrictions.
- Perform weekly surveys and wipes. Document results.
- Perform Decay-in-Storage for radioactive wastes. Maintain documentation.
- Meet / perform other regulatory obligations (survey meter calibrations; annual ALARA audit; pay annual DPH fees to maintain license; respond to periodic questionnaires from the DPH, such as the annual low level waste survey).

Selecting ^{131}I treatment dosage

- A detailed dosing regimen for feline hyperthyroidism treatment is not within the scope of this training. Authorized Users are expected to be proficient in the clinical aspects of treatment, for instance by collaborating with other AUs who perform similar treatments. Documentation of such training will be required during license application.

- Examples of several dosing regimens have been published in scientific journals. Some utilize SPECT imaging using ^{99m}Tc as part of the protocol. The majority of cases use **2 to 4 mCi** of ^{131}I, with approx. **3 mCi** being the most favored. Few examples are listed below:

- Peterson M. E, and M. Rishniw. 2021. A dosing algorithm for individualized radioiodine treatment of cats with hyperthyroidism. *J Vet Intern Med*. 35(5):2140-2151. https://doi.org/10.1111/jvim.16228

- Morré W. A, D. L Panciera, G. B Daniel, W. E. Monroe, and S. Werre. 2018. Investigation of a novel variable dosing protocol for radioiodine treatment of feline hyperthyroidism. *J Vet Intern Med*. 32:1856–1863. https://doi.org/10. 1111/jvim.15296

- Vagney, M., L. Desquilbet, E. Reyes-Gomez, F. Delisle, P. Devauchelle, M. I. Rodriguez-Piñeiro, D. Rosenberg, and P. de Fornel-Thibaud. 2018. *Journal of Feline Medicine and Surgery*, 20(6): 528-534. https://journals.sagepub.com/doi/full/10.1177/1098612X17718416

Pre-Screening Interview

Because the treatment material is radioactive, a pre-screening interview must be conducted with the pet owner to verify that they (and their family) can meet certain time and distance restrictions to maintain their radiation dose below the federally mandated public dose limit of 100 mrem/year. They must understand that their pet will be radioactive for a certain amount of time (several weeks).

The following points must be discussed:

- If the cat is on Hill's prescription Y/D diet; that must be discontinued at least 2 weeks prior to treatment. Antithyroid medication such as Tapazole (methimazole) must be discontinued al least 1 week prior to treatment. Other diet / medications may be recommended.
- The cat will have to remain hospitalized for at least 96 hours (4 complete days). If the release criteria (0.25 mR/ @ 12 inches) is not achieved at that time, the cat will have be hospitalized longer, and the duration could be as high as 2 weeks or more.
- The cat's favorite toy or blanket may be provided by the owner, but such items will not be returned because they will be treated as radioactive waste, and disposed of.
- When the cat is in the hospital, no visitors will be allowed, because treated animals are housed in a restricted area.
- Petting / co-sleeping / holding restrictions will last at least 2 weeks after release.
- Children (under 18 yrs) and pregnant women will not be allowed to have any contact with the cat whatsoever for 2 weeks, including caring for the cat, handling its wastes, cleaning it, cleaning up any vomitus, etc.
- To the extent possible, the cat should be confined to a single room for 2 weeks.

Pre-Screening Interview *(continued)*

- If the cat were to need medical attention during the 2 weeks after discharge, it must be brought to the ^{131}I treating facility; if not, the veterinarian / provider must be informed that the cat has had radioiodine treatment, and should contact the treating facility for possible handling precautions.
- Flushable kitty liter must be used, and flushed down the drain for 2 weeks. If not feasible (due to septic system or other restrictions), all kitty litter and potentially contaminated items from the first 2 weeks must be stored for 80 days (rounded to 3 months) before disposal. Disposable gloves, or dedicated rubber gloves must be used while handling wastes, and the waste must be stored in an isolated area, away from people and animals.
- It is extremely important that the owners DO NOT dispose of kitty litter, or any items potentially contaminated with radioiodine in household trash until the 80 day holding period is over. Trash transfer stations have powerful radiation monitors that scan every incoming dumpster truck for radioactive materials, in the interests of homeland security. They are sensitive enough to detect ^{131}I contaminated materials in the truck, and if detected, the owner's residence is easily traceable. The residence will be visited by law enforcement personnel and State hazmat teams, and may result in significant fines and charges by the trash disposal company for isolating the waste and holding it for decay (potentially thousands of dollars).
- If the cat were to die within a 2 week period after treatment, its body has to be frozen for two and a half months (10 physical half lives of 80 days applies in this case).

The owners must be interviewed prior to the treatment to determine if such restrictions can be met. Owner instructions must be signed, and a copy retained at the facility. If they are unwilling or incapable of meeting restrictions, the animal is not a candidate for radioisotope treatment.

It becomes the AU's responsibility to get a reasonable feel for where the owners will follow these instructions. If any doubt persists, it is better not to treat the cat with radioiodine.

Written Directive

A prescription for radioisotope therapy is called a Written Directive. A sample format is presented here:

Written Directive
For Administration of Iodine-131 for Feline Hyperthyroidism

TO BE COMPLETED AND SIGNED BY AU BEFORE THERAPY

Pet Name: _____

Patient ID Number or MRN: _____ Date of birth: _____

Owner's name: _____

Clinical condition: _____
(functional thyroid adenoma, toxic nodular goiter, malignant carcinoma, etc.)

Procedure requested by: _____
(name of veterinarian)

Radiopharmaceutical: ^{131}I Prescribed Dosage:_____ mCi

Route of Administration (check one): SC injection

Proposed treatment date: _____

Special precautions / patient instructions provided? _____

Authorized User: _____
Name (PRINT) Signature Date Time

Ordering and Receiving Radioiodine

- ^{131}I doses are typically ordered as unit doses, and are calibrated to decay to a specific activity at a given time, for example, 2.5 mCi at 9 am on the proposed treatment date. Doses may be ordered to arrive a day (or more) earlier, to facilitate check-in.

- The facility has to provide a copy of the current radioactive materials license to the vendor, such as Cardinal Health, Jubilant, or RLS (formerly GE Healthcare), prior to setting up a deliveries.

- Deliveries are made in ammo cases or softboxes, and contain one or more doses in lead or tungsten containers. The cases are heavy, and hand carrying them over a distance is not recommended. The dose vendor must be provided written instructions (initially and annually) on where in the building the deliveries are to be made – generally to a lock box, or hot lab / treatment room. Lock box keys, or code for combination lock may be provided to the courier, or they may me picked up by the courier upon arrival. Alternatively, site personnel may escort the courier to the drop off location, and lock the door after the delivery is made. The delivery method needs to be specified, along with the route the courier will take inside the building, as part of the licensing paperwork.

- Once delivered, the dose must be secured under lock and key until use. Specific check-in procedures must be completed **within 3 hours** after the dose is delivered to the facility.

- The individual who checks-in the package must have **DOT/HAZMAT training** initially (within 90 days of starting such activity), and every 3 years thereafter. Training can be arranged via an online tutorial with F.X Masse Associates.

Radioactive package Marking and Labeling

Radioactive Material Packages have MARKINGs and LABELs.

Radioiodine will arrive in a package with Type A Package Markings and a Radioactive White I or Yellow II label

RADIOACTIVE WHITE-I Label: The Entire label has white background, and the 'I' is in red.

RADIOACTIVE YELLOW - II Label: Top half of the triangle is in yellow, and the 'II' is in red.

RADIOACTIVE YELLOW - III Label: Top half of the triangle is in yellow, and the 'III' is in red.

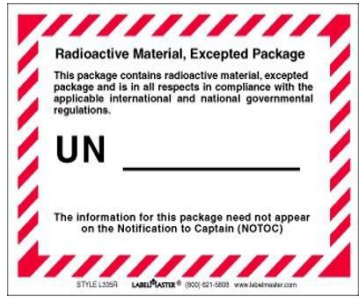
Radioactive Material
Type A Package, UN 2915

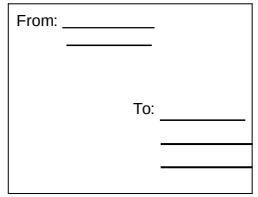
USA DOT 7A Type A

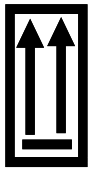
UN 2910

UN 2911

RQ **115 lbs**







Examples of common radioactive package **markings**. These include proper shipping names, package types, UN numbers, and From/To addresses, orientation markers, and weights. For excepted packages, the candy-striped UN number sticker is optional; a simple sign stating the UN number (UN 2910) can be used instead.

Specific DOT training is available through FX Massé Associates at www.fxmasse.com

The choice of White I, Yellow II and yellow III depend on the measured dose rate at the surface of the package.
Ensure that trained / informed personnel are available on-site to accept the delivery with signature.
Delivery drivers WILL NOT leave the package unattended outside the facility and walk away.

Check-in procedure

- 'Checking in' means performing a survey, wipe test, and filling out paperwork to document receipt of the package:
  - Perform package survey as described below.
  - Perform package wipe test (procedure described on page 18).
  - Fill out package receipt paperwork, as shown in the example that follows.
- If the contents are free of contamination and meet DOT dose rate requirements, the doses can be used.
- If the package is wet, crushed or leaking, Inform the RSO. Unless it is determined not to be a spill from the syringe, treat the package as radioactive waste and do not use it; set it aside for dacay-in-storage.
- Survey method: Use the Ludlum model 3 or 14C, with pancake GM probe (model 44-9 or equivalent), and survey all 6 sides of the package, along the surface. While moving the meter during survey, do not exceed a speed of 1 inch per second. For an Excepted Package, no other survey is necessary. For a White I, Yellow II or Yellow III package, also survey all 6 sides at a distance of 1 meter (3.3 feet). This is best accomplished by placing the package on the floor or a workbench, holding the ratemeter at 1 meter, and noting the mR/h reading. Flip the package 5 more times so each side can be similarly measured. Note down the HIGHEST reading on the surface and at 1 meter. The table below lists maximum allowable dose rates. You are allowed to subtract natural background (0.02 to 0.05 mR/h) from the measured readings, but for most practical purposes, the packages should meet these standards even without background subtraction.
- Wipe test method: Perform a wipe test on the outer surface of the container. Open the container, and extract the individual pigs / canisters containing dose syringes. Wipe test the outside of each canister as well. The permissible contamination level is shown on the table (next page).

Check-in procedure *(continued)*

Allowable maximum dose rates for different types of Packages			
Type of package	**Surface dose rate (mrem/h)**	**Dose rate at 1 meter (mrem/h)**	**Transport Index (TI)**
Excepted (UN 2910)	< 0.5	N/A	N/A
White I	< 0.5	< 0.05	N/A
Yellow II	> 0.5 but < 50	> 0.05 but < 1.0	0.1 to 1.0
Yellow III	> 50 but < 200	> 1.0 but < 10.0	1.0 to 10.0
Maximum permitted package wipe test result			
< 2,200 dpm / 100 cm^2. Can be scalable, such as < 6.600 dpm / 300 cm^2. (2,200 dpm works out to 1 nanocurie of contamination, irrespective of what the radioisotope is)			

TI is a unitless number, and refers to the dose rate at 1 meter rounded up to the first decimal point. It is applicable only for Yellow II and Yellow III packages

Check-in procedure *(continued)*

Fill out the Record for check-in of radioisotope.

If the containers is free from contamination, set it aside to be returned to the vendor, after putting the used syringe back in the pig.

RADIOACTIVE MATERIALS RECEIPT SURVEY

RECEIPT SURVEY PROCEDURE

Use Ludlum Pancake GM Probe. Measure dose rate on the surface of the container. Next measure at 1 meter (3.3 feet) from container surface. Wipe test the outer container and syringe surfaces. Compare against action levels posted. If dose rates are very different or surface contamination is found, **notify RSO.**

Measurement		Type of Package (EP, W-1, Y-2, Y-3)	Dose	Surface	1 Meter	Trasport	Surface Wipe Test	Initials	Retn.
Date	Time		mCi or GBq	mR/hr	mR/hr	Index	dpm / 100 cm^2		Pkg ?

✓ if <u>return package</u> external dose rates and wipe tests are within trigger levels

Treatment Procedure

- Only personnel whose presence is essential must be present in the treatment room. This generally includes one or more SIs (Supervised Individuals, such as a technicians or nurses) to hold the cat, an AU (Authorized User, generally the veterinarian listed on the RAM license) to perform the injection.

- Prepare the cage by laying down absorbent material (chux) and taping it securely; and positioning water, kitty litter, etc. as needed. The cage must be labeled with the cat's name, other relevant details, and must have a '**Caution Radioactive Materials**' sign.

- All personnel in the room must be wearing buttoned-down lab coats, pants, closed-toe footwear, and gloves. Face masks are preferred by many users to avoid getting splashed by the cat's body fluids. Heavy-duty leather gloves to hold the cat steady and prevent scratching may be needed.

- All personnel who handle a radioiodine dose or an injected cat must also be wearing dosimetry badges and rings.

- The subcutaneous Injection is generally done on the scruff of the neck, on the injection table.

- Immediately after the injection, transfer the cat to its cage, and survey all work areas for possible spills / hot spots. Decontaminate if / as necessary.

- It is good practice to measure the dose rate from the cat at 24 hour intervals. To make measurements consistent, it is best place the cat in a small / tight carry-cage to prevent movement; place it at a pre-determined location marked on the floor such that the GM probe can be held at 12 inches from its neck. Readings should be posted and updated.

In-house activities

- Wellness checks and routine care of treated cats may only be done by Supervised Individuals (who receive annual radiation safety training).

- Cat owners may be provided updates as needed, including pictures or videos, or by face-timing. However, personnel must be aware of the dose rates close to the cage (updated every day and posted), and minimize time spent in the treatment room to the extent possible.

- Cat wastes / kitty litter should be removed as necessary, following hospital policy and procedures. All wastes must be bagged and placed in a dedicated, labeled waste container which is lead-shielded.

- At the end of each day, survey all 'cold' trash cans in the treatment room to ensure no radioactive material has been inadvertently placed in them. Document this in in the end-of-day closeout.

- Periodically, wastes may be moved to a long term storage area, where they will be held for up to 10 physical half lives (80 days) for **decay-in-storage (DIS)** before being surveyed and released as regular trash. It is best to bag accumulated wastes, and label it with a number, start and end date.

- Ensure that **NO** signs, trefoil symbols, or labels indicating 'radioactivity' make their way into wastes that are held for DIS.

- In the 48-72 hour period after injection, all personnel who handled the ^{131}I dose perform a thyroid bioassay and document results.

Release Criteria

- It is strongly recommended to follow the release guidelines provided by the NRC (NUREG 1556 Vol 7 Rev 1, Appendix D):

- A cat can be released after treatment with ^{131}I when –

  (a) It is held for not less than **96 hours** (**4 complete days**), AND

  (b) Exposure rate at **12 inches** from the cat is less than **0.25 mR/h** (or less than 1 mR/h at 6 inches), AND

  (c) Written instructions are provided to the owners, AND

  (d) it is demonstrated that a member of the general public will not receive >**2 mrem in 1 hr**, and >**100 mrem in 1 yr** from the treated and released cat.

- If ANY of the above criteria (primarily, 0.25 mR/h at 12 inches) are not met, the cat must be held longer, until its exposure rate decreases to this level. While the majority of cats treated with 3 mCi will achieve this, some may not, requiring longer hospital stays.

- Criteria (a) and (d) are analyzed on the next page. Means to achieve criteria (d) has to be part of release instructions to the owners, and is achieved by prohibiting petting and co-sleeping for 2 weeks, and drastically limiting the time a cat can be touched in any 1 hour.

Release Criteria *(continued)*

- Criteria (a), exposure rate of **0.25 mR/h at 1 foot** (30 cm), translates to 225 mR/h at 1 cm, by inverse square calculation. Given that the gamma constant for ^{131}I is 2200 mR/h per mCi at 1 cm, the exposure rate of 225 mR/h translates to an activity of 0.1 mCi. Assuming that the injected activity is 3 mCi, for this dose to decrease down to 0.1 mCi indicates a half life of merely 20 hours, which is significantly more conservative than the assumed effective half life of 2.54 days (60.96 hrs), or the physical half life of 8.04 days (193 hrs).

- Criteria (d) stipulates that no individual member of the general public will receive more than **2 mrem in 1 hr** from the cat. At the time of release, assuming the cat measures 0.25 mR/h at 1 foot: This translates to 0.22 mrem/h. Assuming that the ^{131}I is located as a point source in the thyroid, 1 inch below the fur of the cat, the dose rate translates to 31.7 mrem/h on the cat's fur by inverse square calculation. This means, anyone touching the cat will potentially be receiving 2 mrem in 3.8 min, or 3 min and 48 sec. Therefore, stipulating that an individual may touch the treated cat for no more than **3 min in any 1 hr** period, and that too only for wiping the cat (or for a similar necessity), will ensure that the 2 mrem in 1 hr standard is easily met. This itself is an overly conservative estimate, since the calculated dose here is for the hands of the person, and not to their whole body, which is what the standard is for. A 2 week restriction period will be sufficient.

- Criteria (d) also stipulates that no individual member of the general public will receive more than **100 mrem in 1 yr** from the cat. Assuming that at the time of release the dose at 1 foot is 0.25 mR/h (i.e, 0.22 mrem/h): An individual would have to spend 454 hours at 1 foot from the cat to receive a 100 mrem dose, with the dose rate being constant (non-decaying) during this time: which is an absurd proposition. Performing a more realistic, but extreme assessment: If the dose in the cat at the time of release is 0.1 mCi (as shown above), and the restriction period is 2 weeks, the 0.1 mCi dose will decay to 0.03 mCi assuming physical decay alone (ignoring biological elimination). At the end of the restriction period, if an individual spends 8 hours per day (which translates to an occupancy factor of 0.33), every day, at 1 foot from the cat, the cumulative dose to that individual would be about **7 mrem**. The calculation is shown on the next page. The 100 mrem in 1 year standard is therefore also easily met.

Release Criteria *(continued)*

Example 1. Using the assumptions on the previous page: a cat is treated with 3 mCi ^{131}I; dose in the cat is down to 0.1 mCi at time of release, and further decays to 0.03 mCi at the end of the 2 week restriction period. Suppose the person we are talking about is Crazy Cat Lady from The Simpsons. If Eleanor Abernathy spends a third of her day with the cat, every single day (after the restriction period of course) at a distance of 1 foot, what is her cumulative dose from the cat? How many of her cats could she treat in a year, assuming similar behavior?

This can be calculated using modification to Equation B-1 in Reg Guide 8.39, 2020, 'Release of patients administered radioactive material', which was assigned reading in module 7.

$$D(\infty) = \frac{34.6\,\Gamma\,Q_o T_p E}{r^2}$$

Where $D(\infty)$ is the dose to infinity in rem; 34.6 is a constant (24h/d *total integration of decay, 1.44); Γ is gamma constant, Q_0 is the initial activity in mCi; T_p is physical half life, E is occupancy factor, and r is distance in cm

https://simpsons.fandom.com

Answer:

In this case, Γ = 2.2 R/h per mCi @ 1cm; Q_0 = 0.03 mCi; T_p = 8.04 d; E = 8h/24h = 0.33, and r = 30 cm.

Therefore, dose = (34.6)(2.2)(0.03)(8.04)(0.33) / (30^2) = 0.0067 rem = **6.7 mrem**

Eleanor could treat 14 of her cats in a year, and still be below the general public dose limit.

Release Instructions for Owners

Recommendations from NUREG 1557 Vol 7 may be used to formulate instructions. Example:

Instructions to Caretakers of Cats treated with ^{131}I for Hyperthyroidism

Your cat _____ (name) has been treated with _____ mCi of radioactive material [radioiodine, ^{131}I] on _____, and still contains a low level of radioactivity. The present level of radioactivity is below the regulatory agency level necessary for isolating the animal from humans. Because some radioactivity will be present for the next few weeks, it is necessary that the following safety precautions be exercised for the **next 2 weeks**:

Avoid public transportation; avoid staying in public accommodations (e.g., hotels). Transport your cat in its carrier as far from passengers as is reasonable and safe for the animal.

To the extent possible, the cat should be confined to a single room, and not let outdoors.

The cat should not be permitted to have any contact with children under the age of 18, or pregnant women, including handling its wastes. Close contact (only necessary grooming, cleaning) should be limited to less than 3 minutes in any 1 hour, and less than 20 minutes overall per adult individual, in a day.

Preferably, distance with the cat should be kept to a distance of more than 1 meter or 3 feet for this period.

Use plastic litter pan liners and scoopable litter.

Disposable gloves should be worn whenever handling animal waste, including changing the litter box.

Wash hands after contact with the animal or the litter.

Call _____ to discuss any other radiation safety concerns.

Radioactive Waste Management

- Store all radioactive wastes in a restricted area, which is locked and posted with a Caution Radioactive Materials Sign (this indicates a dose rate < 5 mR/h at 30 cm). This can be a dedicated room, or your Hot Lab.
- Ensure that no 'radioactive' signs, wording, labels, etc. are put into the waste bin, since these will go out as 'regular' trash once decay-in-storage (DIS) is complete. Such items must be obliterated with a permanent marker pen.
- Label each waste bag with its number, start date and end date.
- Survey a remote waste room weekly, or after a bag of wastes is added. Wipe testing is not required on the drums or the room.
- At the end of the holding period (80 days, or 3 months), each waste bag is surveyed, and disposed of as regular trash if it reads no more than background radiation.

Signage for restricted areas

Dedicated radioactive waste receptacle: note waste log on top of container. For temporary / hot lab storage, the container must be lead lined. For long term DIS in a remote area, steel drums may be acceptable

- Maintain documentation for DIS, including bag number, date of storage, date of disposal, background reading, bag reading at time of disposal and initials of the individual. It is <u>not necessary</u> to estimate or document the amount (mCi) of ^{131}I in the waste, or to measure the dose rate of a waste bag at the start of disposal.

Radiation Safety Practices and Records

- At each stage of the treatment where there is a possibility of a leakage of spill, the GM survey meter is utilized to survey and check for ambient dose rate and contamination. After the procedure, all equipment and paraphernalia, all trash containers, hands and feet of personnel, floors, injection table, and areas around the animal housing cage are thoroughly surveyed.

- The used syringe may be stored in its case for pickup by the vendor's courier when he/she delivers the next set of doses. Alternatively, syringes are stored in a leaded sharps container for Decay-In-Storage.

- At the end of each day that a cat is held after treatment, an ambient survey is done, and the daily closeout form is completed. This is done in conjunction with cleaning out kitty litter / feeding the cat; the dose rate outside each cage is noted.

- Once a cat is released, its cage is cleaned out; the chux is carefully surveyed for contamination and set aside for DIS if necessary. If the absence of contamination is confirmed, it may be put it regular 'cold' trash.

- A thorough area survey and wipe test is performed weekly (or during cage cleanup after a cat's release), and documented. Remote waste rooms are surveyed weekly.

- Once an area survey and wipe test are documented, the next survey only needs to be done when another cat is treated; weeks of 'non-use' may be indicated on the daily closeout record.

- If a spill happens, most likely during injection, an **AREA CONTAMINATION FORM** and a **PERSONNEL CONTAMINATION FORM** are completed.

- Thyroid bioassays are performed and documented.

Radiation Safety Practices and Records *(continued)*

- Initial and annual radiation safety instruction is provided to all radiation workers, including AUs and SIs. Additionally, anyone expected to exceed 100 mrem DDE has to have documented training.
- Annual training / instructions /notifications are made to the dose vendor and the local fire department (if required by regulations).
- DOT /HAZMAT training is done initially and once every 3 years (per US DOT requirements) by personnel involved in receiving and checking-in packages, and preparing return shipments. T
- Dosimeters are exchanged at the end of each wear period (monthly or quarterly). Personnel dosimetry records and area monitoring badge data are reviewed periodically (typically quarterly).
- Survey meters are calibrated annually, and documentation (calibration certificates) maintained.
- An annual RSO ALARA audit is documented, to include personal dosimetry summary, status of signs and postings, review of surveys, wipes, incoming shipment records, waste management records, spills, personnel contamination, bioassay records, annual training, license changes and survey meter calibrations. This document is generally requested by regulators during inspections.
- A detailed **POLICY and PROCEDURE MANUAL** is maintained, to cover all aspects of radioisotope use at the facility.
- All records are retained for 3 years or 5 years (depending on the type of record) for regulatory review.