Appendix F

GUIDELINES FOR BIOASSAY REQUIREMENTS FOR TRITIUM

Nuclear Regulatory Commission

Division of Fuel Cycle and Material Safety

October 19, 1977

AB/REA

BIOASSAY REQUIREMENTS FOR TRITIUM

I. Conditions Requiring Bioassay

A. Routine Bioassay is required when quantities processed by an individual at any one time, or total amount processed per month, exceed those for the respective forms of tritium as shown in the attached Table 1.

B. Above 0.1 of, but less than, the levels in Table 1, routine bioassay is required unless a written justification is submitted for not performing bioassays.

C. Except as stated in I.D. below, bioassay is not required for process quantities less than 0.1 of those in Table 1.

D. Special bioassay measurements should be performed to verify the effectiveness of respiratory protection devices and other protective clothing. If an individual wearing a respiratory protective device or protective clothing is subjected to a concentration of tritium in air (in any form) such that his or her intake with no protection would have exceeded that which would result from exposure for 40 hours per week for 13 weeks at uniform concentrations of tritium in air as specified in Appendix B, Table I, Column I, 10 CFR 20,* bioassays should be

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*Multiplying the concentration given in Appendix B, 5×10^{-6} μCi/ml, by 6.3×10^{8} ml gives the corresponding quarterly intake of tritium by inhalation. This is assumed equal to the uptake of tritium (as HTO) by absorption through the skin unless the form of tritium in the air can be demonstrated to have lower uptakes. The total uptake, including skin absorption, would be assumed to be about 6.3 mCi, which delivers a dose commitment of about 1.25 rems to standard man.

$(5 \times 10^{-6}\ \mu c/ml) \times (6.3 \times 10^{8}\ ml) = 3.15 \times 10^{3}\ \mu c$

3.15 mc

performed to determine the resulting actual tritium intake. These special bioassay procedures should also be conducted, for personnel wearing respirators, if for any reason the average tritium concentration in air and the duration of exposure are unknown.

II. Who Should Participate

All workers involved in the processing of tritium, under conditions specified in I above, or sufficiently close that intake is possible, should participate.

III. What Types of Bioassays Should be Performed

A. Baseline (including Pre-employment, or Pre-operational Urinalysis, not more than one month prior to beginning work with tritium requiring bioassay under Section I above).

B. Routine Urinalysis

C. Post-operational. Within one month of last possible exposure to tritium.

D. Diagnostic. Within one week of any sample exceeding levels given as action points in Section V below. See V.A.2.(d).

IV. How Often

A. Initial Routine Samples

Within 48 hours following entry of an individual into an area where operations require bioassay according to Section I.A and

B above, and then every two weeks or more frequently thereafter as long as the individual is working with ^{3}H.

B. After 3 Months

The sampling frequency selected in accordance with Section IV.A above may be changed to quarterly if, after 3 months, the following 3 conditions are met:

(1) The average urinary tritium concentration from specimens obtained during the 3-month period does not exceed 3 μCi/l,

(2) Where measurements of the concentration of tritium in air are required as a condition of the license, the quarterly average concentration (μCi/ml) to which workers are exposed, multiplied by the factor 6.3×10^{8} ml, does not exceed 0.8 mCi, and

(3) The working conditions during the 3-month period, with respect to the potential for tritium exposure, are representative of working conditions during the period in which a quarterly urinalysis frequency is employed, and there is no reasonable expectation that the criteria given in (1) and (2) above will be exceeded.

V. Action Points and Corresponding Actions

A. Bi-Weekly or More Frequent Sampling

1. If urinary excretion rates exceed 5 μCi/liter, but are less

than 50 μCi/liter, the following course of action should be taken:

(a) a survey of the operations involved, including air and area monitoring, should be carried out to determine the cause(s) of exposure and evaluate potential for further larger exposures.

(b) Implement any reasonable corrective actions indicated in the survey that may lower the potential for further exposures.

(c) A repeat urine sample should be taken within one week of the previous sample and should be evaluated within a week after collection.

(d) Any evidence from (a) and (b) indicating that further work in the area might result in an employee receiving a dose commitment in excess of the limits established in §20.101 should serve as cause to remove the employee from work in this operation until the source of exposure is discovered and corrected.

2. If urinary excretion rates exceed 50 μCi/liter, the following course of action should be taken:

(a) Carry out all steps as in 1.(a) to (d) above.

(b) If the projected dose commitment exceeds 5 rems, report the incident to the NRC in accordance with §20.403 of 10 CFR Part 20.

(c) Refer the case to appropriate medical/health physics consultation for recommendations regarding therapeutic procedures that may be carried out to accelerate removal of tritium from the body and reduce the dose as low as reasonably achievable.

(d) Carry out repeated sampling (urine collections of at least 100 ml each) at approximately one-week intervals, at least until samples show an excretion rate less than 5 μCi/liter. If there is a possibility of long-term organic compartments of tritium that require evaluation, continue sampling as long as necessary to ensure that appreciable exposures to these other compartments do not go undetected.

B. Quarterly Sampling

Carry out actions at levels as indicated under A. above, and if the excretion rate continues to exceed 5 μCi/liter, also reinstitute biweekly (or more frequent) sampling for at least the next 6-month period, even when urinary excretion falls below 5 μCi/liter.

TYPES OF OPERATION	HTO FORM (& forms other than those on right-hand cols.)	HT or T_2 GAS IN SEALED PROCESS VESSELS	NUCLEOTIDE PRECURSORS	HTO MIXED WITH MORE THAN 10K$_g$ OF INERT H_2O OR OTHER SUBSTANCES
PROCESSES IN OPEN ROOM OR BENCH, WITH POSSIBLE ESCAPE OF TRITIUM FROM PROCESS VESSELS	0.1 Ci	100 Ci	0.01 Ci	0.01 Ci/K$_g$
PROCESSES WITH POSSIBLE ESCAPE OF TRITIUM, CARRIED OUT WITHIN A FUME HOOD OF ADEQUATE DESIGN, FACE VELOCITY, AND PERFORMANCE RELIABILITY	1 Ci	1000 Ci	0.1 Ci	0.1 Ci/K$_g$
PROCESSES CARRIED OUT WITHIN GLOVEBOXES, ORDINARILY CLOSED, BUT WITH POSSIBLE RELEASE OF TRITIUM FROM PROCESS AND OCCASIONAL EXPOSURE TO CONTAMINATED BOX AND BOX LEAKAGE	10 Ci	10,000 Ci	1 Ci	1 Ci/K$_g$

Table 1

ACTIVITY LEVELS OR CONCENTRATIONS ABOVE WHICH BIOASSAY SHALL BE REQUIRED

Quantities present (< 10Kg) may be considered either the amount processed by an individual at any one time (when accidental intake is more likely), or the amount of activity entered into process (throughput) during any one month (when routine handling of repeated batches is the more likely source of exposure). Concentrations in the right-hand column may be used when activity in process is always diluted in more than 10K$_g$ of other reagents, as in nuclear reactor coolant systems.

U.S. NUCLEAR REGULATORY COMMISSION

Revision 1
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REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

Appendix G

REGULATORY GUIDE 8.20

APPLICATIONS OF BIOASSAY FOR I-125 AND I-131 **

A. INTRODUCTION

Section 20.108, "Orders Requiring Furnishing of Bioassay Services," of 10 CFR Part 20, "Standards for Protection Against Radiation," indicates that the Nuclear Regulatory Commission (NRC) may incorporate into a license provisions requiring a specific program of bioassay measurements as necessary or desirable to aid in determining the extent of an individual's exposure to concentrations of radioactive material. In certain cases, the requirement of bioassay may also be included in the license by reference to procedures specifying in vivo measurements, measurements of radioactive material in excreta, or both.

This guide provides criteria acceptable to the NRC staff for the development and implementation of a bioassay program for any licensee handling or processing I-125 or I-131. It further provides guidance to such licensees regarding the selection of workers who should participate in a program to detect and measure possible internal radiation exposure. The guide is programmatic in nature and does not deal with measurement techniques and procedures.

B. DISCUSSION

The topics treated in this guide include determinations of (1) whether bioassay should be performed, (2) frequencies of bioassay, (3) who should participate, (4) the actions to take based on bioassay results, and (5) the particular results that should initiate such actions.

For the user's convenience, the following terms are presented with their definitions as used in this guide.

Bioassay-The determination of the kind, quantity or concentration, and location of radioactive material in the human body by direct (in vivo) measurement or by analysis in vitro of materials excreted or removed from the body.

Intake-The total quantity of radioactive material entering the body.

In vivo measurements-Measurement of gamma- or x-radiation emitted from radioactive material located within the body for the purpose of detecting or estimating the quantity of radioactive material present.

In vitro measurements-Measurement of radioactivity in samples of material excreted from the human body.

C. REGULATORY POSITION

1. Conditions Under Which Bioassay Is Necessary

a. Routine[1] bioassay is necessary when an individual handles in open form unsealed[2] quantities of radioactive iodine that exceed those shown in Table 1 of this guide. The quantities shown in Table 1 apply to both the quantity handled at any one time or integrated as the total amount of activity introduced into a process by an employee over any 3-month period.

b. When quantities handled in unsealed form are greater than 10% of Table 1 values.

**Lines indicate substantive changes from previous issue

[1] Routine means here that an individual is assigned on a scheduled and repeatable basis to submit specimens for bioassay or to report for in vivo measurements. Either radiochemical bioassay of urine or in vivo counting is acceptable to the NRC staff for estimating internal radioactivity burdens or intakes. In some cases, however, a licensee may wish to corroborate estimates from urinalysis data with in vivo determinations. Since there are adequate references in the literature to help devise bioassay measurements, this guide does not include recommended analytical procedures. Each installation should adopt procedures or obtain services best suited to its own needs.

[2] See discussion in the footnote to Table 1 of this guide.

routine bioassay may still be necessary under certain circumstances. A written justification for not performing such measurements should be prepared and recorded for subsequent review during NRC inspections whenever bioassay is not performed and the quantities handled exceed 10% of the levels in Table 1.

c. Except as stated in regulatory position 1.e, bioassay is not required when process quantities handled by a worker are less than 10% of those in Table 1.

d. In nuclear reactor installations, employees should be bioassayed by an in vivo count within 30 days after the end of exposure in work locations where concentrations exceeded, or might have exceeded, 9×10^{-9} μCi/ml averaged over any 40-hour period. Table 1 and regulatory position 4 regarding frequency of bioassays are not applicable to reactor licensees.

e. Special bioassay measurements should be performed to verify the effectiveness of respiratory protection devices and protective clothing. If an individual wearing a respiratory protective device or protective clothing is subjected to a concentration of I-125 or I-131 (in any form) in air such that his or her intake with no protection would have exceeded the limits specified in paragraph 20.103(a)(1) of 10 CFR Part 20,[3] bioassays should be performed to determine the resulting actual I-125 or I-131 intake. These special bioassay procedures should also be conducted for personnel wearing respirators if for any reason the I-125 or I-131 concentration in air and the duration of exposure are unknown or cannot be conservatively estimated by calculation.

2. Participation

All workers handling radioactive iodine or sufficiently close to the process so that intake is possible (e.g., within a few meters and in the same room as the worker handling the material) should participate in bioassay programs described in regulatory position 1.

[3]Multiplying the concentrations given in Appendix B to 10 CFR Part 20, Table I, Column 1, 5×10^{-9} μCi/ml for I-125 (soluble) and 9×10^{-9} μCi/ml for I-131 (soluble), by 6.3×10^{6} ml gives the corresponding quarterly intake of the respective iodines by inhalation. These quarterly intakes would be about 3.2 μCi for I-125 and 5.7 μCi for I-131, which would give a thyroid dose commitment of about 7.5 rems to a 20-gram thyroid integrated over all future time using effective half-lives of 41.8 days for I-125 and 7.6 days for I-131 and using a quality factor (QF) of 1.7 to calculate effective disintegration energy in the case of I-125. (This QF of 1.7 is used for conservatism, even though the International Commission on Radiological Protection (1969) and the National Council on Radiation Protection (1971) have published a QF of 1, because some calculations in more recent scientific literature have suggested the use of QF values higher than 1 for electron or beta energies of 0.03 MeV or less.)

3. Types of Bioassays That Should Be Performed

a. Baseline (preemployment or preoperational). Prior to beginning work with radioactive iodine in sufficient quantity that bioassay is specified in regulatory position 1.

b. Routine. At the frequency specified in regulatory position 4.

c. Emergency. As soon as possible after any incident that might cause thyroid uptakes to exceed burdens given in regulatory position 5.a(2), so that actions recommended in regulatory position 5.a(2)(b) can be most effective.

d. Postoperational and with Separation Physical. A bioassay should be performed within 2 weeks of the last possible exposure to I-125 or I-131 when operations are being discontinued or when the worker is terminating activities with potential exposure to these radionuclides.

e. Diagnostic. Followup bioassay should be performed within 2 weeks of any measurements exceeding levels given as action points in regulatory position 5 in order to confirm the initial results and, in the case of a single intake, to allow an estimate of the effective half-life of radioiodine in the thyroid.

4. Frequency

a. Initial Routine. Except in situations where thyroid burdens may exceed quantities specified in regulatory position 5.a(2), a bioassay sample or measurement should be obtained within 72 hours following entry of an individual into an area where bioassay is performed in accordance with regulatory positions 1 and 2 (but waiting at least 6 hours for distribution of a major part of the iodine to the thyroid[4]) and every 2 weeks or more frequently thereafter as long as the conditions described in regulatory positions 1 and 2 exist. When work with radioactive iodine is on an infrequent basis (less frequently than every 2 weeks), bioassay should be performed within 10 days of the end of the work period during which radioactive iodine was handled (but not sooner than 6 hours unless emergency actions to obtain an early prognosis and thyroid blocking treatment are appropriate[4]).

b. After 3 Months. When a periodic measurement frequency has been selected in accordance with regulatory position 4.a, it may be changed to quarterly if, after 3 months, all the following conditions are met:

(1) The average thyroid burden for each individual working in a given area was

[4]NCRP Report No. 55, "Protection of the Thyroid Gland in the Event of Releases of Radioiodine," National Council on Radiation Protection and Measurements, Washington, D.C., August 1, 1977, p. 21.

less than 0.12 μCi of I-125, less than 0.04 μCi of I-131, and less than the corresponding proportionate amount[5] of a mixture of these nuclides during the initial 3-month period:

(2) The quarterly average radioiodine concentration (μCi/ml) in air breathed by any worker (as obtained when measurements of radioiodine concentrations in air are required) does not exceed 25% of the concentration values for "soluble"(s) iodine given in Appendix B to 10 CFR Part 20, Table I, Column 1, (5×10^{-9} μCi/ml for I-125 and 9×10^{-9} μCi/ml for I-131), i.e., 25% of these concentrations multiplied by the total air breathed by an employee at work during one calendar quarter, 6.3×10^{8} ml, does not exceed 0.8 μCi of I-125 or 1.4 μCi of I-131. The appropriate proportionate amount[5] of a mixture of these nuclides should be used as a guide when both I-125 and I-131 are present; and

(3) The working conditions during the 3-month period with respect to the potential for exposure are representative of working conditions during the period in which the quarterly bioassay frequency will be employed, and there is no reasonable expectation that the criteria in regulatory positions 4.b(1) and 4.b(2) above will be exceeded.

c. After Use of Respiratory Protection Devices. Between 6 and 72 hours after respiratory protective devices, suits, hoods, or gloves are used to limit exposure as stated in regulatory position 1.e.

For individuals placed on a quarterly schedule, sampling should be randomly distributed over the quarter but should be done within one week after a procedure involving the handling of I-125 or I-131. This will provide a more representative assessment of exposure conditions

5. Action Points and Corresponding Actions

a. Biweekly or More Frequent Measurements

(1) Whenever the thyroid burden at the time of measurement exceeds 0.12 μCi of I-125 or 0.04 μCi of I-131, the following actions should be taken:

(a) An investigation of the operations involved, including air and other in-plant surveys, should be carried out to determine the causes of exposure and to evaluate the potential for further exposures.

(b) If the investigation indicates that further work in the area might result in exposure of a worker to concentrations that would cause the limiting intakes established in § 20.103 of 10 CFR Part 20 to be exceeded, the licensee should restrict the worker from further exposure until the source of exposure is discovered and corrected.

(c) Corrective actions that will eliminate or lower the potential for further exposures should be implemented.

(d) A repeat bioassay should be taken within 2 weeks of the previous measurement and should be evaluated within 24 hours after measurement in order to confirm the presence of internal radioiodine and to obtain an estimate of its effective half-life for use in estimating dose commitment.

(e) Reports or notification must be provided as required by §§ 20.405, 20.408, and 20.409 of 10 CFR Part 20 or as required by conditions of the license pursuant to § 20.108 of 10 CFR Part 20.

(2) If the thyroid burden at any time exceeds 0.5 μCi of I-125 or 0.14 μCi of I-131, the following actions should be taken.

(a) Carry out all steps described in regulatory position 5.a(1).

(b) As soon as possible, refer the case to appropriate medical consultation for recommendations regarding therapeutic procedures that may be carried out to accelerate removal of radioactive iodine from the body. This should be done within 2-3 hours after exposure when the time of exposure is known so that any prescribed thyroid blocking agent would be effective.[4]

(c) Carry out repeated measurements at approximately 1-week intervals at least until the thyroid burden is less than 0.12 μCi of I-125 or 0.04 μCi of I-131. If there is a possibility of longer-term compartments containing I-125 or I-131 that require evaluation, continue measurements as long as necessary to ensure that appreciable exposures to these other compartments do not go undetected.

b. Quarterly Measurements. Carry out actions at levels as indicated under regulatory position 5.a(1) and (2). If measurements and surveys indicate an appreciable likelihood that a worker will receive further exposures exceeding the criteria of regulatory positions 4.b(1) and 4.b(2), reinstitute biweekly or more frequent bioassays.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding

[5] See Appendix B to this guide for a description and example of using this condition for mixtures

the NRC staff's plans for using this regulatory guide.

Except in those cases in which the applicant or licensee proposes an acceptable alternative method, the staff will use the methods described herein after December 15, 1979, in evaluating the radiation protection programs of licensees who have bioassay requirements incorporated in their licenses in accordance with § 20.108 of 10 CFR Part 20.

If an applicant or licensee wishes to use the method described in this regulatory guide on or before December 15, 1979, the pertinent portions of the application or the licensee's performance will be evaluated on the basis of this guide.

Table 1

ACTIVITY LEVELS ABOVE WHICH BIOASSAY FOR I-125 OR I-131 IS NECESSARY

Types of Operation	Activity Handled in Unsealed Form Making Bioassay Necessary*	
	Volatile or Dispersible*	Bound to Nonvolatile Agent*
Processes in open room or bench, with possible escape of iodine from process vessels	1 mCi	10 mCi
Processes with possible escape of iodine carried out within a fume hood of adequate design, face velocity, and performance reliability	10 mCi	100 mCi
Processes carried out within gloveboxes, ordinarily closed, but with possible release of iodine from process and occasional exposure to contaminated box and box leakage	100 mCi	1000 mCi

*Quantities may be considered the cumulative amount in process handled by a worker during a 3-month period, e.g., the total quantity introduced into a chemical or physical process over a 3-month period, or on one or more occasions in that period, by opening stock reagent containers from which radioactive iodine may escape. Quantities in the right-hand column may be used when it can be shown that activity in process is always chemically bound and processed in such a manner that I-125 or I-131 will remain in nonvolatile form and diluted to concentrations less than 0.1 mCi/mg of nonvolatile agent. Capsules (such as gelatin capsules given to patients for diagnostic tests) may be considered to contain the radioiodine in nonfree form, and bioassay would not be necessary unless a capsule were inadvertently opened (e.g., dropped and crushed). However, certain compounds where radioiodine is normally bound are known to release radioiodine when the material is in process, and the left-hand column may then be applicable. In those laboratories working only with I-125 in radioimmunoassay (RIA) kits, the quantities of I-125 are very small and in less volatile forms; thus, bioassay requirements may be judged from the right-hand column. In field operations, where reagent containers are opened outdoors for simple operations such as pouring liquid solutions, the above table does not apply; bioassay should be performed whenever an individual employee handles in open form (e.g., an open bottle or container) more than 50 mCi at any one time.

Operations involving the routine use of I-125 or I-131 in an open room or bench should be discouraged. Whenever practicable, sealed bottles or containers holding more than 0.1 mCi of I-125 or I-131 should be opened at least initially within hoods having adequate face velocities of 0.5 m/sec or more.

$\frac{.5\,M}{sec} \times \frac{39''}{M} \times \frac{1\,ft}{12''} \times \frac{60\,sec}{1\,min} = 1.97\,ft/min$

$97.5\ ft/min$

APPENDIX A

SUGGESTED REFERENCES TO ASSIST IN ESTABLISHING A BIOASSAY PROGRAM

In response to public comments, this list of publications is provided to assist the licensee in establishing measurements and administrative procedures for a bioassay program appropriate to his operations. This list is not intended to be exhaustive and does not replace the need for professional assistance in establishing analytical procedures or services.

1. American National Standard, ANSI N44.3-1973, "Thyroid Radioiodine Uptake Measurements Using a Neck Phantom," American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018, approved August 24, 1973.

2. R. C. Brown, "^{125}I Ingestions in Research Personnel," Operational Health Physics, pp. 276-278, 1976, proceedings of the Ninth Midyear Topical Symposium of the Health Physics Society, Denver, Colorado, February 1976 (P. L. Carson, W. R. Hendee, and D. C. Hunt, Eds., Central Rocky Mountain Chapter, Health Physics Society, P.O. Box 3229, Boulder, Colorado 80303, $15).

3. E. J. Browning, K. Banerjee, and W. E. Reisinger, Jr., "Airborne Concentration of I-131 in a Nuclear Medicine Laboratory," J. Nucl. Med., vol. 19, pp. 1078-1081, 1978.

4. J. G. Dare and A. H. Deutchman, "The Decay Scheme of Iodine-125 and Its Relationship to Iodine Bioassay," op. cit., Ref. 2, pp. 250-254.

5. B. C. Fasiska, "Radiation Safety Procedures and Contamination Control Practices Involved in High Level I-131 Thyroid Therapy Cases," op. cit., Ref. 2, pp. 287-291.

6. A. Gavron and Y. Feige, "Dose Distribution and Maximum Permissible Burden of ^{125}I in the Thyroid Gland," Health Physics, vol. 23, pp. 491-499, 1972.

7. B. Y. Howard, "Safe Handling of Radioiodinated Solutions," op. cit., Ref. 2, pp. 247-249.

8. ICRP Publication 10, "Report of Committee IV on Evaluation of Radiation Doses to Body Tissues from Internal Contamination Due to Occupational Exposure," Recommendations of the International Commission on Radiological Protection, Pergamon Press, Oxford, p. 17, 1968.

9. ICRP Publication 10A, "The Assessment of Internal Contamination Resulting from Recurrent or Prolonged Uptakes," Recommendations of the International Commission on Radiological Protection, Pergamon Press, Oxford, 1969.

10. A. L. Orvis, "What Is a 'Reportable' Thyroid Burden?" op. cit., Ref. 2., pp. 268-271.

11. P. Plato, A. P. Jacobson, and S. Homan, "In Vivo Thyroid Monitoring for Iodine-131 in the Environment," Int. J. Applied Radiat. and Isotopes, vol. 27, pp. 539-545, 1976.

12. Radiological Protection Bulletin 25, "Safe Working with Iodine-125," National Radiological Protection Board, Harwell, Didcot, Oxon, England, pp. 19-20, 1978.

13. R. P. Rossi, J. Ovadia, K. Renk, A. S. Johnston, and S. Pinsky, "Radiation Safety Considerations in the Management of Patients Receiving Therapeutic Doses of ^{131}I," op. cit., Ref. 2, pp. 279-286.

14. C. T. Schmidt, "Thyroid Dosimetry of ^{125}I and an Instrumental Bioassay Procedure," Program and Abstracts: Twenty-Third Annual Conf. on Bioassay, Environmental, and Analytical Chemistry, IDO-12063, Sept. 15, 16, 1977.

15. A. Taylor, J. W. Verba, N. P. Alazraki, and W. C. McCutchen, "Monitoring of I-125 Contamination Using a Portable Scintillation Camera," J. Nucl. Med., vol. 19, pp. 431-432, 1978.

16. Technical Reports Series No. 148, "Control of Iodine in the Nuclear Industry," International Atomic Energy Agency, Vienna, 1973.

APPENDIX B

CALCULATION OF ACTION LEVELS FOR MIXTURES OF I-125 AND I-131

B.1 Controlling Instantaneous Thyroid Burdens

Regulatory position 4.b(1) is based on controlling the instantaneous amount in the thyroid and is taken as 25% of the maximum permissible organ burden (MPOB) of I-125 or I-131 that would give a dose rate of 0.6 rem/week if continuously present in the thyroid. If a mixture of both nuclides is present in the thyroid and X is the fractional activity that is I-125, a 3-month interval may be resumed when the total activity of I-125 and I-131 is below

$$0.12X + 0.04(1 - X)$$

Example

If the measurements of I-125 and I-131 in a worker's thyroid are 0.10 μCi of I-125 and 0.05 μCi of I-131, the fractional I-125 activity is

$$X = 0.10/(0.10 + 0.05)$$
$$= 0.667$$

Then

$$0.12X + 0.04(1 - X) = 0.12(0.667) + 0.04(0.33)$$
$$= 0.0932$$

$$\text{Total} = 0.10 + 0.05 = 0.15\ \mu\text{Ci}$$

Thus, in this case, the worker involved should remain on the biweekly (or more frequent) schedule and should not be put on the quarterly frequency.

B.2 Controlling Total Intakes

Regulatory position 4.b(2) is based on controlling total intakes[6] during a quarterly period when air concentration data are available to assess the potential exposure of the worker either to random single intakes or to variable or constant continuous exposures. The quantities of 0.8 μCi of I-125 and 1.4 μCi of I-131 were obtained by calculating 25% of the total quarterly intakes of 3.2 μCi of I-125 or 5.7 μCi of I-131 (see footnote 3) that would be inhaled when breathing a total of 6.3×10^8 ml per quarter working at the standard man breathing rate for 40 hours per week for 13 weeks.

Example

If the average quarterly concentrations estimated from air sampled in a worker's breathing zone are 3×10^{-9} μCi/ml for I-125 and 5×10^{-9} μCi/ml for I-131, the total quarterly intakes are:

$$3 \times 10^{-9} \times 6.3 \times 10^8 = 1.89\ \mu\text{Ci I-125}$$

$$5 \times 10^{-9} \times 6.3 \times 10^8 = 3.15\ \mu\text{Ci I-131}$$

$$\text{Total} = 5.04\ \mu\text{Ci}$$

Also, X, the proportion of I-125, is 1.89/5.04 = 0.375

Thus the control level for maintaining biweekly or more frequent bioassay checks is:

$$0.8X + 1.4(1 - X) = 0.8(0.375) + 1.4(1 - 0.375)$$
$$\text{Total} = 1.18\ \mu\text{Ci for this mixture.}$$

Since the intake of 5.04 μCi is greater than 1.18, this employee should stay on the more frequent bioassay schedule.

Note: The numbers of significant digits carried in the above calculations do not imply any given degree of accuracy of measurement. Enough digits are carried to allow following the arithmetic for purposes of the examples.

[6] The limiting total quarterly intakes are in different proportions for I-125 and I-131 than are the MPOBs. This difference is a result of the fact that permissible concentrations are inversely proportional to effective half-lives whereas an MPOB is calculated assuming a constant burden in the organ of concern that is maintained by continuous intake of activity balanced by an equal rate of elimination from the organ.

ATTACHMENT #16

Formal Training in Radiation Safety

(MS) PATRICIA HAWTHORNE

a. Principles and practices of radiation protection

- On the job training

b. Radioactivity measurement standardization and monitoring techniques and instruments

- On the job training

c. Mathematics and calculations basic to the use and measurement of radioactivity

- On the job training

d. Biological effects of radiation

- On the job training

ATTACHMENT #16

Formal Training in Radiation Safety

(MS) ANNE M. HORACZEK

a. Principles and practices of radiation protection

- Radiobiology, Wayne State U. - 1 semester 1961
- NIOSH Training Course #584 Ionizing Radiation

b. Radioactivity measurement standardization and monitoring techniques and instruments

- Radiobiology, Wayne State U.
- NIOSH Training Course #584
- On the job training

c. Mathematics and calculations basic to the use and measurement of radioactivity

- Physics, U. of Mich. - 1 yr. 1957
- Calculus, Wayne State U. - 1 yr. 1967

d. Biological effects of radiation

- Radiobiology, Wayne State U.
- NIOSH Training Course #584

ATTACHMENT #16

Formal Training in Radiation Safety

(DR) CHARLES W. WHITAKER

a. Principles and practices of radiation protection

- Radioactive Tracers, Brigham Young Univ., 1 semester 1973

- On the job training

b. Radioactivity measurements, standardization and monitoring techniques and instruments

- Radioactive Tracers, Brigham Young Univ.

- On the job training

c. Mathematics and calculations basic to the use and measurement of radioactivity

- Radioactive Tracers, Brigham Young Univ.

- Physics, B.Y.U., 1966-67

- Calculus, B.Y.U., 1966-67

d. Biological effects of radiation

- Radioactive Tracers, Brigham Young Uni.

- General Microbiology, B.Y.U., 1970

- On the job training

ATTACHMENT #17 Experience

Individual	Isotope	Maximum Amount	Where Experience Was Gained	Duration of Experience	Type of Use
(Ms.) Anne M. Horaczek	I-125	1.5 mc	Parke-Davis/W.L.	11 yrs.	1. Labeling globulin proteins 2. Allergen test kit assays
	C-14, P-32, S-35		Parke-Davis/W.L.	3 yrs.	Making synthetic media for tissue culture
	I-125, C-14, H-3, P-32, S-35, N_1-63		Parke-Davis/W.L.	11 yrs.	Detroit & Rochester Isotope Safety Officer
(Ms. Patricia Hawthorne	I-125	10.0 uc	Parke-Davis/W.L.	6 yrs.	Routine screening of plasma for hepatitis antigen
(Dr.) Charles W. Whitaker	I-125	1.0 mc	Mt. Sinai School of Medicine	3 yrs.	Radioimmunoassay for monoclonal antibodies
	P-32	1.0 mc		2 yrs.	DNA/RNA gene sequencing
	H-3, C-14	1.0 mc	Brigham Young Univ.	9 yrs.	Labeling viral proteins and nucleic acid