Radiographic equipment - X-ray equipment used for the production of static x-ray images.

Radiologic technologist - An individual specifically trained in the use of radiographic equipment and the positioning of patients for radiographic examinations and who meets the requirements set forth in 21 CFR Section 900.12(a)(2).

Review physician - A physician who, by meeting the requirements set out in 21 CFR Section 900.4(c)(5), is qualified to review clinical images on behalf of the accreditation body.

Screening mammography - Radiographic procedure provided to a woman, who has no signs or symptoms of breast cancer, for the purpose of early detection of breast cancer. The procedure entails two views of each breast and includes a physician's interpretation of the results of the procedure.

Serious adverse event - An adverse event that may significantly compromise clinical outcomes, or an adverse event for which a facility fails to take appropriate corrective action in a timely manner.

Serious compliant - A report of a serious adverse event.

Standard breast - A 4.2 centimeter (cm) thick compressed breast consisting of fifty percent (50%) glandular and fifty percent (50%) adipose tissue.

Survey - An on-site physics consultation and evaluation of a facility quality assurance program performed by a medical physicist.

Time cycle - The film development time.

Traceable to a national standard - An instrument is calibrated at either the National Institute of Standards and Technology (NIST) or at a calibration laboratory that participates in a proficiency program with NIST at least once every two (2) years and the results of the proficiency test conducted within 24 months of calibration show agreement within plus or minus three percent (± 3%) of the national standard in the mammography energy range.

b. **Accreditation**.

1. All facilities performing screening or diagnostic mammography shall be accredited every three (3) years by the Arkansas Department of Health or the American College of Radiology. Such accreditation shall be in accordance with the Food and Drug Administration (FDA) 21 CFR Part 16 and the "Mammography Quality Standards Act," Subchapter I to Chapter I of 21 CFR.

2. No mammography shall be performed in an unaccredited facility after January 1, 1990. The owners of any unaccredited facility where in mammography is performed after January 1, 1990 shall be subject to a civil penalty imposed by the Arkansas Department of Health in an amount not to exceed one hundred dollars ($100) for each day the facility operates without accreditation by the Department.

c. **Quality standards**.

1. **Personnel**.

The following requirements apply to personnel involved in any aspect of mammography, including production, processing, and interpretation of mammograms and related quality assurance activities.

A. **Interpreting physicians**.

Interpreting physicians shall meet the minimum requirements of 21 CFR Part 900.12(a)(1) of the Food and Drug Administration's "Mammography Quality Standards Act."

B. **Radiological technologist**.

i. Radiological technologists shall meet the minimum requirements of 21 CFR Part 900.12.(a)(2) of the Food and Drug Administration's "Mammography Quality Standards Act."

ii. Licensed by the State of Arkansas as a Registered Radiologic Technologist.

C. **Mammography imaging medical physicist**.

i. Mammography imaging medical physicists shall meet the minimum requirements of 21 CFR Part 900.12.(a)(3) of the Food and Drug Administration's "Mammography Quality Standards Act."

ii. All mammography imaging medical physicists must be registered with the State as a vendor as required by RH-34.

2. **Medical physicist's survey requirements**.

A. Medical physicist's surveys must be performed at least annually.

B. A mammography medical physicist who meets the qualification requirements of RH-1610.c.1.C. must sign all physicist survey reports.

C. Mammography medical physicists who sign a facility survey report must have been present in that facility during the survey.

D. Medical physicist's surveys must meet the requirements of 21 CFR Part 900.12(e)(9) of the Food and Drug Administration (FDA).

3. **Obtaining and preserving records**.

All reasonable efforts must be made to obtain any of the beneficiary's previous mammogram records, including original images and films, copies of written reports prepared by interpreting physicians, and other relevant information pertinent to previous mammograms that might be available from others, for comparison with current mammogram records. All reporting and record keeping must meet the requirements of 21 CFR Part 900.12(c) of the Food and Drug Administration (FDA).

4. **Equipment**.

The equipment used to perform mammography should be specifically designed for mammography and must meet the following standards:

A. **Food and Drug Administration (FDA), Subchapter I entitled "Mammography Quality Standards Act."**

21 CFR Part 900.12(b).

B. **Food and Drug Administration (FDA), Subchapter J entitled "Radiological Health."**

Certified equipment must meet the FDA performance standards for diagnostic x-ray systems and their major components at 21 CFR 1020.30 and FDA's standards for radiographic equipment at 21 CFR 1020.31.

C. **Focal spot size**.

The measured focal spot size of the x-ray tube should not exceed 0.7 mm.

D. **Control panel indicators**.

The equipment must have a control panel that includes a device (usually a milliammeter) or means for an audible signal to give positive indication of the production of x-rays whenever the x-ray tube is energized. The control panel must include appropriate indicators (labeled control settings of meters that show the physical factors such as kilovoltage potential [kVp], milliampere seconds [mAs], exposure time, or whether timing is automatic) used for exposure.

E. All mammography units must be registered with the State of Arkansas as required by RH-21.

F. **Mammography equipment evaluations**.

All variable parameters of the equipment must be evaluated and adjusted as needed to comply with 21 CFR Part 900.12(e)(10) of the FDA's "Mammography Quality Standards Act." This includes but is not limited to the following:

i. When the equipment is installed;

ii. After any major changes or replacement of parts;

iii. When quality assurance tests indicate that calibration or other maintenance is needed;

iv. When equipment is disassembled and reassembled.

5 **Safety standards**.

Mammograms must be conducted using equipment and operating procedures free of unnecessary hazards and providing minimum radiation exposure to patients, personnel, and other persons in the immediate environment.

A. **Safety precautions**.

Proper safety precautions must be maintained. This includes adequate shielding for patients, personnel, and facilities. The equipment must be operable only from a shielded position.

B. **Exposure badges**.

Personnel operating the equipment must be monitored in accordance with RH-1301. and RH-1302.

C. **Equipment inspection**.

Periodic inspection of equipment and shielding must be made by a staff or consultant medical physicist or by a physicist approved by an appropriate State or local government agency as meeting the qualification requirements of RH-1610. Identified hazards must be promptly corrected.

D. **Protection against electrical hazards**.

All equipment must be shockproof and grounded.

6. **Quality assurance**.

Each facility must establish and maintain a quality assurance program that meets the requirements of 21 CFR Part 900.12(d) of the FDA's "Mammography Quality Standards Act."

A. **Responsibilities for the lead interpreting physician**.

The lead interpreting physician has the following responsibility:

i. Ensuring that the facility's quality assurance program meets all the requirements of 21 CFR Part 900.12(d) of the FDA's "Mammography Quality Standards Act."

B. **Responsibilities for the mammography medical physicist**.

The person furnishing medical physics support has the overall responsibility for establishing and conducting the ongoing equipment quality assurance program. That individual's specific duties must include:

i. The duties outlined in 21 CFR Part 900.12 (d)(iii) of the FDA's "Mammography Quality Standards Act."

ii. Conducting or training others to conduct equipment performance monitoring functions;

iii. Analyzing the monitoring results to determine if there are any problems requiring correction; and

iv. Carrying out or arranging for the necessary corrective actions as well as for the calibrations and other preventive maintenance.

v. Conduct an annual survey of the facility's equipment quality assurance program as required by 21 CFR Part 900.12(e)(9) of the FDA's "Mammography Quality Standards Act."

vi. Submit a written report describing the results of the survey as required by 21 CFR Part 900.12(e)(9)(iii) of the FDA's "Mammography Quality Standards Act."

C. **Responsibilities of the quality control technologist**.

The quality control technologist must perform the tasks within the quality assurance program that are not assigned to the lead interpreting physician or the medical physicist.

D. **Quality assurance**.

The facility must ensure the quality of mammography by maintaining a quality assurance program that meets the requirements found in 21 CFR Part 900.12(e) of the FDA's "Mammography Quality Standards Act" and verifying that the action limits described in Part 900.12(e) have been met. These tests and their frequencies are as follows:

i. **Daily**.

Processor performance tests, which includes assessment of base plus fog density, mid-density, and density difference.

ii. **Weekly**.

Image quality evaluation test using an FDA-approved phantom.

iii. **Quarterly**.

Fixer retention in film test, repeat film analysis.

iv. **Semi-annually**.

Dark room fog evaluation, screen film contact test and compression device evaluation.

v. **Annual testing**.

Automatic exposure control performance, kilovoltage peak (kVp) accuracy and reproducibility, focal spot condition, breast entrance air kerma and AEC reproducibility, dosimetry, x-ray field/light field/image receptor/compression paddle alignment, uniformity of screen speed, radiation output, system artifacts, and decompression.

vi. **Mobile units**.

The facility shall verify that mammography units used to produce mammograms at more than one location meet the requirements in paragraphs (e)(1) through (e)(6) of 21 CFR Part 900.12. In addition, at each examination location, before any examinations are conducted, the facility shall verify satisfactory performance of such units using a test method that establishes the adequacy of the image quality produced by the unit.

vii. **Quality control tests - other modalities**.

For systems with image receptor modalities other than screen-film, the quality assurance program shall be substantially the same as the quality assurance program recommended by the image receptor manufacturer, except that the maximum allowable dose shall not exceed the maximum allowable dose for screen-film systems in the FDA 21 CFR Part 900.12 (e)(5)(vi).

viii. The facility shall establish and implement adequate protocols for maintaining darkroom, screen, and view box cleanliness and shall document that all cleaning procedures are performed at the frequencies specified in the protocols.

ix. **Infection control**.

Facilities shall establish and comply with a system specifying procedures to be followed by the facility for cleaning and disinfecting mammography equipment after contact with blood or other potentially infectious materials. This system shall specify the methods for documenting facility compliance with the infection control procedures established and shall comply with the requirements in the FDA 21 CFR Part 900.12(e)(13).

E. **Evaluation of monitoring results**.

Quality assurance test results must be evaluated in a timely manner by the individual that is responsible for performing the test to ensue compliance with 21 CFR Part 900.12(e)(8) of the FDA "Mammography Quality Standards Act." The responsible individuals are limited to the lead interpreting physician, the medical physicist and the quality control technologist.

F. **Medical outcomes audit**.

Each facility must establish and maintain a medical outcomes audit program to follow-up positive mammographic assessments and to correlate pathology results to the interpreting physician's findings. This program must comply with 21 CFR Part 900.12(f) of the FDA "Mammography Quality Standards Act."

G. **Procedures and techniques for mammography of patients with breast implants**.

Each facility must have procedures, which specify techniques, and procedures for imaging patients with breast implants. These procedures must comply with 21 CFR Part 900.12(g) of the FDA "Mammography Quality Standards Act."

H. **Consumer complaint mechanism**.

Each facility must have a consumer complaint mechanism. This mechanism must comply with 21 CFR Part 900.12(h) of the FDA "Mammography Quality Standards Act."

7. **Standards for diagnostic mammography**.

Facilities who wish to be accredited for diagnostic mammography shall, in addition to meeting all of the requirements for mammography also:

A. Have the interpreting physician as defined in RH-1610.c.1.A. present during all diagnostic mammography for direct supervision of the exam and film interpretation.

B. Have mammography systems with cone down compression and magnification capabilities, to enhance film interpretation.

d. **Applications and fees**.

Applications for accreditation or renewal shall be made on forms supplied by the Department. Evidence of compliance with all of the requirements for performing screening and/or diagnostic mammography and the accreditation fee must be included with the application.

e. **Additional review and patient notification**.

1. When quality assurance tests indicate that calibration is needed, and the Department believes that mammography quality at a facility has been compromised and may present a serious risk to human health, the facility shall provide clinical images and other relevant information, as specified by the Department, for review by the accreditation body. This additional mammography review will help the Department to determine whether the facility is in compliance with RH-1610. and, if not, whether there is a need to notify affected patients, their physicians or the public that the reliability, clarity and accuracy of interpretation of mammograms has been compromised.

2. If the Department determines that any activity related to the provision of mammography at a facility may present a serious risk to human health such that patient notification is necessary, the facility shall notify patients or their designees, their physicians or the public of action that may be taken to minimize the effects of the risk. Such notification shall occur within a timeframe and in a manner specified and approved by the Department.

f. **Retention of personnel records**.

Facilities shall maintain records to document the qualifications of all personnel who worked at the facility as interpreting physicians, radiologic technologists, or medical physicists. These records must be available for review by the MQSA inspectors. Records of personnel no longer employed by the facility should not be discarded until the next annual inspection has been completed, and FDA has determined that the facility is in compliance with MQSA personnel requirements.

g. **Quality assurance record keeping**.

All quality assurance record keeping shall meet the requirements of 21 CFR Part 900.12(d)(2) of the Food and Drug Administration (FDA) "Mammography Quality Standards Act." The lead interpreting physician, quality control technologist, and medical physicist shall ensure that records concerning mammography technique and procedures, quality control (including monitoring data, problems detected by analysis of that data, corrective actions, and the effectiveness of the corrective actions), safety, protection, and employee qualifications to meet assigned quality assurance tasks, are properly maintained and updated. The quality control records shall be kept for each test specified in paragraphs (e) and (f) of 21 CFR Part 900.12 until the next annual inspection has been completed, and FDA has determined that the facility is in compliance with the quality assurance requirements or until the test has been performed two additional times at the required frequency, whichever is longer.

h. **Clinical image quality**.

Clinical images produced by any certified facility must continue to comply with the standards for clinical image quality established by that facility's accreditation body.

RH-1611. **Bone Densitometry**.

a. Bone densitometry systems shall be:

1. Certified by the U.S. Department of Health and Human Services.

2. Registered in accordance with these ~~Regulations~~ Rules; and

3. Maintained and operated in accordance with the manufacturer's specifications.

b. Operators of bone densitometry systems shall be:

1. Licensed, certified, or permitted as a radiologic technologist by the Department; or

2. Licensed as a practitioner of the healing arts; or

3. Permitted or approved by the Department as a bone densitometry operator.

c. During the operation of any bone densitometry system:

1. The operator, ancillary personnel, and members of the general public shall be positioned at least one meter from the patient and bone densitometry system during the examination.

2. The operator shall advise the patient the bone densitometry examination is a type of x-ray procedure.

d. The registrant shall keep maintenance records for bone densitometry systems as prescribed. These records shall be maintained for inspection by the Department recordkeeping timelines as appropriate.

e. Bone densitometry on human patients shall be conducted only:

1. Under a prescription of a licensed practitioner of the healing arts; or

2. Under a screening program approved by the Department.

f. Any person proposing to conduct a bone densitometry screening program shall submit the information outlined in Schedule A to Section 3 with the exception of g, h, i, j, k, and m, and include the name and address of the individual who will interpret the screening results.

SCHEDULE A TO SECTION 3

INFORMATION TO BE SUBMITTED BY PERSONS PROPOSING TO CONDUCT HEALING ARTS SCREENING

Persons requesting that the Department approve a healing arts screening program shall submit the following information and evaluation:

a. Name and address of the applicant and, where applicable, the names and addresses of agents within this State;

b. Diseases or conditions for which the x-ray examinations are to be used in diagnoses;

c. A detailed description of the x-ray examinations proposed in the screening program;

d. Description of the population to be examined in the screening program, i.e., age, sex, physical condition, and other appropriate information;

e. An evaluation of any known alternate methods not involving ionizing radiation which could achieve the goals of the screening program and why these methods are not used instead of the x-ray examinations;

f. An evaluation by a qualified expert of the x-ray system(s) to be used in the screening program. The evaluation by the qualified expert shall show that such system(s) do satisfy all requirements of these ~~Regulations~~ Rules. The evaluation shall include a measurement of patient exposures from the x-ray examinations to be performed;

g. A description of the diagnostic x-ray quality control program;

h. A copy of the technique chart for the x-ray examination procedures to be used;

i. The qualifications of each individual who will be operating the x-ray system(s);

j. The qualifications of the individual who will be supervising the operators of the x-ray system(s). The extent of supervision and the method of work performance evaluation shall be specified;

k. The name and address of the individual who will interpret the radiograph(s);

l. A description of the procedures to be used in advising the individual screening procedure and any further medical needs indicated;

m. A description of the procedures for the retention or disposition of the radiographs and other records pertaining to the x-ray examinations;

n. An indication of the frequency of screening and the duration of the entire screening program.

RH-1612. **Scope and Purpose – Analytical X-ray Equipment**.

This Part provides special requirements for analytical x-ray equipment. The requirements of this Part are in addition to, and not in substitution for, applicable requirements in other Parts of these ~~Regulations~~ Rules.

a. **Definitions**.

Analytical x-ray equipment - X-Ray equipment used for x-ray diffraction fluorescence analysis or spectroscopy.

Analytical x-ray system - A group of local and remote components utilizing x-rays to determine the elemental composition or to examine the microstructure of materials. Local components include those that are struck by x-rays such as radiation source housings, port and shutter assemblies, collimators, sample holders, cameras, goniometers, detectors and shielding. Remote components include power supplies, transformers, amplifiers, readout devices, and control panels.

Fail-safe characteristics - A design feature which causes beam port shutters to close or otherwise prevents emergence of the primary beam, upon the failure of a safety or warning device.

Local components - Part of an analytical x-ray system and include areas exposed to x-rays, such as radiation source housings, port and shutter assemblies, collimators, sample holders, cameras, goniometers, detectors and shielding, but does not include power supplies, transformers, amplifiers, readout devices and control panels.

Normal operating procedures - Operating procedures for conditions suitable for analytical purposes with shielding and barriers in place. These do not include maintenance but do include routine alignment procedures. Routine and emergency radiation safety considerations are part of these procedures.

Open-beam configuration - An analytical x-ray system in which an individual could accidentally place some part of his/her body in the primary beam path during normal operation.

Primary beam - Ionizing radiation which passes through an aperture of the source housing by a direct path from the x-ray tube located in the radiation source housing.

RH-1612. (Cont'd)

b. **Equipment Requirements**.

1. **Safety device**.

A device which prevents the entry of any portion of an individual's body into the primary x-ray beam path or which causes the beam to be shut off upon entry into its path shall be provided on all open-beam configurations. A registrant may apply to the Department for an exemption from the requirement of a safety device. Such application shall include:

A. A description of the various safety devices that have been evaluated;

B. The reason each of these devices cannot be used; and

C. A description of the alternative methods that will be employed to minimize the possibility of an accidental exposure, including procedures to assure that operators and others in the area will be informed of the absence of safety devices.

2. **Warning devices**.

A. Open-beam configurations shall be provided with a readily discernible indication of:

i. X-ray tube status **(ON-OFF)** located near the radiation source housing, if the primary beam is controlled in this manner; and/or

ii. Shutter status **(OPEN-CLOSED)** located near each port on the radiation source housings, if the primary beam is controlled in this manner.

B. Warning devices shall be labeled so that their purpose is easily identified. On equipment installed after January1, 1979, warning devices shall have fail-safe characteristics.

3. **Ports**.

Unused ports on radiation machine source housings shall be secured in the closed position in a manner which will prevent casual opening.

RH-1612.b. (Cont'd)

4. **Labeling**.

All analytical x-ray equipment shall be labeled with a readily discernible sign or signs bearing the radiation symbol and the words:

A. "**CAUTION - HIGH INTENSITY X-RAY BEAM**," or words having a similar intent, on the x-ray source housing; and

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B. "**CAUTION RADIATION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED**," or words having a similar intent, near any switch that energizes an x-ray tube.

5. **Shutters**.

On open-beam configurations installed after January 1, 1979, each port on the radiation source housing shall be equipped with a shutter that cannot be opened unless a collimator or a coupling has been connected to the port.

6. **Warning lights**.

A. An easily visible warning light labeled with the words "**X-RAY ON**" or words having a similar intent, shall be located near any switch that energizes an x-ray tube and shall be illuminated only when the tube is energized.

B. On equipment installed after January 1, 1979, warning lights shall have fail-safe characteristics.

7. **Radiation source housing**.

Each radiation source housing shall be subject to the following requirements:

A. Each x-ray tube housing shall be equipped with an interlock that shuts off the tube if it is removed from the radiation source housing or if the housing is disassembled.

8. **Generator cabinet**.

Each x-ray generator shall be supplied with a protective cabinet which limits leakage radiation measured at a distance of five (5) centimeters from its surface such that it is not capable of producing a dose in excess of 0.25 millirem in one hour.

c. **Area Requirements**.

1. **Radiation levels**.

The local components of an analytical x-ray system shall be located and arranged and shall include sufficient shielding or access control such that no radiation levels exist in any area surrounding the local component group which could result in a dose to an individual present therein in excess of the dose limits given in RH-1208. These levels shall be met at any specified tube rating.

2. **Surveys**.

A. Radiation surveys, as required by RH-1300., of all analytical x-ray systems sufficient to show compliance with RH-1612.c.1. shall be performed:

i. Upon installation of the equipment;

ii. Following any change in the initial arrangement, number or type of local components in the system;

iii. Following any maintenance requiring the disassembly or removal of a local component in the system;

iv. During the performance of maintenance and alignment procedures, if the procedures require the presence of a primary x-ray beam when any local component in the system is disassembled or removed;

v. Any time a visual inspection of the local components in the system reveals an abnormal condition; and

vi. Whenever personnel monitoring devices show a significant increase over the previous monitoring period or the readings are approaching the limits specified in RH-1200.

B. Radiation survey measurements shall not be required if a registrant can demonstrate compliance to the satisfaction of the Department with RH-1612.c.1. in some other manner.

3. **Posting**.

Each area or room containing analytical x-ray equipment shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words "**CAUTION - X-RAY EQUIPMENT**" or words having a similar intent.

d. **Operating Requirements**.

1. **Procedures**.

Normal operating procedures shall be written and available to all analytical x-ray equipment workers. No person shall be permitted to operate analytical x-ray equipment in any manner other than that specified in the procedures unless such person has obtained written approval of the Radiation Safety Officer.

2. **Bypassing**.

No person shall bypass a safety device unless such person has obtained the approval of the Radiation Safety Officer. When a safety device has been bypassed, a readily discernible sign bearing the words "**SAFETY DEVICE NOT WORKING**," or words having a similar intent, shall be placed on the radiation source housing.

3. **Repair or modification of x-ray tube systems**.

Except as specified in RH-1612.d.2., no operation involving removal of covers, shielding materials or tube housings or modifications to shutters, collimators or beam stops shall be performed without ascertaining that the tube is off and will remain off until safe conditions have been restored. The main switch, rather than interlocks, shall be used for routine shutdown in preparation for repairs.

RH-1612. (Cont'd)

e. **Personnel Requirements**.

1. **Instruction**.

A. No person shall be permitted to operate or maintain analytical x-ray equipment unless such person has received instruction in and demonstrated competence as to:

i. Identification of radiation hazards associated with the use of the equipment;

ii. Significance of the various radiation warning and safety devices incorporated into the equipment or the reasons they have not been installed on certain pieces of equipment and the extra precautions required in such cases;

iii. Proper operating procedures for the equipment;

iv. Symptoms of an acute localized exposure; and

v. Proper procedures for reporting an actual or suspected exposure.

2. **Personnel monitoring**.

A. Finger or wrist dosimetric devices shall be provided to and shall be used by:

i. Analytical x-ray equipment workers using systems having an open-beam configuration and not equipped with a safety device; and

ii. Personnel maintaining analytical x-ray equipment if the maintenance procedures require the presence of a primary x-ray beam when any local component in the analytical x-ray system is disassembled or removed.

B. Reported dose values shall not be used for the purpose of determining compliance with RH-1200. and RH-1208. unless evaluated by a qualified expert.

RH-1613. **Computed Tomography**.

a. **Definitions**.

Computed tomography dose index (CTDI) - The integral from 7T to +7T of the dose profile along a line perpendicular to the tomographic plane divided by the product of the nominal tomographic section thickness and the number of tomograms produced in a single scan.

NOTE: This definition assumes that the dose profile is centered around z = 0 and that, for a multiple tomogram system, the scan increment between adjacent scans is nT.

Contrast scale (CS) - The change in the linear attenuation coefficient per CTN relative to water, that is:

$\overline{CTN}_x$ = of the material of interest; and
$\overline{CTN}_w$ = of water.

CT conditions of operation - All selectable parameters governing the operation of a CT x-ray system including, but not limited to, nominal tomographic section thickness, filtration, and the technique factors as defined.

CT gantry - The tube housing assemblies, beam-limiting devices, detectors, and the supporting structures and frames that hold these components.

CT number (CTN) - The number used to represent the x-ray attenuation associated with each elemental area of the CT image.

$$\overline{CTN} = \frac{k(\mu_x - \mu_w)}{\mu_w}$$

where: k = A constant, a normal value of 1,000 when the Houndsfield scale of CTN is used;

μ_x = Linear attenuation coefficient of the material of interest; and

μ_w = Linear attenuation coefficient of water.

Dose profile - The dose as a function of position along a line.

Elemental area - The smallest area within a tomogram for which the x-ray attenuation properties of a body are depicted. (See also "Picture element.")

Multiple tomogram system - A computed tomography x-ray system that obtains x-ray transmission data simultaneously during a single scan to produce more than one tomogram.

Noise - The standard deviation of the fluctuation in CTN expressed as a percentage of the attenuation coefficient of water. Its estimate (S_n) is calculated using the following expression:

$$S_n = \frac{100 \cdot \overline{CS} \cdot s}{\mu_w}$$

where: $\overline{CS}$ = Linear attenuation coefficient of the material of interest;

μ_w = Linear attenuation coefficient of water; and

s = Standard deviation of the CTN of picture elements in a specified area of the CT image.

Nominal tomographic section thickness - The full width at half-maximum of the sensitivity profile taken at the center of the cross-sectional volume over which x-ray transmission data are collected.

Picture element - An elemental area of a tomogram.

Reference plane - A plane that is displaced from and parallel to the tomographic plane.

Scan - The complete process of collecting x-ray transmission data for the production of a tomogram. Data can be collected simultaneously during a single scan for the production of one or more tomograms.

Scan increment - The amount of relative displacement of the patient with respect to the CT x-ray system between successive scans measured along the direction of such displacement.

Scan sequence - A pre-selected set of two or more scans performed consecutively under pre-selected CT conditions of operation.

Scan time - The period of time between the beginning and end of x-ray transmission data accumulation for a single scan.

Single tomogram system - A CT x-ray system that obtains x-ray transmission data during a scan to produce a single tomogram.

Tomographic plane - That geometric plane which is identified as corresponding to the output tomogram.

Tomographic section - The volume of an object whose x-ray attenuation properties are imaged in a tomogram.

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b. **Requirements for equipment**.

1. **Termination of exposure**.

A. Means shall be provided to terminate the x-ray exposure automatically by either de-energizing the x-ray source or shuttering the x-ray beam in the event of equipment failure affecting data collection. Such termination shall occur within an interval that limits the total scan time to no more than 110 percent (110%) of its preset value through the use of either a backup timer or devices which monitor equipment function.

B. A visible signal shall indicate when the x-ray exposure has been terminated

C. The operator shall be able to terminate the x-ray exposure at any time during a scan, or series of scans under CT x-ray system control, of greater than one-half second duration.

2. **Tomographic plane indication and alignment**.

A. For any single tomogram system, means shall be provided to permit visual determination of the tomographic plane or a reference plane offset from the tomographic plane.

B. For any multiple tomogram system, means shall be provided to permit visual determination of the location of a reference plane. This reference plane can be offset from the location of the tomographic planes.

C. If a device is using a light source, the light source shall provide illumination levels sufficient to permit visual determination of the location of the tomographic plane or reference plane under ambient light conditions of up to 500 lux.

3. **Beam-on and shutter status indicators and control switches**.

A. The CT x-ray control and gantry shall provide visual indication whenever x-rays are produced and, if applicable, whether the shutter is open or closed.

B. Each emergency button or switch shall be clearly labeled as to its function.

4. **Indication of CT conditions of operation**.

A. The CT x-ray system shall be designed such that the CT conditions of operation to be used during a scan or a scan sequence shall be indicated prior to the initiation of a scan or a scan sequence. On equipment having all or some of these conditions of operation at fixed values, this requirement may be met by permanent markings. Indication of CT conditions of operation shall be visible from any position from which scan initiation is possible.

B. **Extraneous radiation**.

When data are not being collected for image production, the radiation adjacent to the tube port shall not exceed that permitted by RH-1602.b.3.

C **Maximum surface Computed Tomography Dose Index (CTDI) identification**.

The angular position where the maximum surface CTDI occurs shall be identified to allow for reproducible positioning of a CT dosimetry phantom.

5. **Additional requirements applicable to CT x-ray systems containing a gantry manufactured after September 3, 1985**.

A. The total error in the indicated location of the tomographic plane or reference plane shall not exceed five (5) millimeters.

B. If the x-ray production period is less than one-half second, the indication of x-ray production shall be actuated for at least one-half second. Indicators at or near the gantry shall be discernible from any point external to the patient opening where insertion of any part of the human body into the primary beam is possible.

C. The deviation of indicated scan increment versus actual increment shall not exceed plus or minus one (±1) millimeter with any mass from 0 to 100 kilograms resting on the support device. The patient support device shall be incremented from a typical starting position to the maximum incremented distance or 30 centimeters, whichever is less, and then returned to the starting position. Measurement of actual versus indicated scan increment may be taken anywhere along this travel.

D. Premature termination of the x-ray exposure by the operator shall necessitate resetting of the CT conditions of operation prior to the initiation of another scan.

c. **Facility design requirements**.

1. **Aural communication**.

A. Provision shall be made for two-way aural communication between the patient and the operator at the control panel.

2. **Viewing systems**.

A. Windows, mirrors, closed-circuit television, or an equivalent shall be provided to permit continuous observation of the patient during irradiation and shall be so located that the operator can observe the patient from the control panel.

B. When the primary viewing system is by electronic means, an alternate viewing system (which may be electronic) shall be available for use in the event of failure of the primary viewing system.

d. **Surveys, calibrations, spot checks, and operating procedures**.

1. **Surveys**.

A. All CT x-ray systems shall have a survey made by, or under the direction of, a qualified expert. In addition, such surveys shall be done after any change in the facility or equipment which might cause a significant increase in radiation hazard.

B. The registrant shall obtain a written report of the survey from the qualified expert, and a copy of the report shall be made available to the Department upon request.

2. **Radiation calibrations**.

A. The calibration of the radiation output of the CT x-ray system shall be performed by, or under the direction of, a qualified expert who is physically present at the facility during such calibration.

B. The calibration of a CT x-ray system shall be performed at intervals specified by a qualified expert and after any change or replacement of components that, in the opinion of the qualified expert, could cause a change in the radiation output.

C. The calibration of the radiation output of a CT x-ray system shall be performed with a calibrated dosimetry system. The calibration of such system shall be traceable to a national standard. The dosimetry system shall have been calibrated within the preceding two (2) years.

D. CT dosimetry phantom(s) shall be used in determining the radiation output of a CT x-ray system. Such phantom(s) shall meet the following specifications and conditions of use:

i. CT dosimetry phantom(s) shall be right circular cylinders of polymethyl methacrylate of density 1.19 plus or minus 0.01 grams per cubic centimeter. The phantom(s) shall be at least 14 centimeters in length and shall have diameters of 32.0 centimeters for testing CT x-ray systems designed to image any section of the body and 16.0 centimeters for systems designed to image the head or for whole body scanners operated in the head scanning mode;

ii. CT dosimetry phantom(s) shall provide means for the placement of a dosimeter(s) along the axis of rotation and along a line parallel to the axis of rotation 1.0 centimeter from the outer surface and within the phantom. Means for the placement of dosimeters or alignment devices at other locations may be provided;

iii. Any effects on the doses measured due to the removal of phantom material to accommodate dosimeters shall be accounted for through appropriate corrections to the reported data or included in the statement of maximum deviation for the values obtained using the phantom; and

iv. All dose measurements shall be performed with the CT dosimetry phantom placed on the patient couch or support device without additional attenuation materials present.

E. The calibration shall be required for each type of head, body, or whole-body scan performed at the facility.

F. Calibration shall meet the following requirements:

i. The dose profile along the center axis of the CT dosimetry phantom for the minimum, maximum, and midrange values of the nominal tomographic section thickness used by the registrant shall be measurable. Where less than three (3) nominal tomographic thicknesses can be selected, the dose profile determination shall be performed for each available nominal tomographic section thickness;

ii. The CTDI along the two (2) axes shall be measured. (For the purpose of determining the CTDI, the manufacturer's statement as to the nominal tomographic section thickness for that particular system may be utilized.) The CT dosimetry phantom shall be oriented so that the measurement point 1.0 centimeter from the outer surface and within the phantom is in the same angular position within the gantry as the point of maximum surface CTDI identified. The CT conditions of operation shall correspond to typical values used by the registrant; and

iii. Spot checks shall be made in accordance with RH-1613.d.3.

G. Calibration procedures shall be in writing. Records of calibrations performed shall be maintained for inspection by the Department.

3. **Spot checks**.

A. The spot-check procedures shall be in writing and shall have been developed by a qualified expert.

B. The spot-check procedures shall incorporate the use of a CT dosimetry phantom which has a capability of providing an indication of contrast scale, noise, nominal tomographic section thickness, the resolution capability of the system for low and high contrast objects, and measuring the mean CTN for water or other reference material.

C. All spot checks shall be included in the calibration required by RH-1613.d.2. and at time intervals and under system conditions specified by a qualified expert.

D. Spot checks shall include acquisition of images obtained with the CT dosimetry phantom(s) using the same processing mode and CT conditions of operation as are used to perform calibrations. The images shall be retained, until a new calibration is performed, in two (2) forms as follows:

i. Photographic copies of the images obtained from the image display device; and

ii. Images stored in digital form on a storage medium compatible with the CT x-ray system.

E. Written records of the spot checks performed shall be maintained for inspection by the Department.

4. **Operating procedures**.

A. The CT x-ray system shall not be operated except by an individual who has been specifically trained in its operation.

B. Information shall be available at the control panel regarding the operation and calibration of the system. Such information shall include the following:

i. Dates of the latest calibration and spot checks and the location within the facility where the results of those tests may be obtained;

ii. Instructions on the use of the CT dosimetry phantom(s) including a schedule of spot checks appropriate for the system, allowable variations for the indicated parameters, and the results of at least the most recent spot checks conducted on the system;

RH-1613.d.4.B. (Cont'd)

iii. The distance in millimeters between the tomographic plane and the reference plane if a reference plane is utilized; and a current technique chart available at the control panel which specifies for each routine examination the CT conditions of operation and the number of scans per examination.

C. If the calibration or spot check of the CT x-ray system identifies that a system operating parameter has exceeded a tolerance established by the qualified expert, use of the CT x-ray system on patients shall be limited to those uses permitted by established written instructions of the qualified expert.

RH-1614.- RH-1699. Reserved.

PART H.
[RESERVED]

RH-1700.- RH-1702. Deleted.

RH-1703.- RH-1799. Reserved.

PART I.
LICENSES FOR INDUSTRIAL RADIOGRAPHY AND RADIATION SAFETY REQUIREMENTS FOR INDUSTRIAL RADIOGRAPHIC OPERATIONS

RH-1800. **General Provisions**.

a. **Purpose and scope.**

1. The ~~regulations~~ rules in this Part prescribe requirements for the issuance of licenses for the industrial use of sealed sources in industrial radiography and establish radiation safety requirements for persons utilizing sources of radiation in industrial radiography. The ~~regulations~~ rules in this Part apply to all licensees or registrants who use sources of radiation for industrial radiography. Except for the ~~regulations~~ rules in this Part clearly applicable only to sealed radioactive sources - radiation machines, accelerators, and sealed radioactive sources are covered by this Part. The provisions of this Part do not apply to medical uses of sources of radiation.

2. The requirements of this Part are in addition to, and not in substitution for, other applicable requirements of these ~~Regulations~~ Rules. In particular, requirements in Sections 1, 2, 3, 4, 6, and 12 ~~of these Regulations~~ apply to applicants, licensees, and registrants subject to this Part.

b. **Specific licensing provisions**.

1. **Application for a specific license**.

A person, as defined in RH-1100., shall file an application for a specific license authorizing the use of sealed sources in industrial radiography in accordance RH-403. and RH-404.

2. **Specific licenses for industrial radiography**.

An application for a specific license for the use of licensed material in industrial radiography will be approved if:

A. The applicant satisfies the general requirements specified in RH-404., as applicable, and any special requirements contained in this Part;

RH-1800.b.2. (Cont'd)

B. The applicant submits an adequate program for training radiographers and radiographers' assistants that meets the requirements of RH-1802.b.;

C. The applicant submits adequate procedures for verifying and documenting the certification status of radiographers and for ensuring that the certification of individuals acting as radiographers remains valid;

D. The applicant submits written operating and emergency procedures as described in RH-1802.e.;

E. The applicant submits a description of a program for inspections of the job performance of each radiographer and radiographer's assistant at intervals not to exceed 6 months as described in RH-1802.b.5.;

F. The applicant submits a description of the applicant's overall organizational structure as it applies to the radiation safety responsibilities in industrial radiography, including specified delegations of authority and responsibility;

G. The applicant submits the qualifications of the individual(s) designated as the Radiation Safety Officer as described in RH-1802.d.;

H. The applicant who intends to collect leak test samples of sealed sources or exposure devices containing depleted uranium (DU) shielding has described the procedures for performing the sampling and the qualifications of the individual(s) authorized to do the sampling. If the applicant intends to analyze its own wipe samples, the application shall include a description of the procedures to be followed. The description shall include the:

i. Instrumentation to be used;

ii. Methods of performing the analysis; and

iii. Pertinent experience of the individual(s) who will analyze the wipe samples.

I. The applicant who intends to perform calibrations of survey instruments and/or alarming ratemeters describes methods to be used and the experience of the individual(s) who will perform the calibrations. All calibrations must be performed according to the procedures described and at the intervals prescribed in RH-1801.e.3. and RH-1802.f.7.D.

J. The applicant identifies and describes the location(s) of all field stations and permanent radiographic installations; and

K. The applicant identifies the locations(s) where all records required by this Part and other Sections of these ~~Regulations~~ Rules will be maintained.

c. **Definitions**.

Access panel - Any barrier or panel which is designed to be removed or opened for maintenance or service purposes, requires tools to open and permits access to the interior of the cabinet.

ALARA (acronym for "as low as is reasonably achievable") - Making every reasonable effort to maintain exposures to radiation as far below the dose limits specified in Part C, "Permissible Doses, Levels, and Concentrations," of Section 3 as is practical, consistent with the purpose for which the licensed or registered activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvement in relation to benefits to the public health and safety, and other societal and socio-economic considerations, and in relation to utilization of nuclear energy, licensed materials, and x-ray equipment in the public interest.

Annual refresher safety training - A review conducted or provided by the licensee or registrant for its employees on radiation safety aspects of industrial radiography. The review may include, as appropriate, the results of internal inspections, new procedures or equipment, new or revised ~~regulations~~ rules, accidents or errors that have been observed, and should also provide opportunities for employees to ask safety questions.

Aperture - Any opening in the outside surface of the cabinet, other than a port, which remains open during generation of x-radiation.

Associated equipment - Equipment that is used in conjunction with a radiographic exposures device to make radiographic exposures that drives, guides, or comes in contact with the source, (e.g., guide tube, control tube, control (drive) cable, removable source stop, "J" tube and collimator when it is used as an exposure head.)

Becquerel (Bq) - One (1) disintegration per second.

Cabinet radiography - Industrial radiography conducted in an enclosed cabinet which is so shielded that every location on the exterior meets conditions for an unrestricted area as specified in RH-1208.

Cabinet x-ray system - An x-ray system with the x-ray tube installed in an enclosure (hereinafter termed "cabinet") which, independently of existing architectural structures except the floor on which it may be placed, is intended to contain at least that portion of a material being irradiated, provide radiation attenuation and exclude personnel from its interior during generation of x-radiation. Included are all x-ray systems designed primarily for the inspection of carry-on baggage at airline, railroad and bus terminals and in similar facilities. An x-ray tube used within a shielded part of a building or x-ray equipment which may temporarily or occasionally incorporate portable shielding is not considered a cabinet x-ray system.

Certified cabinet system - X-ray systems which are subject to regulations promulgated under Public Law 90-602, the Radiation Control for Health and Safety Act of 1968.

Certifying Entity - An independent certifying organization meeting the requirements in Schedule B of this Section or an Agreement State meeting the requirements in Schedule B, Parts II and III.

Collimator - a radiation shield that is placed on the end of the guide tube or directly onto a radiographic exposure device to restrict the size of the radiation beam when the sealed source is cranked into position to make a radiographic exposure.

Control (drive) cable - The cable that is connected to the source assembly and used to drive the source to and from the exposure location.

Control drive mechanism - A device that enables the source assembly to be moved to and from the exposure device.

Control tube - A protective sheath for guiding the control cable. The control tube connects the control drive mechanism to the radiographic exposure device.

Door - Any barrier which is designed to be movable or opened for routine operations purposes, does not generally require tools to open and permits access to the interior of the cabinet. For the purposes of RH-1803.g.1.A. of this Section, inflexible hardware rigidly affixed to the door shall be considered part of the door.

Enclosed radiography - Industrial radiography conducted in an enclosed cabinet or room and includes cabinet radiography, cabinet x-ray systems and shielded room radiography.

Exposure head - A device that locates the gamma radiography sealed source in the selected working position. (An exposure head is also known as a source stop).

External surface - The outside surface of the cabinet x-ray system, including the high-voltage generator, doors, access panels, latches, control knobs and other permanently mounted hardware and including the plane across any aperture or port.

Field station - A facility where licensed material or registered x-ray equipment may be stored or used and from which equipment is dispatched.

Floor - The underside external surface of the cabinet.

Gray - The SI unit of absorbed dose. A gray is equal to an absorbed dose of one (1) Joule/kilogram. It is also equal to 100 rads.

Ground fault - An accidental electrical grounding of an electrical conductor.

Guide tube (Projection sheath) - A flexible or rigid tube (i.e., "J" tube) for guiding the source assembly and the attached control cable from the exposure device to the exposure head. The guide tube may also include the connections necessary for attachment to the exposure device and to the exposure head.

Hands-on experience - Experience in all of those areas considered to be directly involved in the radiography process.

Independent Certifying Organization - An independent organization that meets all the criteria of Schedule B to Section 3.

Industrial radiography (radiography) - An examination of the structure of materials by non-destructive methods, utilizing ionizing radiation to make radiographic images.

Lay-barge radiography - Industrial radiography performed on any water vessel used for laying pipe.

Offshore platform radiography – Industrial radiography performed from a platform over a body of water.

Permanent radiographic installation - An enclosed shielded room, cell, or vault, not located at a temporary jobsite, in which radiography is performed.

Port - Any opening in the outside surface of the cabinet which is designed to remain open, during generation of x-rays, for the purpose of conveying material to be irradiated into and out of the cabinet or for partial insertion for irradiation of an object whose dimensions do not permit complete insertion into the cabinet.

Practical examination - A demonstration through practical application of the safety rules and principles in industrial radiography including use of all appropriate equipment and procedures.

Primary beam - The x-radiation emitted directly from the target and passing through the window of the x-ray tube.

Radiation Safety Officer for industrial radiography - An individual with the responsibility for the overall radiation safety program on behalf of the licensee or registrant and who meets the requirements of RH-1802.d.

Radiographer - Any individual who performs or who, in attendance at the site where sources of radiation are being used, personally supervises industrial radiographic operations and who is responsible to the licensee or registrant for assuring compliance with the requirements of these ~~Regulations~~ Rules and the conditions of registration or of a license.

Radiographer's assistant - Any individual who, under the direct supervision of a radiographer, uses radiographic exposure devices, sources of radiation, related handling tools, or radiation survey instrumentation in industrial radiography.

Radiographer certification - Written approval received from a certifying entity stating that an individual has satisfactorily met certain established radiation safety, testing, and experience criteria.

Radiographic exposure device - Any instrument containing a sealed source fastened or contained therein, in which the sealed source or shielding thereof may be moved or otherwise changed, from a shielded to unshielded position for purposes of making a radiographic exposure.

Radiographic operations - All activities associated with the presence of x-ray machines, accelerators, or radioactive sources in radiographic exposure devices, during use of the machine, accelerator, or device, or transport (except when being transported by a common or contract carrier), to include surveys to confirm the adequacy of boundaries, setting up equipment, and any activity inside restricted area boundaries. Transporting a radiation machine or accelerator is not considered a radiographic operation.

Radiography - See "industrial radiography."

Safety interlock - A device which is intended to prevent the generation of x-radiation when access by any part of the human body to the interior of the cabinet x-ray system through a door or access panel is possible.

Sealed source - Any radioactive material that is encased in a capsule designed to prevent leakage or escape of the radioactive material.

Shielded room radiography - Industrial radiography conducted in an enclosed room, the interior of which is not occupied during radiographic operations, which is so shielded that every location on the exterior meets the conditions for an unrestricted area as specified in RH-1208.

Shielded position - The location within the radiographic exposure device or source changer where the sealed source is secured and restricted from movement.

Sievert - The SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rem).

RH-1800.c. (Cont'd)

Source Assembly - An assembly that consists of the sealed source and a connector that attaches the source to the control cable. The source assembly may also include a stop ball used to secure the source in the shielded position.

Source changer - A device designed and used for replacement of sealed sources in radiographic exposure devices, including those also used for transporting and storage of sealed sources.

S-tube - A tube through which the radioactive source travels when inside a radiographic exposure device.

Storage area - Any location, facility, or vehicle which is used to store, to transport, or to secure a radiographic exposure device, a storage container, or a sealed source when it is not in use and which is locked or has a physical barrier to prevent accidental exposure, tampering with, or unauthorized removal of the device, container, or source.

Storage container - A container in which sealed sources are secured and stored.

Temporary job site - A location where radiographic operations are conducted and where licensed material may be stored other than the location(s) of use authorized on the license or registration.

Transport container - A package that is designed to provide radiation safety and security when sealed sources are transported and meets all applicable requirements of the U.S. Department of Transportation.

Underwater radiography - Industrial radiography performed when the radiographic exposure device and/or related equipment are beneath the surface of the water.

X-ray system - An assemblage of components for the controlled generation of x-rays.

X-ray tube - Any electron tube which is designed for the conversion of electrical energy into x-ray energy.

RH-1800. (Cont'd)

d. **Recordkeeping Requirements**.

1. **Records of the specific license for industrial radiography**.

Each licensee shall maintain a copy of its license, license conditions, documents incorporated by reference, and amendments to each of these items until superseded by new documents approved by the Department or until the Department terminates the license.

2. **Records of receipt and transfer of sealed sources**.

A Each licensee shall maintain records showing the receipts and transfers of sealed sources and devices using depleted uranium (DU) for shielding and retain each record for three (3) years after it is made.

B These records must include the date, the name of the individual making the record, radionuclide, number of curies (becquerels) or mass (for depleted uranium (DU)) and manufacturer, model, and serial number of each sealed source and/or device, as appropriate.

3. **Records of radiation survey instruments**.

Each licensee or registrant shall maintain records of the calibrations of its radiation survey instruments that are required in RH-1801.e. and retain each record for three (3) years after it is made.

4. **Records of leak testing of sealed sources and devices containing depleted uranium (DU).**

Each licensee shall maintain records of leak test results for sealed sources and for devices containing depleted uranium (DU). The results must be stated in units of microcuries (bequerels). The licensee shall retain each record for three (3) years after it is made or until the source in storage is removed.

5. **Records of quarterly inventory**.

A. Each licensee shall maintain records of the quarterly inventory of sealed sources and of devices containing depleted uranium (DU) as required by RH-1801.g. and retain each record for three (3) years after it is made.

B. The record must include the date of the inventory, name of the individual conducting the inventory, radionuclide, number of curies (becquerels) or mass (for DU) in each device, location of sealed source and/or devices, and manufacturer, model, and serial number of each sealed source and/or device, as appropriate.

6. **Records of utilization logs**.

A Each licensee or registrant shall maintain utilization logs showing for each sealed source or x-ray unit the following information:

i A description, including the make, model, and serial number of the radiographic exposure device or transport or storage container in which the sealed source or x-ray tube is located;

ii The identity and signature of the radiographer to whom assigned; and

iii The plant or site where used and dates of use, including the dates removed and returned to storage.

B. The licensee or registrant shall retain the logs required by RH-1800.d.6.A.for three (3) years after the log is made.

7. **Records of inspection and maintenance of radiographic exposure devices, transport and storage containers, associated equipment, source changers, and survey instruments**.

A. Each licensee or registrant shall maintain records specified in RH-1801.i. of equipment problems found in daily checks and quarterly inspections of radiographic exposure devices,

transport and storage containers, associated equipment, source changers, and survey instruments and retain each record for three (3) years after it is made.

RH-1800.d.7. (Cont'd)

B. The record must include the date of the check or inspection, name of the inspector, equipment involved, any problems found, and what repair and/or maintenance, if any, was done.

8. **Records of alarm system and entrance control checks at permanent radiographic installation**.

Each licensee or registrant shall maintain records of alarm system and entrance control device tests required under RH-1801.j. and retain each record for three (3) years after it is made.

9. **Records of training and certification**.

Each licensee or registrant shall maintain the following records (of training and certification) for three (3) years after the record is made:

A. Records of training of each radiographer and each radiographer's assistant. The record must include radiographer certification documents and verification of certification status, copies of written tests, dates of oral and practical examinations, and names of individuals conducting and receiving the oral and practical examinations; and

B. Records of annual refresher safety training and semi-annual inspections of job performance for each radiographer and each radiographer's assistant. The records must list the topics discussed during the refresher safety training, the dates the annual refresher safety training was conducted, and the names of the instructors and attendees. For inspections of job performance, the records must also include a list showing the items checked and any non-compliances observed by the Radiation Safety Officer (RSO).

10. **Copies of Operating and Emergency Procedures**.

Each licensee or registrant shall maintain a copy of current operating and emergency procedures until the Department

terminates the license or registration. Superseded material must be retained for three (3) years after the change is made.

RH-1800.d. (Cont'd)

11. **Records of Personnel Monitoring Procedures**.

Each licensee or registrant shall maintain the following exposure records specified in RH-1802.f.:

A. Direct reading dosimeter readings and yearly operability checks required by RH-1802.f.2. and f.3. for three (3) years after the record is made.

B. Records of alarming ratemeter calibrations for three (3) years after the record is made.

C. Personnel dosimeter results ~~received from the accredited NVLAP processor~~ until the Department terminates the license or registration.

D. Records of estimates of exposures as a result of off-scale personal direct reading dosimeters, or lost or damaged personnel dosimeters, until the Department terminates the license or registration.

12. **Records of Radiation Surveys**.

Each licensee or registrant shall maintain a record of each exposure device survey conducted before the device is placed in storage as specified in RH-1803.c.3. if that survey is the last one performed in the workday. Each record must be maintained for three (3) years after it is made.

13. **Form of Records**.

Each record required by RH-1800.d. must be legible throughout the specified retention period. The record may be the original or a reproduced copy or a microform provided that the copy or microform is authenticated by authorized personnel and that the microform is capable of reproducing a clear copy throughout the required retention period. The record may also be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records, such as letters, drawings, and specifications, must include all pertinent information, such as stamps, initials, and

signatures. The licensee or registrant shall maintain adequate safeguards against tampering with and loss of records.

RH-1800.d. (Cont'd)

14. **Location of documents and records**.

A. Each licensee or registrant shall maintain copies of records required by RH-1800.d. and other applicable ~~regulations~~ rules at the location specified in the licensee's license application.

B. Each licensee or registrant shall also maintain copies of the following documents and records sufficient to demonstrate compliance at each applicable field station and each temporary jobsite:

i. The license or certificate of registration authorizing the use of licensed material or x-ray equipment.

ii. A current copy of the Arkansas State Board of Health Rules ~~and Regulations~~ for Control of Sources of Ionizing Radiation.

iii. Utilization records for each radiographic exposure device dispatched from that location as required by RH-1800.d.6.

iv. Records of equipment problems identified in daily checks of equipment as required by RH-1800.d.7.

v. Records of alarm system and entrance control checks as required by RH-1801.j., if applicable.

vi. Records of direct reading dosimeters such as pocket dosimeter and/or electronic personal dosimeters readings as required by RH-1800.d.11.

vii. Operating and emergency procedures as required by RH-1802.e.

viii. Evidence of the latest calibration of the radiation survey instruments in use at the site as required by RH-1801.e.

ix. Evidence of the latest calibration of alarm rate-meters and operability checks of pocket dosimeters and/or electronic personal dosimeters as required by RH-1800.d.11.

x. Latest survey records as required by RH-1803.c.

RH-1800.d.14.B. (Cont'd)

xi. The shipping papers for the transportation of radioactive materials as required by RH-3005; and

xii. When operating under reciprocity pursuant to RH-750, a copy of the Agreement State or U.S. Nuclear Regulatory Commission license authorizing the use of licensed materials.

RH-1801. **Equipment Control**.

a. **Performance requirements for radiography equipment**.

Equipment used in industrial radiographic operations must meet the following minimum criteria:

1. Each radiographic exposure device, source assembly or sealed source, and all associated equipment must meet the requirements specified in American National Standards Institute N432-1980, "Radiological Safety for the Design and Construction of Apparatus for Gamma Radiography," (published as NBS Handbook 136, issued January 1981).

This publication may be purchased from the American National Standards Institute, Inc., 25 West 43rd Street, New York, New York 10036; Telephone: (212) 642-4900.

A copy of the document is available for inspection in the office of the Arkansas Department of Health, Radiation Control, 5800 West 10th Street, Suite 100, Little Rock, Arkansas 72204.

Engineering analysis may be submitted by an applicant or licensee to demonstrate the applicability of previously performed testing on similar individual radiography equipment components. Upon review, the Department may find this an acceptable alternative to actual testing of the component pursuant to the above referenced standard.

RH-1801.a. (Cont'd)

2. In addition to the requirements specified in RH-1801.a.1., the following requirements apply to radiographic exposure devices, source changers, source assemblies and sealed sources.

   A. The licensee shall ensure that each radiographic exposure device has attached to it by the user a durable, legible, clearly visible label bearing the:

      i. Chemical symbol and mass number of the radionuclide in the device;

      ii. Activity and the date on which this activity was last measured;

      iii. Model number (or product code) and serial number of the sealed source;

      iv. Manufacturer's identity of the sealed source; and

      v. Licensee's name, address, and telephone number.

   B. Radiographic exposure devices intended for use as Type B transport containers must meet the applicable requirements of Section 4, "Transportation of Radioactive Materials."

   C. Modification of radiographic exposure devices, source changers, source assemblies, and associated equipment is prohibited, unless the design of any replacement component, including the source holder, source assembly, controls or guide tubes would not compromise the design safety features of the system.

3. In addition to the requirements specified in RH-1801.a.1. and 2., the following requirements apply to radiographic exposure devices, source assemblies, and associated equipment that allow the source to be moved out of the device for radiographic operation or to source changers.

A. The coupling between the source assembly and the control cable must be designed in such a manner that the source assembly will not become disconnected if cranked outside the guide tube. The coupling must be such that it cannot be unintentionally disconnected under normal and reasonably foreseeable abnormal conditions.

RH-1801.a.3. (Cont'd)

B. The device must automatically secure the source assembly when it is cranked back into the fully shielded position within the device. This securing system may only be released by means of a deliberate operation on the exposure device.

C. The outlet fittings, lock box, and drive cable fittings on each radiographic exposure device must be equipped with safety plugs or covers which must be installed during storage and transportation to protect the source assembly from water, mud, sand, or other foreign matter.

D. Each sealed source or source assembly must have attached to it or engraved on it, a durable, legible, visible label with the words "**DANGER – RADIOACTIVE**." The label must not interfere with the safe operation of the exposure device or associated equipment.

E. The guide tube must be able to withstand a crushing test that closely approximates the crushing forces that are likely to be encountered during use and be able to withstand a kinking resistance test that closely approximates the kinking forces likely to be encountered during use.

F. Guide tubes must be used when moving the source out of the device.

G. An exposure head or similar device designed to prevent the source assembly from passing out of the end of the guide tube must be attached to the outermost end of the guide tube during industrial radiographic operations.

H. The guide tube exposure head connection must be able to withstand the tensile test for control units specified in ANSI N432- 1980.

I. Source changers must provide a system for ensuring that the source will not be accidentally withdrawn from the changer when connecting or disconnecting the drive cable to or from a source assembly.

4. All radiographic exposure devices and associated equipment in use after January 10, 1996 must comply with the requirements of this section.

RH-1801.a. (Cont'd)

5. Notwithstanding RH-1801.a.1., equipment used in industrial radiographic operations need not comply with Section 8.9.2(c) of the Endurance Test in American National Standards Institute N432-1980, if the prototype equipment has been tested using a torque value representative of the torque that an individual using the radiography equipment can realistically exert on the lever or crankshaft of the drive mechanism.

b. **Limits on external radiation levels from storage containers and source changers**.

The maximum exposure rate limit for storage containers and source changers are 200 millirem (2 millisieverts) per hour at any exterior surface and ten (10) millirem (0.1 millisieverts) per hour at one (1) meter from any exterior surface with the sealed source in the shielded position.

c. **Locking of radiographic exposure devices, storage containers, and source changers**.

1. Each radiographic exposure device must have a lock or outer locked container designed to prevent unauthorized or accidental removal of the sealed source from its shielded position. The exposure device and/or its container must be kept locked (and if a keyed-lock, with the key removed at all times) when not under the direct surveillance of a radiographer or a radiographer's assistant except at permanent radiographic installations as in RH-1803.a. In addition, during radiographic operations, the sealed source assembly must be secured in the shielded position each time the source is returned to that position.

2. Each sealed source storage container and source changer must have a lock or outer locked container designed to prevent unauthorized or accidental removal of the sealed source from its shielded position. Storage containers and source changers must be kept locked (and if a keyed-lock, with the key removed at all

times) when containing sealed sources except when under the direct surveillance of a radiographer or a radiographer's assistant.

3. The control panel of each radiation machine shall be equipped with a lock that will prevent the unauthorized use of an x-ray system or the accidental production of radiation. The radiation machine shall be kept locked and the key removed at all times except when under the direct visual surveillance of a radiographer or a radiographer's assistant.

RH-1801. (Cont'd)

d. **Storage precautions**.

1. Locked radiographic exposure devices, storage containers and radiation machines shall be physically secured to prevent tampering or removal by unauthorized personnel. The licensee shall store radioactive material in a manner which will minimize danger from explosion or fire.

2. Radiographic exposure devices, source changers, or transport containers that contain radioactive material may not be stored in residential locations. This rule does not apply to storage of radioactive material in a vehicle in transit for use at temporary job sites, if the licensee complies with RH-1801.d.3. and if the vehicle does not constitute a permanent storage location as described in RH-1801.d.4.

3. If a vehicle is to be used for storage of radioactive material, a vehicle survey shall be performed after securing radioactive material in the vehicle and before transport to ensure that radiation levels do not exceed the limits specified in RH-1208. at the exterior surface of the vehicle.

4. A storage or use location is permanent if radioactive material is stored or used at the location for more than ninety (90) days and any one (1) or more of the following applies to the location:

A. Telephone service is established by the licensee;

B. Industrial radiographic services are advertised for or from the location;

C. Industrial radiographic operations are conducted at other sites due to arrangements made from the location.

e. **Radiation survey instruments**.

1. The licensee or registrant shall keep sufficient calibrated and operable radiation survey instruments at each location where radioactive material or industrial radiographic x-ray equipment is present to make the radiation surveys as required by this Part and RH-1300.

RH-1801.e. (Cont'd)

2. Instrumentation required by this Part must be capable of measuring a range from two (2) milliroentgens (0.02 millisieverts) per hour through one (1) roentgen (0.01 sievert) per hour.

3. The licensee or registrant shall have each radiation survey instrument required in RH-1801.e.1.calibrated:

A. At intervals not to exceed six (6) months and after each instrument servicing, except for battery changes;

B. For linear scale instruments, at two (2) points located approximately one-third and two-thirds of full-scale; for logarithmic scale instruments, at midrange of each decade and at two (2) points on at least one decade; and for digital instruments, at three (3) points between 2 and 1000 millirems (0.02 and 10 millisieverts) per hour; and

C. So that an accuracy within plus or minus twenty percent (± 20%) of the calibration source can be demonstrated at each point checked.

4. The licensee shall maintain records of these calibrations in accordance with RH-1800.d.3.

5. Each radiation survey instrument shall be checked with a radiation source at the beginning of each day of use and at the beginning of each work shift to ensure it is operating properly.

f. **Leak testing and replacement of sealed sources**.

1. The replacement of any sealed source fastened to or contained in a radiographic exposure device and leak testing of any sealed source must be performed only by persons specifically authorized to do so

by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State.

2. The opening, repair, or modification of any sealed source must be performed only by persons specifically authorized to do so by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State.

RH-1801.f. (Cont'd)

3. **Testing and recordkeeping requirements**.

A. Each licensee who uses a sealed source shall have the source tested for leakage in accordance with RH-1212. and as prescribed in this Part. Tests for leakage must be performed at intervals not to exceed six (6) months. The leak testing of the source must be performed using a method approved by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State. The wipe sample should be taken from the nearest accessible point to the sealed source where contamination might accumulate. The wipe sample must be analyzed for radioactive contamination. The analysis must be capable of detecting the presence of 0.005 microcurie (185 Bq) of radioactive material on the test sample and must be performed by a person specifically authorized by the Department, or designee, the U.S. Nuclear Regulatory Commission, or an Agreement State to perform the analysis.

B. The licensee shall maintain records of the leak tests in accordance with RH-1800.d.4.

C. Unless a sealed source is accompanied by a certificate from the transferor that shows that it has been leak tested within six (6) months before the transfer, it may not be used by the licensee until tested for leakage. Sealed sources that are in storage and not in use do not require leak testing but must be tested before use or transfer to another person if the interval of storage exceeds six (6) months.

4. Any test conducted pursuant to the requirements of RH-1801.f. which reveals the presence of 0.005 microcurie (185 Bq) or more of removable radioactive material must be considered evidence that the sealed source is leaking. The licensee shall immediately

withdraw the equipment involved from use and shall cause it to be decontaminated and repaired or disposed of in accordance with ~~Regulations~~ rules of the Department. A report must be filed with the Department within five (5) days of any test with results that exceed the threshold in this paragraph, describing the equipment involved, the test results, and the corrective action taken.

RH-1801.f. (Cont'd)

5. Each exposure device using depleted uranium (DU) shielding and an "S" tube configuration must be tested for DU contamination at intervals not to exceed twelve (12) months. The analysis must be capable of detecting the presence of 0.005 microcurie (185 Bq) of radioactive material on the test sample and must be performed by a person specifically authorized by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State to perform the analysis.

Should such testing reveal the presence of 0.005 microcurie (185 Bq) or more of removable DU contamination, the exposure device must be removed from use until an evaluation of the wear on the S-tube has been made. Should the evaluation reveal that the S-tube is worn through, the device may not be used again. DU shielded devices do not have to be tested for DU contamination while in storage and not in use. Before using or transferring such a device however, the device must be tested for DU contamination if the interval of storage exceeds twelve (12) months. A record of the DU leak test must be made in accordance with RH-1800.d.4.

g. **Quarterly inventory**.

1. Each licensee shall conduct a quarterly physical inventory to account for all sealed sources and for devices containing depleted uranium (DU) received and possessed under this license.

2 The licensee shall maintain records of the quarterly inventory in accordance with RH-1800.d.5.

h. **Utilization logs**.

Each licensee or registrant shall maintain current logs, which shall be kept available for inspection by the Department, showing for each source of radiation the following information:

1. A description, including the make, model and serial number of each radiation machine, each radiographic exposure device or transport or storage container in which a sealed source is located, and each sealed source;

2. The identity and signature of the radiographer to whom assigned;

3. Locations where used and dates of use; and

RH-1801.h. (Cont'd)

4. The date(s) each source of radiation is removed from storage and returned to storage.

i. **Inspection and maintenance of radiographic exposure devices, transport and storage containers, associated equipment, source changers, and survey instruments**.

1. The licensee or registrant shall perform visual and operability checks on survey meters, radiographic exposure devices, transport and storage containers, associated equipment, source changers, and shutters on x-ray units before use on each day the equipment is used to ensure that the equipment is in good working condition, that the sources are adequately shielded, and that required labeling is present. Survey instrument operability must be performed using check sources or other appropriate means. If equipment problems are found, the equipment must be removed from service until repaired.

2. Each licensee or registrant shall have written procedures for:

A. Inspection and routine maintenance of radiographic exposure devices, source changers, associated equipment, transport and storage containers, and survey instruments at intervals not to exceed three (3) months or before the first use thereafter to ensure the proper functioning of components important to safety. Replacement components shall meet design specifications. If equipment problems are found, the equipment must be removed from service until repaired.

B. Inspection and maintenance necessary to maintain the Type B packaging used to transport radioactive materials. The inspection and maintenance program must include procedures to assure that Type B packages are shipped and

maintained in accordance with the Certificate of Compliance or other approval.

C. Records of equipment problems and of any maintenance performed under RH-1801.i.1.and i.2. must be made in accordance with RH-1800.d.7.

RH-1801. (Cont'd)

j. **Permanent radiographic installations**.

1. Each entrance that is used for personnel access to the high radiation area in a permanent radiographic installation must have either:

A. An entrance control of the type described in RH-1303.c.2.A. that reduces the radiation level upon entry into the area, or

B. Both conspicuous visible and audible warning signals to warn of the presence of radiation. The visible signal must be activated by radiation whenever the source is exposed. The audible signal must be actuated when an attempt is made to enter the installation while the source is exposed.

2. The alarm system must be tested for proper operation with a radiation source each day before the installation is used for radiographic operations. The test must include a check of both the visible and audible signals. Entrance control devices that reduce the radiation level upon entry (designated in RH-1801.j.1.A.) must be tested monthly. If an entrance control device or an alarm is operating improperly, it must be immediately labeled as defective and repaired within seven (7) calendar days.

The facility may continue to be used during this seven (7) day period, provided the licensee or registrant implements the continuous surveillance requirements of RH-1803.a. and uses an alarming ratemeter. Test records for entrance controls and audible and visual alarm must be maintained in accordance with RH-1800.d.8.

k. **Notifications**.

1. In addition to the reporting requirements specified in RH-601. and under other Sections, each licensee or registrant shall provide a written report to the Arkansas Department of Health, Radiation Control Section, 4815 West Markham Street, Slot 30, Little Rock, Arkansas, 72205-3867 within thirty (30) days of the occurrence of any of the following incidents involving radiographic equipment:

   A. Unintentional disconnection of the source assembly from the control cable.

RH-1801.k.1. (Cont'd)

   B. Inability to retract the source assembly to its fully shielded position and secure it in this position.

   C. Failure of any component (critical to safe operation of the device) to properly perform its intended function.

   D. An indicator on a radiation machine fails to show that radiation is being produced, an exposure switch fails to terminate production of radiation when turned to the "**OFF**" position, or a safety interlock fails to terminate x-ray production.

2. The licensee or registrant shall include the following information in each report submitted under RH-1801.k.1. and in each report of overexposure submitted under RH-1504. which involves failure of safety components of radiography equipment:

   A. A description of the equipment problem.

   B. Cause of each incident, if known.

   C. Name of the manufacturer and model number of equipment involved in the incident.

   D. Place, time, and date of the incident.

   E. Actions taken to establish normal operations.

   F. Corrective actions taken or planned to prevent recurrence.

   G. Qualifications of personnel involved in the incident.

3. Any licensee or registrant conducting radiographic operations or storing radioactive material at any location not listed on the license

or registration for a period in excess of 180 days in a calendar year, shall notify the Department prior to exceeding the 180 days.

RH-1801. (Cont'd)

l. **Labeling, storage, and transportation**.

1. The licensee may not use a source changer or a container to store radioactive material unless the source changer or the storage container has securely attached to it a durable, legible, and clearly visible label bearing the standard trefoil radiation caution symbol in conventional colors, i.e., magenta, purple or black on a yellow background having a minimum diameter of 25 mm, and the wording

"**CAUTION**,*
RADIOACTIVE MATERIAL,
NOTIFY CIVIL AUTHORITIES [or name of company]."

***** or **DANGER**

2. The licensee may not transport licensed material unless the material is packaged, and the package is labeled, marked, and accompanied with appropriate shipping papers in accordance with ~~regulations~~ rules set forth in Section 4, "Transportation of Radioactive Materials."

3. Locked radiographic exposure devices, storage containers, source changers and radiation machines must be physically secured to prevent tampering or removal by unauthorized personnel. The licensee shall store radioactive material in a manner which will minimize danger from explosion or fire.

4. The licensee shall lock and physically secure the transport package containing radioactive material in the transport vehicle to prevent accidental loss, tampering, or unauthorized removal of the radioactive material from the vehicle.

RH-1802. **Personnel Radiation Safety Requirements for Radiographers and Radiographer's Assistants**.

a. **Conducting industrial radiographic operations**.

1. Whenever radiography is performed at a location other than a permanent radiographic installation, the radiographer must be accompanied by at least one other qualified radiographer or an individual who has at a minimum met the requirements of RH-1802.b.3. The additional qualified individual shall observe the operations and be capable of providing immediate assistance to prevent unauthorized entry. Radiography may not be performed if only one (1) qualified individual is present.

2. All radiographic operations conducted at locations of use authorized on the license or on the x-ray registration must be conducted in a permanent radiographic installation, unless specifically authorized by the Department.

3. A licensee or registrant may conduct lay-barge or underwater radiography only if the procedures have been approved by the Department, by an Agreement State, or by the U.S. Nuclear Regulatory Commission.

b. **Training**.

1. The licensee or registrant may not permit any individual to act as a radiographer until the individual has received training in RH-1804., in addition to a minimum of two (2) months of on-the-job training under the supervision of a radiographer, and is certified through a radiographer certification program by a certifying entity in accordance with the criteria specified in Schedule B to Section 3.

RH-1802.b. (Cont'd)

2. In addition, the licensee or registrant may not permit any individual to act as a radiographer until the individual:

   A. Has received copies of and instructions in the requirements described in this Part; RH-107.; in the applicable sections of Section 3, "Standards for Protection Against Radiation," (including its Part N, "Notices, Instructions, and Reports to Workers; Inspections"); in applicable Department of Transportation (DOT) regulations as referenced in Section 4 of these ~~Regulations~~ Rules and the U.S. Nuclear Regulatory Commission's (NRC) 10 CFR Part 71; in the Department license(s) under which the radiographer will perform industrial radiography; and the licensee's or registrant's operating and emergency procedures;

   B. Has demonstrated understanding of the licensee's license and the licensee's or registrant's operating and emergency procedures by successful completion of a written or oral examination covering this material.

   C. Has received training in the use of the licensee's or registrant's radiographic exposure devices, sealed sources, in the daily inspection of devices and associated equipment, and in the use of radiation survey instruments.

   D. Has demonstrated understanding of the use of radiographic exposure devices, sources, survey instruments and associated equipment described above in RH-1802.b.2.A. and RH-1802.b.2.C. by the successful completion of a practical examination covering this material.

3. The licensee or registrant may not permit any individual to act as a radiographer's assistant until the individual:

A. Has received copies of and instructions in the requirements described in this Part; RH-107.; in the applicable sections of Section 3, "Standards for Protection Against Radiation," (including its Part N, "Notices, Instructions, and Reports to Workers; Inspections"); in applicable Department of Transportation (DOT) regulations as referenced in Section 4 of these ~~Regulations~~ Rules and the U.S. Nuclear Regulatory Commission's (NRC) 10 CFR Part 71; in the Department license(s) under which the radiographer's assistant will perform industrial radiography; and the licensee's or registrant's operating and emergency procedures;

RH-1802.b.3. (Cont'd)

B. Has developed competence in the use, under the personal supervision of the radiographer, radiographic exposure devices, sealed sources, associated equipment, and radiation survey instruments that the assistant will use; and

C. Has demonstrated understanding of the instructions provided above in RH-1802.b.3.A. by the successful completion of a written test on the subjects covered and has demonstrated competence in the use of hardware described in RH-1802.b.3.B. by the successful completion of a practical examination on the use of such hardware.

4. The licensee or registrant shall provide annual refresher safety training for each radiographer and radiographer's assistant at intervals not to exceed twelve (12) months.

5. Except as provided in RH-1802.b.5.D., the RSO or designee shall conduct an inspection program of the job performance of each radiographer and radiographer's assistant to ensure that the Department's ~~regulations~~ rules, license requirements, and the applicant's operating and emergency procedures are followed. The inspection program must:

A. Include observation of the performance of each radiographer and radiographer's assistant during an actual industrial radiographic operation, at intervals not to exceed six (6) months; and

B. Provide that, if a radiographer or radiographer's assistant has not participated in an industrial radiographic operation for more than six (6) months since the last inspection, the radiographer must demonstrate knowledge of the training requirements of RH-1802.b.2.C., and the radiographer's

assistant must re-demonstrate knowledge of the training requirements of RH-1802.b.3.B., by a practical examination before these individuals can next participate in a radiographic operation.

C. The Department may consider alternatives in those situations where the individual serves as both radiographer and RSO.

D. In those operations where a single individual serves as both radiographer and RSO, and performs all radiography operations, an inspection program is not required.

RH-1802.b. (Cont'd)

6. The licensee or registrant shall maintain records of the above training to include certification documents, written and practical examinations, refresher safety training and inspections of job performance in accordance with RH-1800.d.9.

7. The licensee or registrant shall include the subjects detailed in RH-1804.

8. Records of radiographer certification maintained in accordance with RH-1800.d.9.A. provide appropriate affirmation of certification requirements specified in RH-1802.b.1.

c. **Radiographer certificate card confiscation**.

The Department may confiscate any radiographer's certification card should there be serious health and safety violations relating to the ~~Regulations~~ rules, license conditions, and/or licensee operating and emergency procedures. The radiographer will be restricted from conducting radiographic operations within the State of Arkansas.

1. Following the confiscation of the radiographer's certification card, the conduct of any radiographic operations by this radiographer within the State of Arkansas shall be deemed deliberate misconduct as detailed in RH-107.

2. The Department shall notify the licensee's management and the Certifying Entity of the certification card confiscation and the restrictions placed on the radiographer.

3. The Department shall return the Certification Card when the radiographer has been satisfactorily retrained and/or recertified by a Certifying Entity.

RH-1802. (Cont'd)

d. **Radiation Safety Officer for industrial radiography**.

The Radiation Safety Officer (RSO) shall ensure that radiation safety activities are being performed in accordance with approved procedures and regulatory requirements in the daily operation of the licensee's or registrant's program.

1. The minimum qualifications, training, and experience of Radiation Safety Officers (RSO) for industrial radiography are as follows:

   A. Completion of the training and testing requirements of RH-1802.b.1.;

   B. 2000 hours of hands-on experience as a qualified radiographer in industrial radiographic operations; and

   C. Formal training in the establishment and maintenance of a radiation protection program.

2. The Department will consider alternatives when the RSO has appropriate training and/or experience in the field of ionizing radiation, and in addition, has adequate formal training with respect to the establishment and maintenance of a radiation safety protection program.

3. The specific duties and authorities of the RSO include, but are not limited to:

   A Establishing and overseeing all operating, emergency, and ALARA procedures as required by this Section, "Standards for Protection Against Radiation," and reviewing them regularly to ensure that the procedures in use conform to

current Section 3 procedures, conform to other Department ~~regulations~~ rules, and to the license conditions.

B. Overseeing and approving all phases of the training program for radiographic personnel, ensuring that appropriate and effective radiation protection practices are taught;

C. Ensuring that required radiation surveys and leak tests are performed and documented in accordance with the ~~regulations~~ rules, including any corrective measures when levels of radiation exceed established limits;

RH-1802.d.3. (Cont'd)

D. Ensuring that personnel monitoring devices are calibrated and used properly by occupationally exposed personnel, that records are kept of the monitoring results, and that timely notifications are made as required by RH-1504.; and

E. Ensuring that operations are conducted safely and to assume control for instituting corrective actions including stopping of operations when necessary.

e. **Operating and emergency procedures**.

1. The licensee's or registrant's operating and emergency procedures must include as a minimum, instructions in the following:

A. Appropriate handling and use of licensed sealed sources, radiographic exposure devices, and x-ray equipment (if used) so that no person is likely to be exposed to radiation doses in excess of the limits established in Part C of this Section;

B. Methods and occasions for conducting radiation surveys;

C. Methods for posting and controlling access to radiographic areas;

D. Methods and occasions for locking and securing radiographic exposure devices, transport and storage containers and sealed sources;

E. Personnel monitoring and the use of personnel monitoring equipment;

F. Transporting sealed sources to field locations, including packing of radiographic exposure devices and storage containers in the vehicles, placarding of vehicles when needed, and control of the sealed sources during transportation.

G. The inspection, maintenance, and operability checks of radiographic exposure devices, survey instruments, transport containers, and storage containers;

RH-1802.e.1. (Cont'd)

H. Steps that must be taken immediately by radiography personnel in the event a pocket dosimeter is found to be off-scale or an alarm ratemeter alarms unexpectedly.

I. The procedure for notifying proper persons in the event of an accident;

J. Minimizing exposure of persons in the event of an accident;

K. Source recovery procedure if licensee will perform source recovery;

L. Maintenance of records.

2. The licensee or registrant shall maintain copies of current operating and emergency procedures in accordance with RH-1800.d.10.and RH-1800.d.14.

f. **Personnel monitoring**.

1. A licensee or registrant may not permit any individual to act as a radiographer or a radiographer's assistant unless, at all times during radiographic operations, each individual wears, on the trunk of the body, a combination of a direct reading pocket dosimeter, an operable alarming ratemeter, and a personnel dosimeter ~~that is processed and evaluated by an accredited National Voluntary Laboratory Accreditation Program (NVLAP) processor~~. At permanent radiograph~~y~~ic installations where other appropriate alarming or warning devices are in routine use, the wearing of an alarming ratemeter is not required.

A. Pocket dosimeters shall have a range from zero to 200 millirems (2 millisieverts) and must be recharged at the start of each shift. Electronic personal dosimeters may only be used in place of ion-chamber pocket dosimeters.

B. Each personnel dosimeter must be assigned to and worn by only one (1) individual.

C. Personnel dosimeters that ~~are processed and evaluated by the accredited National Voluntary Laboratory Accreditation Program (NVLAP) processor~~ require replacement must be replaced at periods not to exceed one (1) month. All personnel dosimeters must be evaluated at periods not to exceed one (1) month.

RH-1802.f.1. (Cont'd)

D. After replacement, each personnel dosimeter must be processed as soon as possible.

2. Direct reading dosimeters such as pocket dosimeters or electronic personal dosimeters, must be read and the exposures recorded at the beginning and end of each shift, and records must be maintained in accordance with RH-1800.d.11.

3. Pocket dosimeters, or electronic personal dosimeters, must be checked at periods not to exceed twelve (12) months for correct response to radiation, and records must be maintained in accordance with RH-1800.d.11. Acceptable dosimeters shall be read within plus or minus twenty percent (± 20%) of the true radiation exposure.

4. If an individual's pocket dosimeter is found to be off-scale, or if his or her electronic personal dosimeter reads greater than 200 millirems (2 millisieverts), and the possibility of radiation exposure cannot be ruled out as the cause, the individual's personnel dosimeter that requires processing must be sent for processing and evaluation within twenty-four (24) hours. For personnel dosimeters that do not require processing, evaluation of the dosimeter must be started within twenty-four (24) hours. In addition, the individual may not resume work associated with licensed ~~material or other~~ or registered sources of radiation until a determination of the individual's radiation ~~exposure had~~ dose has been made. This determination must be made by the Radiation Safety Officer (RSO) or the RSO's designee. The results of this determination must be included in the records maintained in accordance with RH-1800.d.11.

5. Dosimetry ~~reports received from the accredited NVLAP personnel dosimeter processor~~ results must be retained in accordance with RH-1800.d.11.

6. If a personnel dosimeter that is required ~~in~~ by RH-1802.f.1. is lost or damaged, the worker shall cease work immediately until a replacement personnel dosimeter meeting the requirements in RH-1802.f.1. is provided and the exposure is calculated for the time period from issuance to loss or damage of the personnel dosimeter. The results of the calculated exposure and the time period for which the personnel dosimeter was lost or damaged must be included in the records maintained in accordance with RH-1800.d.11.

RH-1802.f. (Cont'd)

7. Each alarming ratemeter shall:

   A. Be checked ~~to ensure that the alarm functions properly (sounds) before using~~ without being exposed to radiation prior to use at the start of each work shift~~;~~, to ensure that the audible alarm is functioning properly;

   B. Have an audible alarm sufficient to be heard by the individual wearing the alarming ratemeter or have other visual or physical notification of alarming conditions;

   ~~B~~ C. Be set to give an alarm signal at a preset dose rate of 500 mrem/hr (5 mSv/hr)~~;~~ or lower with an accuracy ~~rate~~ of plus or minus twenty percent (± 20%) of the true radiation dose rate;

   ~~C~~ D. Require special means to change the preset alarm function; and

   ~~D~~ E. Be calibrated for correct response to radiation at ~~periods~~ intervals not to exceed twelve (12) months ~~for correct response to radiation~~. The licensee or registrant shall maintain records of alarming ratemeter calibrations in accordance with RH-1800.d.11.

g. **Reciprocity of a radiographer certification**.

1. Reciprocal recognition by the Department of an individual radiographer certification will be granted provided that:

   A. The individual holds a valid certification in the appropriate category issued by a certifying entity, as defined in RH-1800.c.;

   B. The requirements and procedures of the certifying entity issuing the certification affords the same or comparable certification standards as those afforded by RH-1802.b.1.; and

   C. The individual presents the certification to the Department prior to entry into the State.

2. The Department may withdraw, limit, or qualify its acceptance of any individual radiographer certification based on enforcement actions with the Department, another Agreement State, or the Nuclear Regulatory Commission or sanctions by an independent certifying entity in order to prevent undue hazard to public health and safety or property.

RH-1802.g. (Cont'd)

3. Certified individuals who are granted reciprocity by the Department shall maintain the certification upon which the reciprocal recognition was granted, or prior to the expiration of such certification, shall meet the requirements of RH-1802.b.1.

RH-1803. **Precautionary Procedures in Radiographic Operations**.

a. **Surveillance**.

During each radiographic operation, the radiographer or the other individual present as required in RH-1802.a. shall maintain continuous, direct visual surveillance of the operation to protect against unauthorized entry into a high radiation area, as defined in Section 3, Part D, RH-1303.c., except at permanent radiographic installations where all entryways are locked and the requirements of RH-1801.j. are met.

b. **Posting.**

All areas in which industrial radiography is being performed must be conspicuously posted as required by RH-1303.b.1. and b.2. Exceptions listed in RH-1304. do not apply to industrial radiographic operations.

c. **Radiation surveys**.

The licensee or registrant shall:

1. Conduct surveys with a calibrated and operable radiation survey instrument that meets the requirements of RH-1801.e.

2. Using a survey instrument meeting the requirement of RH-1803.c.1. above, conduct a survey of the radiographic exposure device and the guide tube after each exposure when approaching the device or the guide tube. The survey must determine that the sealed source has been returned to its shielded position before exchanging films, repositioning the exposure head, or dismantling equipment. Radiation machines shall be surveyed after each exposure to determine that the machine is off.

3. Conduct a survey of the radiographic exposure device with a calibrated radiation survey instrument any time the source is exchanged and whenever a radiographic exposure device is placed in a storage area (as defined in RH-1800.c.), to ensure that the sealed source is in its shielded position.

RH-1803.c. (Cont'd)

4. Maintain records in accordance with RH-1800.d.12.

d. **Supervision of radiographer's assistants**.

Whenever a radiographer's assistant uses radiographic exposure devices, associated equipment or sealed sources or conducts radiation surveys required by RH-1803.c.2. to determine that the sealed source has returned to the shielded position after an exposure, the assistant shall be under the personal supervision of a radiographer. The personal supervision shall include:

1. The radiographer's physical presence at the site where the sealed sources are being used,

2. The availability of the radiographer to give immediate assistance if required, and

3. The radiographer's direct observation of the assistant's performance of the operations referred to in this section.

e. **Records required at temporary job sites**.

Each licensee or registrant conducting industrial radiography at temporary job sites shall have the following records available at that site for inspection by the Department:

1. Current copy of appropriate license, certificate of registration or an equivalent document.

2. Operating and emergency procedures.

3. Applicable ~~regulations~~ rules.

4. Survey records required pursuant to RH-1803.c. for the period of operation at the site.

5. Daily pocket dosimeter records for the period of operation at the site.

6. The latest instrument calibration and leak test record for specific devices in use at the site.

RH-1803. (Cont'd)

f. **Specific requirements for radiographic personnel performing industrial radiography**.

1. At a job site, the following shall be supplied by the licensee or registrant:

A. At least one operable, calibrated survey instrument for each exposure device or radiation machine in use;

B. A current whole-body personnel dosimeter ~~that is processed and evaluated by an accredited National Voluntary Laboratory Accreditation Program (NVLAP) processor~~ for each individual performing radiographic operations;

C. An operable, calibrated ~~pocket~~ direct reading dosimeter ~~with a range of zero to 200 milliroentgens~~ for each individual performing radiographic operations;

D. An operable, calibrated alarming ratemeter for each individual performing radiographic operations; and

E. The appropriate barrier ropes and signs.

2. Each radiographer shall have available at the job site a valid certification ID card issued by a ~~c~~Certifying ~~e~~Entity.

3. Industrial radiographic operations shall not be performed if any of the items in paragraphs f.1. and f.2. of this section are not available at the job site or are inoperable.

4. During an inspection by the Department, the ~~Department~~ inspector may terminate an operation if any of the items in paragraphs f.1. and f.2. of this section are not available and operable, or if the required number of radiographic personnel are not present. Operations shall not be resumed until ~~such~~ all required conditions are met.

RH-1803. (Cont'd)

g. **Special requirements and exemptions for enclosed radiography**.

1. **Cabinet x-ray systems**.

A. **Emission limit**.

i. Radiation emitted from the cabinet x-ray system shall not exceed an exposure of 0.5 milliroentgen in one hour at any point five (5) centimeters outside the external surface.

ii. Compliance with the exposure limit in

RH-1803.g.1.A.i. of this section shall be determined by measurements averaged over a cross-sectional area of 10 (ten) square centimeters with no linear dimension greater than five (5) centimeters, with the cabinet x-ray system operated at those combinations of x-ray tube potential, current, beam orientation and conditions of scatter radiation which produce the maximum x-ray exposure at the external surface and with the door(s) and access panel(s) fully closed as well as fixed at any other position(s) which will allow the generation of x-radiation.

B. **Floors**.

A cabinet x-ray system shall have a permanent floor. Any support surface to which a cabinet x-ray system is permanently affixed may be deemed the floor of the system.

C. **Ports and apertures**.

i. The insertion of any part of the human body through any port into the primary beam shall not be possible.

ii. The insertion of any part of the human body through any aperture shall not be possible.

RH-1803.g.1. (Cont'd)

D. **Safety interlocks**.

i. Each door of a cabinet x-ray system shall have a minimum of two (2) safety interlocks. One (1), but not both, of the required interlocks shall be such that door opening results in physical disconnection of the energy supply circuit to the high-voltage generator, and such disconnection shall not be dependent upon any moving part other than the door.

ii. Each access panel shall have at least one safety interlock.

iii. Following interruption of x-ray generation by the functioning of any safety interlock, use of a control provided in accordance with RH-1803.g.1.F. shall be necessary for resumption of x-ray generation.

iv. Failure of any single component of the cabinet x-ray system shall not cause failure of more than one (1) required safety interlock.

E. **Ground fault**.

A ground fault shall not result in the generation of x-rays.

F. **Controls and indicators for all cabinet x-ray systems**.

For all systems to which this section is applicable, there shall be provided:

i. A key-actuated control to insure that x-ray generation is not possible with the key removed.

ii. A control or controls to initiate and terminate the generation of x-rays other than by functioning of a safety interlock or the main power control.

RH-1803.g.1.F. (Cont'd)

iii. Two independent means which indicate when and only when x-rays are being generated, unless the x-ray generation period is less than one-half second, in which case the indicators shall be activated for one-half second, and which are discernible from any point at which initiation of x-ray generation is possible. Failure of a single component of the cabinet x-ray system shall not cause failure of both indicators to perform their intended function. One, but not both, of the indicators required by this subdivision may be a milliammeter labeled to

indicate x-ray tube current. All other indicators shall be legibly labeled "**X-RAY ON**."

iv. Additional means other than milliammeters which indicate when and only when x-rays are being generated, unless the x-ray generation period is less than one-half second, in which case the indicators shall be activated for one-half second, as needed to ensure that at least one indicator is visible from each door, access panel and port and is legibly labeled "**X-RAY ON**."

G. **Additional controls and indicators for cabinet x-ray systems designed to admit humans**.

For cabinet x-ray systems designed to admit humans, there shall also be provided:

i. Compliance with all applicable requirements of this Part and RH-1208. ~~of these Regulations.~~ If such a system is a certified cabinet x-ray system, it shall comply with all applicable requirements of this Part and 21 CFR 1020.40.

ii. Evaluation at intervals not to exceed one (1) year to assure compliance with the applicable requirements as specified in RH-1803.g.1.A. Records of these evaluations shall be maintained for inspection by the Department for a period of (5) years after the evaluation.

RH-1803.g.1.G. (Cont'd)

iii. A control within the cabinet for preventing and terminating x-ray generation, which cannot be reset, over-ridden or bypassed from the outside of the cabinet.

iv. No means by which x-ray generation can be initiated from within the cabinet.

v. Audible and visible warning signals within the cabinet which are actuated for at least ten (10) seconds immediately prior to the first initiation of x-

ray generation after closing any door designed to admit humans. Failure of any single component of the cabinet x-ray system shall not cause failure of both the audible and visible warning signals.

vi. A visible warning signal within the cabinet which remains actuated when and only when x-rays are being generated, unless the x-ray generation period is less than one-half second, in which case the indicators shall be activated for one-half second.

vii. Signs indicating the meaning of the warning signals provided pursuant to RH-1803.g.1.G.v. and vi. and containing instructions for the use of the control provided pursuant to RH-1803.g.1.G.iii. These signs shall be legible, accessible to view and illuminated when the main power control is in the "**on**" position.

H. **Warning labels**.

i. There shall be permanently affixed or inscribed on the cabinet x-ray system at the location of any controls which can be used to initiate x-ray generation, a clearly legible and visible label bearing the statement:

CAUTION:
X-RAYS PRODUCED WHEN ENERGIZED

RH-1803.g.1.H. (Cont'd)

ii. There shall be permanently affixed or inscribed on the cabinet x-ray system at the location of any controls which can be used to initiate x-ray generation, a clearly legible and visible label bearing the statement:

CAUTION:
DO NOT INSERT ANY PART OF THE BODY WHEN SYSTEM IS ENERGIZED--
X-RAY HAZARD

I. **Instructions**.

i. Manufacturers of cabinet x-ray systems shall provide for purchasers and to others upon request at a cost not to exceed the cost of preparation and distribution, manuals and instructions which shall include at least the following technical and safety information: Potential, current and duty cycle ratings of the x-ray generation equipment; adequate instructions concerning any radiological safety procedures and precautions which may be necessary because of unique features of the system; and a schedule of maintenance necessary to keep the system in compliance with this section.

ii. Manufacturers of cabinet x-ray systems which are intended to be assembled or installed by the purchaser, shall provide instructions for assembly, installation, adjustment and testing of the cabinet x-ray system adequate to assure the system is in compliance with applicable provisions of this section when assembled, installed, adjusted and tested as directed.

J. **Additional requirements for x-ray baggage inspection systems**.

X-ray systems designed primarily for the inspection of carry-on baggage at airline, railroad and bus terminals and at similar facilities, shall be provided with means, pursuant to RH-1803.g.1.J.i. and ii., to insure operator presence at the control area in a position which permits surveillance of the ports and doors during generation of x-radiation.

i. During an exposure or preset succession of exposures of one-half second or greater duration, the means provided shall enable the operator to terminate the exposure or preset succession of exposures at any time.

ii. During an exposure or preset succession of exposures of less than one-half second or greater duration, the means provided may allow completion of the exposure in progress but shall enable the operator to prevent additional exposures.

2. **Cabinet Radiography**.

Cabinet radiography units are exempt from other requirements of this Part; however,

A. No licensee or registrant shall permit any individual to operate a cabinet radiography unit until such individual has received a copy of, and instruction in, and has demonstrated an understanding of operating procedures for the unit, and has demonstrated competence in its use.

B. A cabinet radiography unit shall not be operated until a physical radiation survey of the unit and areas adjacent to the unit has been performed. The licensee or registrant shall perform the survey with a properly calibrated instrument as described in RH-1803.c. to determine conformance with RH-1200.

RH-1803.g.2. (Cont'd)

C. The registrant shall perform an evaluation, at intervals not to exceed one (1) year, to determine conformance with Part C of Section 3. If such a system is a certified cabinet x-ray system, it shall be evaluated at intervals not to exceed (1) year to determine conformance with 21 CFR 1020.40. Records of these evaluations shall be maintained for inspection by the Department for a period of five (5) years after the evaluation.

D. The operating personnel must be provided with either a film badge or a thermoluminescent dosimeter, and reports of the results must be maintained for inspection by the Department.

E. Tests for proper operation of high radiation control devices or alarm systems must be conducted and recorded in accordance with RH-1801.i.

3. **Shielded room radiography**.

Shielded room radiography shall comply with all applicable requirements of this Part.

4. Certified cabinet x-ray systems shall be maintained in compliance with 21 CFR 1020.40 unless prior approval has been granted by the Department pursuant to RH-55~~ of these Regulations~~.

g. **Prohibitions**.

Industrial radiography performed with a sealed source which is not fastened to or contained in a radiographic exposure device (fish pole technique) is prohibited unless specifically authorized in a license issued by the Department.

RH-1804. **Subjects to be Covered During the Instruction of Radiographers**.

a. **Fundamentals of radiation safety**.

1. Characteristics of gamma and/or x-ray radiation.

2. Units of radiation dose and quantity of radioactivity.

3. Hazards of exposure to radiation.

RH-1804. (Cont'd)

4. Levels of radiation from sources of radiation.

5. Methods of controlling radiation dose.

A. Time.

B. Distance.

C. Shielding.

b. **Radiation detection instruments**.

1. Use of radiation survey instruments.

A. Operation.

B. Calibration.

C. Limitations.

2. Survey techniques.

3. Use of personnel monitoring equipment.

A. Film badges.

B. Thermoluminescent dosimeters (TLDs).

C. Optically Stimulated Luminescent dosimeters.

D. Pocket dosimeters.

E. Alarm ratemeters.

c. **Equipment to be used**.

1. Operation and control of radiographic exposure equipment, remote handling equipment, and storage containers, including pictures or models of source assemblies (pigtails).

2. Storage, control, and disposal of licensed material.

3. Inspection and maintenance of equipment.

RH-1804.c. (Cont'd)

4. Operation and control of x-ray equipment if applicable.

5. Collimators.

d. The requirements of pertinent Federal and State regulations.

e. The licensee's or registrant's written operating and emergency procedures.

f. Case histories of accidents in radiography.

RH-1805.- RH-1899. Reserved.

SCHEDULE B TO SECTION 3

RADIOGRAPHIC CERTIFICATION

I. **Requirements for an Independent Certifying Organization**.

An independent certifying organization shall:

1. Be an organization such as a society or association, whose members participate in, or have an interest in, the fields of industrial radiography;

2. Make its membership available to the general public nationwide that is not restricted because of race, color, religion, sex, age, national origin or disability;

3. Have a certification program open to nonmembers, as well as members;

4. Be an incorporated, nationally recognized organization, that is involved in setting national standards of practice within its fields of expertise;

5. Have an adequate staff, a viable system for financing its operations, and a policy-and-decision-making review board;

6. Have a set of written organizational by-laws and policies that provide adequate assurance of lack of conflict of interest and a system for monitoring and enforcing those by-laws and policies;

7. Have a committee, whose members can carry out their responsibilities impartially, to review and approve the certification guidelines and procedures, and to advise the organization's staff in implementing the certification program;

8. Have a committee, whose members can carry out their responsibilities impartially, to review complaints against certified individuals and to determine appropriate sanctions;

9. Have written procedures describing all aspects of its certification program, maintain records of the current status of each individual's certification and the administration of its certification program;

10. Have procedures to ensure that certified individuals are provided due process with respect to the administration of its certification program, including the process of becoming certified and any sanctions imposed against certified individuals;

11. Have procedures for proctoring examinations, including qualifications for proctors. These procedures must ensure that the individuals proctoring each examination are not employed by the same company or corporation (or a wholly-owned subsidiary of such company or corporation) as any of the examinees;

12. Exchange information about certified individuals with the Department and other independent certifying organizations and/or the U.S. Nuclear Regulatory Commission and/or Agreement States and allow periodic review of its certification program and related records; and

13. Provide a description to the Department of its procedures for choosing examination sites and for providing an appropriate examination environment.

II. **Requirements for Certification Programs**.

All certification programs must:

1. Require applicants for certification to:

   A. Receive training in the topics set forth in RH-1804. or equivalent NRC and/or Agreement State regulations; and

   B. Satisfactorily complete a written examination covering these topics.

2. Require applicants for certification to provide documentation that demonstrates that the applicant has:

   A. Received training in the topics set forth in RH-1804. or equivalent NRC and/or Agreement State regulations;

   B. Satisfactorily completed a minimum period of on-the-job training; and

   C. Received verification by an Agreement State or NRC licensee that the applicant has demonstrated the capability of independently working as a radiographer;

3. Include procedures to ensure that all examination questions are protected from disclosure;

4. Include procedures for denying an application, revoking, suspending, and reinstating a certificate;

5. Provide a certificate period of not less that three (3) years nor more than five (5) years;

6. Include procedures for renewing certifications and, if the procedures allow renewals without examination, require evidence of recent full-time employment and annual refresher training; and

7. Provide a timely response to inquiries, by telephone or letter, from members of the public, about an individual's certification status.

III. **Requirements for Written Examinations**.

All examinations must be:

1. Designed to test an individual's knowledge and understanding of the topics listed in RH-1804. or equivalent NRC and/or Agreement State regulations;

2. Written in a multiple-choice format; and

3. Have test items drawn from a question bank containing psychometrically valid questions based on the material in RH-1804.

PART J.
LICENSES AND RADIATION SAFETY REQUIREMENTS FOR WIRELINE SERVICE OPERATIONS AND SUBSURFACE TRACER STUDIES

RH-1900. **General Provisions**.

a. **Scope**.

The ~~Regulations~~ rules in this Part apply to all licensees who use sources of radiation for wireline service operations including mineral logging, radioactive markers or subsurface tracer studies.

b. **Purpose**.

The ~~Regulations~~ rules in this Part establish radiation safety requirements for persons utilizing sources of radiation for wireline service operations including mineral logging, radioactive markers and subsurface tracer studies. The requirements of this Part are in addition to and not in substitution for other applicable requirements of these ~~Regulations~~ Rules.

c. **Definitions**.

Energy compensation source (ECS) - A small sealed source, with an activity not exceeding 100 microcuries (3.7 MBq), used within a logging tool, or other tool components, to provide a reference standard to maintain the tool's calibration when in use.

Field station - A facility where radioactive sources may be stored or used and from which equipment is dispatched to temporary job sites.

Fresh water aquifer - A geologic formation that is capable of yielding fresh water to a well or spring.

Injection tool - A device used for controlled subsurface injection of radioactive tracer material.

Irretrievable well logging source - Any sealed source containing radioactive material that is pulled off or not connected to the wireline that suspends the source in the well and for which all reasonable effort at recovery has been expended.

Logging assistant - Any individual who, under the personal supervision of a logging supervisor, handles sealed sources, tracers, or radiation producing machines that are not in logging tools or shipping containers or who performs surveys required by RH-1967.

Logging supervisor - Any individual who uses radioactive material or radiation producing machines, or provides personal supervision in the use of radioactive material or radiation producing machines at a temporary jobsite and who is responsible to the licensee for assuring compliance with the requirements of the Department's ~~Regulations~~ rules and the conditions of the license.

Logging tool - Any device used subsurface to perform well-logging.

Mineral logging - Any logging performed for the purpose of mineral exploration other than oil or gas.

Particle accelerator - Any machine capable of accelerating elections, protons, deuterons or other charged particles in a vacuum and of discharging the resultant particulate or other radiation into a medium at energies usually in excess of one (1) MeV.

Personal supervision - Guidance and instruction by the logging supervisor who is physically present at the job site and watching the performance of the operation in such proximity that contact can be maintained and immediate assistance given as required.

Radioactive marker - Radioactive material placed subsurface or on a structure intended for subsurface use for the purpose of depth determination or direction orientation.

Radioactive material - Byproduct, source or special nuclear material received, processed, used or transferred under a license issued by the Arkansas State Board of Health, Arkansas Department of Health under the ~~regulations~~ rules of this Part.

Sealed source - Any radioactive material that is encased in a capsule designed to prevent leakage or escape of the radioactive material.

Source holder - A housing or assembly into which a radioactive source is placed for the purpose of facilitating the handling and use of the source in well-logging operations.

RH-1900.c. (Cont'd)

Subsurface tracer study - the release of a substance tagged with radioactive material for the purpose of tracing the movement or position of the tagged substance in the well-bore or adjacent formation.

Surface casing for protecting fresh water aquifers - a pipe or tube used as a lining in a well to isolate fresh water aquifers from the well.

Temporary jobsite - A location to which radioactive materials have been dispatched to perform wireline service operations or subsurface tracer studies.

Tritium neutron generator target source - A tritium source used within a neutron generator tube to produce neutrons for use in well-logging applications.

Uranium sinker bar - A weight containing depleted uranium used to pull a logging tool toward the bottom of a well.

Well-bore - A drilled hole in which wireline service operations and subsurface tracer studies are performed.

Well-logging - the lowering and raising of measuring devices or tools which may contain sources of radiation into well-bores or cavities for the purpose of obtaining information about the well and/or adjacent formations.

Wireline - A cable containing one or more electrical conductors which is used to lower and raise logging tools in the well-bore.

Wireline service operation - Any evaluation or mechanical service which is performed in the well-bore using devices on a wireline.

RH-1901- RH-1910. Reserved.

RH-1911. **Application for a Specific License**.

A person, as defined in RH-1100., shall file an application for a specific license authorizing the use of radioactive material in well logging in accordance with RH-403. and RH-404.

RH-1912. Reserved.

RH-1913. **Specific Licenses for Well Logging**.

The Department will approve an application for a specific license for the use of radioactive material in well logging if the applicant meets the following requirements:

a. The application shall satisfy the general requirements specified in RH-404. ~~of these Regulations~~, and any special requirements contained in this Part.

b. The applicant shall develop a program for training logging supervisors and logging assistants and submit to the Department a description of this program which specifies the:

1. Initial training;

2. On-the-job training;

3. Annual safety reviews provided by the licensee;

4. Means the applicant will use to demonstrate the logging supervisor's knowledge and understanding of and ability to comply with the Department's ~~Regulations~~ rules and licensing requirements and the applicant's operating and emergency procedures; and

5. Means the applicant will use to demonstrate the logging assistant's knowledge and understanding of and ability to comply with the applicant's operating and emergency procedures.

c. The applicant shall submit to the Department written operating and emergency procedures as described in RH-1963. or an outline or summary of the procedures that includes the important radiation safety aspects of the procedures.

d. The applicant shall establish and submit to the Department its program for annual inspections of the job performance of each logging supervisor to ensure that the Department's ~~regulations~~ rules, license requirements, and the applicant's operating and emergency procedures are followed. Inspection records must be retained for three (3) years after each annual internal inspection.

RH-1913. (Cont'd)

e. The applicant shall submit a description of its overall organizational structure as it applies to the radiation safety responsibilities in well logging, including specified delegations of authority and responsibility.

f. If an applicant wants to perform leak testing of sealed sources, the applicant shall identify the manufacturers and model numbers of the leak test kits to be used. If an applicant wants to analyze its own wipe samples, the applicant shall establish procedures to be followed and submit a description of these procedures to the Department. The description must include the:

1. Instruments to be used;

2. Methods of performing the analysis; and

3. Pertinent experience of the person who will analyze the wipe samples.

RH-1914. Reserved.

RH-1915. **Agreement with Well Owner or Operator**.

a. A licensee may perform well logging with a sealed source only after the licensee has a written agreement with the employing well owner or operator. This written agreement must identify who will meet the following requirements:

1 If a sealed source becomes lodged in the well, a reasonable effort will be made to recover it.

2. A person may not attempt to recover a sealed source in a manner which, in the licensee's opinion, could result in its rupture.

3. The radiation monitoring required in RH-1969.~~a.~~ will be performed.

4. If the environment, any equipment, or personnel are contaminated with radioactive material, they must be decontaminated before release from the site or release for unrestricted use; and

5. If the sealed source is classified as irretrievable after reasonable efforts at recovery have been expended, the following requirements must be implemented within thirty (30) days:

   A. Each irretrievable well logging source must be immobilized and sealed in place with a cement plug;

   B. A means to prevent inadvertent intrusion on the source unless the source is not accessible to any subsequent drilling operations; and

   C. A permanent identification plaque, constructed of long-lasting material such as stainless steel, brass, bronze, or monel, must be mounted at the surface of the well, unless the mounting of the plaque is not practical. The size of the plaque must be at least seven (7) inches (17cm) square and 1/8-inch (3 mm) thick. The plaque[14/] must contain:

      i. The word "**CAUTION**";

      ii. The radiation symbol (the color requirement in RH-1303.a.1. need not be met);

      iii. The date the source was abandoned;

      iv. The name of the well owner or operator, as appropriate;

      v. The well name and well identification numbers(s) or other designation;

      vi. An identification of the sealed source(s) by radionuclide and quantity;

      vii. The depth of the source and depth to the top of the plug; and

      viii. An appropriate warning, such as "**DO NOT RE-ENTER THIS WELL**."[15/]

b. The licensee shall retain a copy of the written agreement for three (3) years after the completion of the well logging operation.

RH-1915. (Cont'd)

c. A licensee may apply, pursuant to RH-1991., for Department approval, on a case-by-case basis, of proposed procedures to abandon an irretrievable well logging source in a manner not otherwise authorized in RH-1915.a.5. of this section.

d. A written agreement between the licensee and the well owner or operator is not required if the licensee and the well owner or operator are part of the same corporate structure or otherwise similarly affiliated. However, the licensee shall still otherwise meet the requirements of RH-1915.a.1. through RH-1915.a.5.

RH-1916. Reserved.

RH-1917. **Request for Written Statements**.

Each license is issued with the condition that the licensee will, at any time before expiration of the license, upon the Department's request, submit written statements, signed under oath or affirmation, to enable the Department to determine whether or not the license should be modified, suspended, or revoked.

RH-1918.- RH-1930. Reserved.

RH-1931. **Labels, Security, and Transportation Precautions**.

a. **Labels**.

1. The licensee may not use a source, source holder, or logging tool that contains radioactive material unless the smallest component that is transported as a separate piece of equipment with the radioactive material inside bears a durable, legible, and clearly visible marking or label. The marking or label must contain the radiation symbol specified in RH-1303.a.1. and 2., without the conventional color requirements, and the wording

"**DANGER (or CAUTION) RADIOACTIVE MATERIAL**."

RH-1931.a. (Cont'd)

2. The licensee may not use a container to store radioactive material unless the container has ~~a secure,~~ securely attached to it a durable, legible, and clearly visible label. The label must contain the radiation symbol specified in RH-1303.a. and the wording

"**CAUTION**,*
RADIOACTIVE MATERIAL,
NOTIFY CIVIL AUTHORITIES [or name of company] ~~**IF FOUND**~~."

***or DANGER**

3. The licensee may not transport radioactive material unless the material is packaged, labeled, marked, and accompanied with appropriate shipping papers in accordance with Section 4 of these ~~Regulations~~ Rules.

b. **Security precautions during storage and transportation**.

1. The licensee shall store each source containing radioactive material in a storage container or transportation package. The container or package must be locked and physically secured to prevent tampering or removal of radioactive material from storage by unauthorized personnel. The licensee shall store the radioactive material in a manner which will minimize the danger from explosion or fire.

2. The licensee shall lock and physically secure the transport package containing radioactive material in the transporting vehicle to prevent accidental loss, tampering, or unauthorized removal of the radioactive material from the vehicle.

RH-1932. Reserved.

RH-1933. **Radiation Detection Instruments**.

a. The licensee shall keep a calibrated and operable radiation survey instrument capable of detecting beta and gamma radiation at each field station and temporary jobsite to make the radiation surveys required by this Part and by other Parts of Section 3. To satisfy this requirement, the radiation survey instrument must be capable of measuring 0.1 mrem (0.001 mSv) per hour through at least 50 mrem (0.5 mSv) per hour.

RH-1933. (Cont'd)

b. The licensee shall have available additional calibrated and operable radiation detection instruments sensitive enough to detect the low radiation and contamination levels that could be encountered if a sealed source ruptured. The licensee may own the instruments or may have a procedure to obtain them quickly from a second party.

c. The licensee shall have each radiation survey instrument required under RH-1933.a.of this section calibrated:

1. At intervals not to exceed six (6) months and after instrument servicing;

2. For linear scale instruments, at two (2) points located approximately 1/3 and 2/3 of full-scale on each scale; for logarithmic scale instruments, at midrange of each decade, and at two (2) points of at least one decade; and for digital instruments, at appropriate points; and

3. So that an accuracy within plus or minus twenty percent (± 20%) of the calibration standard can be demonstrated on each scale.

d. The license shall retain calibration records for a period of three (3) years after the date of calibration for inspection by the Department.

RH-1934. Reserved.

RH-1935. **Leak Testing of Sealed Sources**.

a. **Testing and recordkeeping requirements**.

Each licensee who uses a sealed source shall have the source leak tested for leakage in accordance with RH-1212. and as prescribed in this section. The licensee shall keep a record of leak test results in units of microcuries and retain the record for inspection by the Department for three (3) years after the leak test is performed.

RH-1935. (Cont'd)

b. **Method of testing**.

The wipe of a sealed source must be performed using a leak test kit or method approved by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State. The wipe sample must be taken from the nearest accessible point to the sealed source where contamination might accumulate. The wipe sample must be analyzed for radioactive contamination. The analysis must be capable of detecting the presence of 0.005 microcuries (185 Bq) of radioactive material on the test sample and must be performed by a person approved by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State to perform the analysis.

c. **Test frequency**.

1. Each sealed source (except an energy compensation source (ECS)) must be tested at intervals not to exceed six (6) months. In the absence of a certificate from a transferor that a test has been made within the six (6) months before the transfer, the sealed source may not be used until tested.

2. Each ECS that is not exempt from testing in accordance with RH-1935.e. must be tested at intervals not to exceed three (3) years. In the absence of a certificate from a transferor that a test has been made within the three (3) years before the transfer, the ECS may not be used until tested.

d. **Removal of leaking source from service**.

1. If the test conducted pursuant to RH-1935.a. and RH-1935.b. reveals the presence of 0.005 microcuries (185 Bq) or more of removable radioactive material, the licensee shall remove the sealed source from service immediately and have it decontaminated, repaired, or disposed of by a Department, U.S. Nuclear Regulatory Commission, or an Agreement State licensee that is authorized to perform these functions. The licensee shall check the equipment associated with the leaking source for radioactive contamination and, if contaminated, have it decontaminated or disposed of by a Department, U.S. Nuclear Regulatory Commission, or an Agreement State licensee that is authorized to perform these functions.

RH-1935.d. (Cont'd)

2. The licensee shall submit a report to the Department within five (5) days of receiving the test results. The report must describe the equipment involved in the leak, the test results, any contamination which resulted from the leaking source, and the corrective actions taken up to the time the report is made.

e. **Exemptions from testing requirements**.

The following sealed sources are exempt from the periodic leak requirements set out in RH-1935.a. through RH-1935.d.:

1. Hydrogen-3 (tritium) sources;

2. Sources containing licensed material with a half-life of thirty (30) days or less;

3. Sealed sources containing licensed material in gaseous form;

4. Sources of beta- or gamma-emitting radioactive material with an activity of 100 microcuries (3.7 MBq) or less; and

5. Sources of alpha- or neutron-emitting radioactive material with an activity of ten (10) microcuries (0.37 MBq) or less.

RH-1936. Reserved.

RH-1937. **Physical Inventory**.

Each licensee shall conduct a quarterly physical inventory to account for all radioactive material received and possessed under the license. The licensee shall retain records of the inventory for three (3) years from the date of the inventory for inspection by the Department. The inventory must indicate the quantity and type of radioactive material, the location of the radioactive material, the date of the inventory, and the name of the individual conducting the inventory.

RH-1938. Reserved.

RH-1939. **Records of Material Use**.

a. Each licensee shall maintain records for each use of radioactive material showing:

1. The make, model number, and a serial number or a description of each sealed source used;

2. In the case of unsealed radioactive material used for subsurface tracer studies, the radionuclide and quantity of activity used in a particular well and the disposition of any unused tracer material;

3. The identity of the logging supervisor who is responsible for the licensed material and the identity of logging assistants present; and

4. The location and date of use of the radioactive material.

b. The licensee shall make the records required by RH-1939.a. of this section available for inspection by the Department. The licensee shall retain the records for three (3) years from the date of the recorded event.

RH-1940. Reserved.

RH-1941. **Design and Performance Criteria for Sealed Sources**.

a. A licensee may use a sealed source in well-logging applications if:

1. The sealed source is doubly encapsulated;

2. The sealed source licensed material whose chemical and physical forms are as insoluble and nondispersible as practical; and

3. Meets the requirements in RH-1941.b., c. or d.

b. For a sealed source manufactured on or before July 14, 1989, a licensee may use the sealed source, for use in well-logging applications if it meets the requirements of USASI N5.10-1968, “Classification of Sealed Radioactive Sources,” or the requirements in RH-1941.c. or d.

c. For a sealed source manufactured after July 14, 1989, a licensee may use the sealed source, for use in well-logging applications if it meets the oil-well logging requirements of ANSI/HPS N43.6-1997, “Sealed Radioactive Sources-Classification.”

RH-1941. (Cont'd)

d. For a sealed source manufactured after July 14, 1989, a licensee may use the sealed source, for use in well-logging applications, if:

1. The sealed source's prototype has been tested and found to maintain its integrity after each of the following tests:

A. **Temperature**.

The test source must be held at - 40º C for 20 minutes, 600º C for one (1) hour, and then be subject to a thermal shock test with a temperature drop from 600º C to 20º C within 15 seconds.

B. **Impact test**.

A 5 kg steel hammer, 2.5 cm in diameter, must be dropped from a height of one (1) meter onto the test source.

C. **Vibration test**.

The test source must be subject to a vibration from 25 Hz to 500 Hz at 5 gram amplitude for 30 minutes.

D. **Puncture test**.

A one (1) gram hammer and pin, 0.3 cm pin diameter, must be dropped from a height of one (1) meter onto the test source.

E. **Pressure test**.

The test source must be subject to an external pressure of 24,600 pounds per square inch absolute (1.695×10^7 pascals).

e. The requirements of RH-1941.a., b., c., and d. do not apply to sealed sources that contain radioactive material in gaseous form.

f. The requirements in RH-1941.a., b., c., and d. do not apply to energy compensation sources (ECS). ECSs must be registered with the U.S. Nuclear Regulatory Commission or with an Agreement State.

RH-1942. Reserved.

RH-1943. **Inspection, Maintenance, and Opening of a Source or Source Holder**.

a. Each licensee shall visually check source holders, logging tools, and source handling tools for defects before each use to ensure that the equipment is in good working condition and that required labeling is present. If defects are found, the equipment must be removed from service until repaired, and a record must be made listing: the date of the check, name of inspector, equipment involved, defects found, and repairs made. These records must be retained for three (3) years after the defect is found.

b. Each licensee shall have a program for semiannual visual inspection and routine maintenance of source holders, logging tools, injection tools, source handling tools, storage containers, transport containers, and uranium sinker bars to ensure that the required labeling is legible and that no physical damage is visible. If defects are found, the equipment must be removed from service until repaired, and a record must be made listing: date, equipment involved, inspection and maintenance operations performed, any defects found, and any actions taken to correct the defects. These records must be retained for three (3) years after the defect is found.

c. Removal of a sealed source from a source holder or logging tool, and maintenance on sealed sources or holders in which sealed sources are contained may not be performed by the licensee unless a written procedure developed pursuant to RH-1963. has been approved either by the Department, the U.S. Nuclear Regulatory Commission, or by an Agreement State pursuant to RH-1913.c.

d. If a sealed source is stuck in the source holder, the licensee may not perform any operation, such as drilling, cutting, or chiseling, on the source holder unless the licensee is specifically approved by the Department, the U.S. Nuclear Regulatory Commission, or by an Agreement State to perform this operation.

e. The opening, repair, or modification of any sealed source must be performed by persons specifically approved to do so by the Department, the U.S. Nuclear Regulatory Commission, or by an Agreement State.

RH-1944. Reserved.

RH-1945. **Subsurface Tracer Studies**.

a. The licensee shall require all personnel handling radioactive tracer material to use protective gloves and, if required by the license, other protective clothing and equipment. The licensee shall take precautions to avoid ingestion or inhalation of radioactive tracer material and to avoid contamination of field stations and temporary jobsites.

b. A licensee may not knowingly inject radioactive material into fresh water aquifers unless specifically authorized to do so by the Department.

RH-1946. **Particle Accelerators**.

No licensee shall permit above-ground testing of particle accelerators that results in the production of radiation, except in areas or facilities controlled or shielded so as to meet the requirements of RH-1200. and RH-1208. ~~of these Regulations~~, as applicable.

RH-1947. **Radioactive Markers**.

The licensee may use radioactive markers in wells only if the individual markers contain quantities of radioactive material not exceeding the quantities specified in RH-901., Schedule B. The use of markers is subject to the requirements of RH-1937.

RH-1948. Reserved.

RH-1949. **Uranium Sinker Bars**.

The licensee may use a uranium sinker bar in well logging applications after July 14, 1988, only if it is legibly impressed with the words

"**CAUTION - RADIOACTIVE - DEPLETED URANIUM**"
and
"**NOTIFY CIVIL AUTHORITIES** [or name of company] **IF FOUND**."

RH-1950. Reserved.

RH-1951. **Use of a Sealed Source in a Well Without a Surface Casing**.

The licensee may use a sealed source in a well without a surface casing for protecting fresh water aquifers only if the licensee follows a procedure for reducing the probability of the source becoming lodged in the well. The procedure must be approved by the Department pursuant to RH-1913.

RH-1952. Reserved.

RH-1953. **Energy Compensation Source**.

The licensee may use an energy compensation source (ECS) which is contained within a logging tool, or other tool components, only if the ECS contains quantities of licensed material not exceeding 100 microcuries (3.7 MBq).

a. For well logging applications with a surface casing for protecting fresh water aquifers, use of the ECS is only subject to the requirements of RH-1935., RH-1937., and RH-1939.

b. For well logging applications without a surface casing for protecting fresh water aquifers, use of the ECS is only subject to the requirements of RH-1915., RH-1935., RH-1937., RH-1939., RH-1951., and RH-1977.

RH-1954. Reserved.

RH-1955. **Tritium Neutron Generator Target Source**.

a. Use of a tritium neutron generator target source, containing quantities not exceeding thirty (30) curies (1,110 MBq) and in a well with a surface casing to protect fresh water aquifers, is subject to the requirements of this part except for RH-1915., RH-1941., and RH-1977.

b. Use of a tritium neutron generator target source, containing quantities exceeding thirty (30) curies (1,110 MBq) or in a well without a surface casing to protect fresh water aquifers, is subject to the requirements of this Part except for RH-1941.

RH-1956- RH-1960. Reserved.

RH-1961. **Training**.

a. The licensee may not permit an individual to act as a logging supervisor until that person:

1. Has completed training in the subjects outlined in RH-1961.e. of this section;

2. Has received copies of, and instruction in:

A. The applicable Parts of Section 3~~ of these Regulations~~;

B. The license under which the logging supervisor will perform well logging; and

C. The licensee's operating and emergency procedures required by RH-1963.

3. Has completed on-the-job training and demonstrated competence in the use of radioactive materials, remote handling tools, and radiation survey instruments by a field evaluation; and

4. Has demonstrated understanding of the requirements in RH-1961.a.1. and RH-1961.a.2. by successfully completing a written test.

b. The licensee may not permit an individual to act as a logging assistant until that person:

1. Has received instruction in applicable Parts of Section 3~~ of these Regulations~~;

2. Has received copies of, and instruction in, the licensee's operating and emergency procedures required by RH-1963.;

3. Has demonstrated understanding of the material in RH-1961.b.1. and RH-1961.b.2. of this section by successfully completing a written or oral test; and

4. Has received instruction in the use of radioactive materials, remote handling tools, and radiation survey instruments, as appropriate for the logging assistant's intended job responsibilities.

c. The licensee shall provide safety reviews for logging supervisors and logging assistants at least once during each calendar year.

RH-1961. (Cont'd)

d. The licensee shall maintain a record on each logging supervisor's and logging assistant's training and annual safety review. The training records must include copies of written tests and dates of oral tests given after July 14, 1987. The training records must be retained until three (3) year following the termination of employment. Records of annual safety reviews must list the topics discussed and be retained for three (3) years.

e. The licensee shall include the following subjects in the training required in RH-1961.a.1. of this section.

1. Fundamentals of radiation safety, including:

A. Characteristics of radiation;

B. Units of radiation dose and quantity of radioactivity;

C. Hazards of exposure to radiation;

D. Levels of radiation from licensed material;

E. Methods of controlling radiation dose (time, distance, and shielding); and

F. Radiation safety practices, including prevention of contamination, and methods of decontamination.

2. Radiation detection instruments, including:

A. Use, operation, calibration, and limitations of radiation survey instruments;

B. Survey techniques; and

C. Use of personnel monitoring equipment.

3. Equipment to be used, including:

A. Operation of equipment, including source handling equipment and remote handling tools;

B. Storage, control, and disposal of ~~radioactive~~ licensed material; and

C. Maintenance of equipment.

RH-1961.e. (Cont'd)

4. The requirements of pertinent Department ~~regulations~~ rules; and

5. Case histories of accidents in well-logging.

RH-1962. Reserved.

RH-1963. **Operating and Emergency Procedures**.

Each licensee shall develop and follow written operating and emergency procedures that cover:

a. The handling and use of radioactive materials including the use of sealed sources in wells without surface casing for protecting fresh water aquifers, if appropriate;

b. The use of remote handling tools for handling sealed sources and radioactive tracer material except low-activity calibration sources;

c. Methods and occasions for conducting radiation surveys, including surveys for detecting contamination, as required by RH-1967.c. through RH-1967.e.;

d. Minimizing personnel exposure including exposures from inhalation and ingestion of radioactive tracer materials;

e. Methods and occasions for locking and securing stored radioactive materials;

f. Personnel monitoring and the use of personnel monitoring equipment;

g. Transportation of radioactive material to field stations or temporary jobsites, packaging of radioactive materials for transport in vehicles; placarding of vehicles when needed, and physically securing radioactive materials in transport vehicles during transportation to prevent accidental loss, tampering, or unauthorized removal;

h. Picking up, receiving, and opening packages containing radioactive materials, in accordance with RH-1307.;

i. For the use of tracers, decontamination of the environment, equipment, and personnel;

RH-1963. (Cont'd)

j. Maintenance of records generated by logging personnel at temporary jobsites;

k. The inspection and maintenance of sealed sources, source holders, logging tools, injection tools, source handling tools, storage containers, transport containers, and uranium sinker bars as required by RH-1943.;

l. Actions to be taken if a sealed source is lodged in a well;

m. Notifying proper persons in the event of an accident;

n. Actions to be taken if a sealed source is ruptured including actions to prevent the spread of contamination and minimize inhalation and ingestion of radioactive materials and actions to obtain suitable radiation survey instruments as required by RH-1933.b.; and

o. Identifying and reporting to the Department defects and noncompliance as required by RH-1935.d.2. and RH-1977.a., b., and d. ~~of these regulations~~.

p. For particle accelerators, testing and use of the accelerator.

RH-1964. Reserved.

RH-1965. **Personnel Monitoring**.

a. The licensee may not permit an individual to act as a logging supervisor or logging assistant unless that ~~persons wears,~~ person wears a personnel dosimeter at all times during the handling of licensed radioactive materials~~, a personnel dosimeter that is processed and evaluated by an accredited National Voluntary Laboratory Accreditation Program (NVLAP) processor~~. Each personnel dosimeter must be assigned to and worn by only one (1) individual. Film badges must be replaced at least monthly and all other personnel dosimeters that require replacement must be replaced at least quarterly. ~~After replacement, each personnel dosimeter must be promptly processed.~~ All personnel dosimeters must be evaluated at least quarterly or promptly after replacement, whichever is more frequent.

b. The licensee shall provide bioassay services to individuals using radioactive materials in subsurface tracer studies if required by the license.

c. The licensee shall retain records of personnel dosimeters and bioassay results for inspection until the Department authorizes disposition of the records.

RH-1966. Reserved.

RH-1967. **Radiation Surveys**.

a. The licensee shall make radiation surveys, including but not limited to the surveys required under RH-1967.b. through RH-1967.e. of this section, of each area where radioactive materials are used and stored.

b. Before transporting radioactive materials, the licensee shall make a radiation survey of the position occupied by each individual in the vehicle and of the exterior of each vehicle used to transport the radioactive materials.

c. If the sealed source assembly is removed from the logging tool before departure from the temporary jobsite, the licensee shall confirm that the logging tool is free of contamination by energizing the logging tool detector or by using a survey meter.

d. If the licensee has reason to believe that, as a result of any operation involving a sealed source, the encapsulation of the sealed source could be damaged by the operation, the licensee shall conduct a radiation survey, including a contamination survey, during and after the operation.

e. The licensee shall make a radiation survey at the temporary jobsite before and after each subsurface tracer study to confirm the absence of contamination, except those using hydrogen-3, carbon-14 and sulfur-35. These surveys shall include measurement of radiation levels before and after the operation.

f. The results of surveys required under RH-1967.a. through RH-1967.e. of this Section must be recorded and must include the date of the survey, the name of the individual making the survey, the identification of the survey, instrument used, and the location of the survey. The licensee shall retain records of surveys for inspection by the Department for three (3) years after they are made.

RH-1968. Reserved.

RH-1969. **Radioactive Contamination Control**.

a. If the licensee detects evidence that a sealed source has ruptured or radioactive materials have caused contamination, the licensee shall initiate immediately the emergency procedures required by RH-1963.

RH-1969. (Cont'd)

b. If contamination results from the use of radioactive material in well logging, the licensee shall decontaminate all work areas, equipment, and unrestricted areas.

c. During efforts to recover a sealed source lodged in the well, the licensee shall continuously monitor, with an appropriate radiation detection instrument or a logging tool with a radiation detector, the circulating fluids from the well, if any, to check for contamination resulting from damage to the sealed source.

RH-1970. Reserved.

RH-1971. **Security**.

a. A logging supervisor must be physically present at a temporary jobsite whenever radioactive materials are being handled or are not stored and locked in a vehicle or storage place. The logging supervisor may leave the jobsite in order to obtain assistance if a source becomes lodged in a well.

b. During well logging, except when radiation sources are below ground or in shipping or storage containers, the logging supervisor or other individual designated by the logging supervisor shall maintain direct surveillance of the operation to prevent unauthorized entry into a restricted area, as defined in RH-1100.

RH-1972. Reserved.

RH-1973. **Documents and Records Required at Field Stations**.

Each licensee shall maintain the following documents and records at the field station:

a. A copy of these ~~Regulations~~ Rules;

b. The license authorizing the use of radioactive material;

c. Operating and emergency procedures required by RH-1963.;

RH-1973. (Cont'd)

d. The record of radiation survey instrument calibrations required by RH-1933.;

e. The record of leak test results required by RH-1935.;

f. Physical inventory records required by RH-1937.;

g. Utilization records required by RH-1939.;

h. Records of inspection and maintenance required by RH-1943.;

i. Training records required by RH-1961.d.; and

j. Survey records required by RH-1967.

RH-1974. Reserved.

RH-1975. **Documents and Records Required at Temporary Jobsites**.

Each licensee conducting operations at a temporary jobsite shall maintain the following documents and records at the temporary jobsite until the well-logging operation is completed:

a. Operating and emergency procedures required by RH-1963.;

b. Evidence of latest calibration of the radiation survey instruments in use at the site required by RH-1933.;

c. Latest survey records required by RH-1967.b., RH-1967.c., and RH-1967.e.

d. The shipping papers for the transportation of radioactive materials required by Section 4 ~~of these Regulations~~;

e. When operating under reciprocity pursuant to Section 2, Part H of these ~~Regulations~~ Rules, a copy of the U.S. Nuclear Regulatory Commission

license or Agreement State license authorizing use of radioactive materials.

RH-1976. Reserved.

RH-1977. **Notification of Incidents and Lost Sources; Abandonment Procedures for Irretrievable Sources**.

a. The licensee shall immediately notify the Department by telephone and subsequently, within thirty (30) days, by confirmatory letter if the licensee knows or has reason to believe that a sealed source has been ruptured. The letter must designate the well or other location, describe the magnitude and extent of the escape of radioactive materials, assess the consequences of the rupture, and explain efforts planned or being taken to mitigate these consequences.

b. The licensee shall notify the Department of the theft or loss of radioactive materials, radiation overexposures, excessive levels and concentrations of radiation, and certain other accidents as required by RH-601., RH-1501., RH-1502., and RH-1504. ~~of these Regulations..~~

c. If a sealed source becomes lodged in a well, and when it becomes apparent that efforts to recover the sealed source will not be successful, the licensee shall:

1. Notify the Department by telephone of the circumstances that resulted in the inability to retrieve the source and

A. Obtain the Department's approval to implement abandonment procedures; or

B. That the licensee implemented abandonment before receiving the Department's approval because the licensee believed there was an immediate threat to public health and safety; and

2. Advise the well owner or operator, as appropriate, of the abandonment procedures under RH-1915.a. or RH-1915.c.; and

3. Either ensure that abandonment procedures are implemented within thirty (30) days after the sealed source has been classified as irretrievable or request an extension of time if unable to complete the abandonment procedures.

RH-1977. (Cont'd)

d. The licensee shall, within thirty (30) days after a sealed source has been classified as irretrievable, make a report in writing to the Department. The licensee shall send a copy of the report to each appropriate State or Federal agency that issued permits or otherwise approved the drilling operation. The report shall contain the following information:

1. Date of occurrence;

2. A description of the irretrievable well-logging source involved including the radionuclide and its quantity, chemical, and physical form;

3. Surface location and identification of the well;

4. Results of effort to immobilize and seal the source in place;

5. A brief description of the attempted recovery effort;

6. Depth of the source;

7. Depth of the top of the cement plug;

8. Depth of the well;

9. The immediate threat to public health and safety justification for implementing abandonment if prior Department approval was not obtained in accordance with RH-1977.c.1.B.;

10. Any other information, such as a warning statement, contained on the permanent identification plaque; and

11. State and Federal agencies receiving a copy of this report.

RH-1978.- RH-1990. Reserved.

RH-1991. **Specific Exemptions**.

The Department may, upon application of any interested person or upon its own initiative, grant such exemptions from the requirements of the ~~regulations~~ rules in this Part as it determines are authorized by law and will not result in undue hazard to public health and safety or property, and are otherwise in the public interest.

~~RH-1992. **Subjects to be Included in Training Courses for Logging Supervisors**.~~

~~a. **Fundamentals of radiation safety**.~~

~~1. Characteristics of radiation.~~

~~2. Units of radiation dose (rem) and quantity of radioactivity (curie).~~

~~3. Significance of radiation dose.~~

~~A. Radiation protection standards.~~

~~B. Biological effects of radiation dose.~~

~~4. Levels of radiation from sources of radiation.~~

~~5. Methods of minimizing radiation dose.~~

~~A. Working time.~~

~~B. Working distances.~~

~~C. Shielding.~~

~~b. **Radiation detection instrumentation to be used**.~~

~~1. Use of radiation survey instruments.~~

~~A. Operation.~~

~~B. Calibration.~~

~~C. Limitations.~~

~~2. Survey techniques.~~

~~3. Use of personnel monitoring equipment.~~

~~c. **Equipment to be used**.~~

~~1. Handling equipment.~~

~~2. Sources of radiation.~~

~~3. Storage and control of equipment.~~

~~4. Operation and control of equipment.~~

~~d. The requirements of pertinent Federal and State regulations.~~

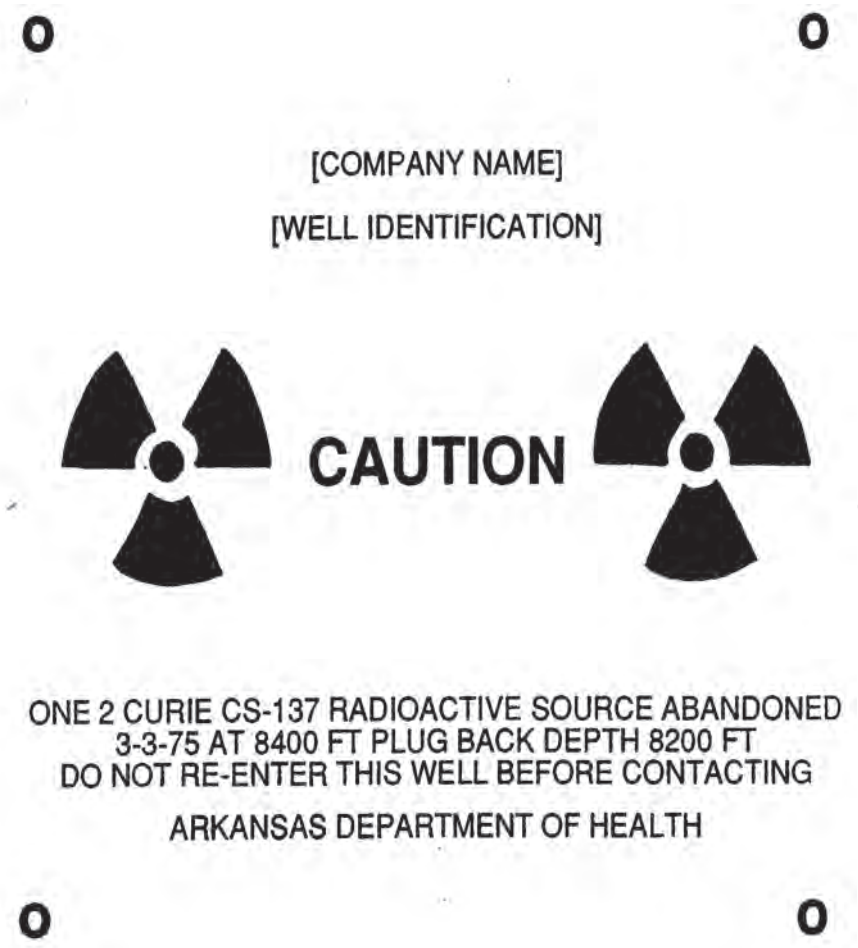
~~e. The licensee's written operating and emergency procedures.~~

~~f. The licensee's record keeping procedures.~~

RH-1993~~3~~2.- RH-1999. Reserved.

SCHEDULE C TO SECTION 3

EXAMPLE OF PLAQUE FOR IDENTIFYING WELLS CONTAINING SEALED SOURCES ~~CONTAINING~~ OF RADIOACTIVE MATERIAL ABANDONED DOWNHOLE



The size of the plaque should be convenient for use on active or inactive wells, e.g., a 7 inch square. Letter size of the word "CAUTION" should be approximately twice the letter size of the rest of the information, e.g., ½-inch and ¼-inch letter size, respectively.

PART K.
EXEMPTIONS AND ADDITIONAL REQUIREMENTS

RH-2000. **Specific Exemptions**.

The Department may, upon application of any interested person or upon its own initiative, grant such exemptions from the requirements of the ~~regulations~~ rules in this Section as it determines are authorized by law and will not result in undue hazard to public health and safety or property, and are otherwise in the public interest.

RH-2001. **Additional Requirements**.

The Department may, by rule~~, regulation,~~ or order, impose upon any licensee such requirements in addition to those established in the ~~regulations~~ rules in this Section as it deems appropriate or necessary to minimize danger to public health and safety or property.

RH-2002.- RH-2109. Reserved.

PART L.
ENFORCEMENT

RH-2110. **Violations**.

a. An injunction or other court order may be obtained prohibiting any violation of any provision of the Act or any ~~regulation~~ rule or order issued thereunder. Any person who willfully violates any provision of the Act or any ~~regulation~~ rule or order issued thereunder may be guilty of a felony, misdemeanor, or crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law. Arkansas Code Annotated §20-21-204 describes criminal and civil penalties which may be assessed.

b. **Impounding**.

Sources of radiation shall be subject to impounding pursuant to Section 5 of these ~~Regulations~~ Rules.

RH-2111.- RH-2199. Reserved.

PART M.
[RESERVED]

RH-2200.- RH-2799. Reserved.

PART N.
NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

RH-2800. Reserved.

RH-2801. **Purpose and Scope**.

This Part establishes requirements for notices, instructions, and reports by licensees or registrants to individuals engaged in work under a license or registration; and options available to such individuals in connection with Department inspection of licensees or registrants to ascertain compliance with the provisions of the Act and the ~~regulations~~ rules, orders, and licenses issued thereunder regarding radiological working conditions. The ~~regulations~~ rules in this Part apply to all persons who receive, possess, use, own, or transfer sources of radiation licensed by or registered with the Department pursuant to these ~~Regulations~~ Rules in Sections 1 and 2, Part I of Section 3, Part J of Section 3, and Sections 6, 7, 8, and 9.

RH-2802. **Posting of Notices to Workers**.

a. Each licensee or registrant shall post current copies of the following documents:

1. A copy of these ~~Regulations~~ Rules;

2. The license or certificate of registration, conditions or documents incorporated into the license by reference and amendments thereto;

3. The operating procedures applicable to work under the license or registration; and

4. Any notice of violation involving radiological working conditions or order issued pursuant to Section 5 and any response from the licensee or registrant.

b. If posting of a document specified in RH-2802.a.1., 2., or 3. is not practicable, the licensee or registrant may post a notice which describes the document and states where it may be examined.

c. ~~Department Form X (Appendix I to Section 3)~~ RC FORM 100, **"**Notice to Employees,**"** shall be posted by each licensee or registrant wherever individuals work in or frequent any portion of a restricted area.

RH-2802. (Cont'd)

d. Documents, notices or forms posted pursuant to this section shall appear in a sufficient number of places to permit individuals engaged in work under the license or registration to observe them on the way to or from any particular work location to which the document applies, shall be conspicuous, and shall be replaced if defaced or altered.

e. Department documents posted pursuant to RH-2802.a.4. shall be posted within two (2) working days after receipt of the documents from the Department; the licensee's or registrant's response, if any, shall be posted within two (2) working days after dispatch from the licensee or registrant. Such documents shall remain posted for a minimum of five (5) working days or until action correcting the violation has been completed, whichever is later.

RH-2803. **Instructions to Workers**.

a. All individuals working in or frequenting any portion of a restricted area:

1. Shall be kept informed of the storage, transfer or use of radioactive materials or of radiation in such portions of the restricted area;

2. Shall be instructed in the health protection problems associated with exposure to radiation and/or radioactive material, in precautions or procedures to minimize exposure, and the purposes and functions of protective devices employed;

3. Shall be instructed in, and required to observe, to the extent within the worker's control, the applicable provisions of Department ~~regulations~~ rules and licenses or registrations for the protection of personnel from exposures to radiation or radioactive material;

4. Shall be instructed of their responsibility to report promptly to the licensee or registrant any condition which may lead to or cause a violation of Department ~~regulations~~ rules and licenses or unnecessary exposure to radiation and/or radioactive material;

5. Shall be instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation and/or radioactive material; and

6. Shall be advised as to the radiation exposure reports which workers may request pursuant to RH-2804.

RH-2803. (Cont'd)

b. In determining those individuals subject to the requirements of RH-2803.a., licensees and registrants must take into consideration assigned activities during normal and abnormal situations involving exposure to radiation and/or radioactive material which can reasonably be expected to occur during the life of a licensed or registered facility. The extent of these instructions shall be commensurate with potential radiological health protection problems present in the work place.

RH-2804. **Notifications and Reports to Individuals**.

a. Radiation exposure data for an individual and the results of any measurements, analyses and calculations of radioactive material deposited or retained in the body of an individual shall be reported to the individual as specified in this section. The information reported shall include data and results obtained pursuant to Department ~~Regulations~~ rules, orders or license conditions, as shown in records maintained by the licensee or registrant pursuant to Department ~~Regulations~~ rules. Each notification and report shall:

1. Be in writing;

2. Include appropriate identifying data such as the name of the licensee or registrant, the name of the individual, the individual's date of birth and the individual's social security number or other unique identifier;

3. Include the individual's exposure information; and

4. Contain the following statement:

"This report is furnished to you under the provisions of Arkansas Department of Health ~~Regulations~~ rules entitled 'Standards for Protection Against Radiation.' You should preserve this report for further reference."

b. Each licensee or registrant shall make dose information available to workers as shown in records maintained by the licensee or registrant under the provisions of RH-1500.f. The licensee or registrant shall provide an annual report to each individual monitored under RH-1302. of the dose received in that monitoring year if:

1. The individual's occupational dose exceeds 100 mrem (1 mSv) TEDE or 100 mrem (1 mSv) to any individual organ or tissue; or

2. The individual requests his or her annual dose report.

c. At the request of a worker formerly engaged in work controlled by the licensee or the registrant, each licensee or registrant shall furnish to the worker a report of the worker's exposure to radiation or radioactive material. Such report shall:

1. Be furnished within thirty (30) days from the time the request is made or within thirty (30) days after the exposure of the individual has been determined by the licensee or registrant, whichever is later;

2. Cover, within the period of time specified in the request, each calendar year in which the worker's activities involved exposure to radiation from radioactive material licensed by, or radiation machines registered with, the Department; and

3. Include the dates and locations of work under the license or registration in which the worker participated during this period.

d. Each licensee or registrant shall furnish to each worker a report of the worker's exposure to radiation or radioactive material upon termination of employment. Such report shall be furnished within thirty (30) days from the time of termination of employment or within thirty (30) days after the exposure of the individual has been determined by the licensee or registrant, whichever is later. The report shall cover each calendar year in which the worker's activities involved exposure to sources of radiation and shall include the dates and locations of work under the license or registration in which the worker participated.

e. At the request of a worker who is terminating employment with the licensee or registrant in work involving radiation dose, or of a worker who, while employed by another person, is terminating assignment to work involving radiation dose in the licensee's or registrant's facility, to each such worker, or to the worker's designee, at termination, a written report regarding the radiation dose received by that worker from operations of the licensee or registrant during that specifically identified calendar year or fraction thereof shall be provided, or a written estimate of that dose must be provided if the finally determined personnel monitoring results are not available at that time. Estimated doses shall be clearly indicated as such.

RH-2804. (Cont'd)

f. When a licensee or registrant is required pursuant to RH-1502., RH-1503., or RH-1504. to report to the Department any exposure of an individual to radiation or radioactive material, the licensee or the registrant shall also provide the individual a report on his or her exposure data included in the report to the Department. The report must be transmitted no later than the transmittal to the Department.

RH-2805. **Presence of Representatives of Licensees or Registrants and Workers During Inspections**.

a. Each licensee or registrant shall afford to the Department at all reasonable times opportunity to inspect materials, machines, activities, facilities, premises, and records pursuant to these ~~Regulations~~ Rules.

b. During an inspection, Department inspectors may consult privately with workers as specified in RH-2806. The licensee or registrant may accompany Department inspectors during other phases of an inspection.

c. If, at the time of inspection, an individual has been authorized by the workers to represent them during Department inspections, the licensee or registrant shall notify the inspectors of such authorization and shall give the workers' representative an opportunity to accompany the inspectors during the inspection of physical working conditions.

d. Each workers' representative shall be routinely engaged in work under control of the licensee or registrant and shall have received instructions as specified in RH-2803.

e. Different representatives of licensees or registrants and workers may accompany the inspectors during different phases of an inspection if there is no resulting interference with the conduct of the inspections; however, only one workers' representative at a time may accompany the inspectors.

f. With the approval of the licensee or registrant and the workers' representative, an individual who is not routinely engaged in work under control of the licensee or registrant, for example, a consultant to the licensee or registrant or to the workers' representative, shall be afforded the opportunity to accompany Department inspectors during the inspection of physical working conditions.

RH-2805. (Cont'd)

g. Notwithstanding the other provisions of this section, Department inspectors are authorized to refuse to permit accompaniment by any individual who deliberately interferes with a fair and orderly inspection. With regard to any area containing proprietary information, the workers' representative for that area shall be an individual previously authorized by the licensee or registrant to enter that area.

RH-2806. **Consultation With Workers During Inspections**.

a. Department inspectors may consult privately with workers concerning matters of occupational radiation protection and other matters related to applicable provisions of Department ~~regulations~~ rules and licenses to the extent the inspectors deem necessary for the conduct of an effective and thorough inspection.

b. During the course of an inspection, any worker may bring privately to the attention of the inspectors, either orally or in writing, any past or present condition which he/she has reason to believe may have contributed to or caused any violation of the Act, these ~~Regulations~~ Rules, or license condition, or any unnecessary exposure of an individual to radiation from licensed radioactive material or a registered radiation machine under the licensee's or registrant's control. Any such notice in writing shall comply with the requirements of RH-2807.a.

RH-2807. **Requests by Workers for Inspections**.

a. Any worker or representative of workers who believes that a violation of the Act, these ~~Regulations~~ Rules or license conditions exists or has occurred in work under a license or registration with regard to radiological working conditions in which the worker is engaged, may request an inspection by giving notice of the alleged violation to the Department. Any such notice shall be in writing, shall set forth the specific grounds for the notice and shall be signed by the worker or representative of the workers. A copy shall be provided to the licensee or registrant by the Department no later than at the time of the inspection except that, upon the request of the worker giving such notice, his/her name and the name of individuals referred to therein shall not appear in such copy or on any record published, released or made available by the Department, except for good cause shown.

RH-2807. (Cont'd)

b. If, upon receipt of such notice, the Department determines that the complaint meets the requirements set forth in RH-2807.a., and that there are reasonable grounds to believe that the alleged violation exists or has occurred, an inspection shall be made as soon as practicable, to determine if such alleged violation exists or has occurred. Inspections pursuant to this section need not be limited to matters referred to in the complaint.

c. No licensee or registrant shall discharge or in any manner discriminate against any worker because such worker has filed any complaint or instituted or caused to be instituted any proceeding under these ~~Regulations~~ Rules or has testified or is about to testify in any such proceeding or because of the exercise by such worker on behalf of himself/herself or others of any option afforded by this Part.

RH-2808. **Inspections Not Warranted; Informal Review**.

a. If the Department determines, with respect to a complaint under RH-2807., that an inspection is not warranted because there are no reasonable grounds to believe that a violation exists or has occurred, the Department shall notify the complainant in writing of such determination.

1. The complainant may obtain review of such determination by submitting a written statement of position to the Director who will provide the licensee or registrant with a copy of such statement by certified mail, excluding, at the request of the complainant, the name of the complainant.

2. The licensee or registrant may submit an opposing written statement of position to the Director who will provide the complainant with a copy of such statement by certified mail.

3. Upon the request of the complainant, the Director may hold an informal conference in which the complainant and the licensee or registrant may orally present their views. An informal conference may also be held at the request of the licensee or registrant, but disclosure of the identity of the complainant will be made only following receipt of written authorization from the complainant.

4. After considering all written or oral views presented, the Director shall affirm, modify, or reverse the determination of the Department and furnish the complainant and the licensee or registrant a written notification of his/her decision and the reason therefore.

RH-2808. (Cont'd)

b. If the Director determines that an inspection is not warranted because the requirements of RH-2807.a. have not been met, he/she shall notify the complainant in writing of such determination. Such determination shall be without prejudice to the filing of a new complaint meeting the requirements of RH-2807.a.

RH-2809.- RH-2899. Reserved.

PART O.
RADIATION SAFETY REQUIREMENTS FOR ANALYTICAL X-RAY EQUIPMENT

RH-2900. **Scope and Purpose**.

This Part provides special requirements for analytical x-ray equipment. The requirements of this Part are in addition to, and not in substitution for, applicable requirements in other parts of these ~~Regulations~~ Rules.

RH-2901. **Definitions**.

Analytical x-ray equipment - X-Ray equipment used for x-ray diffraction fluorescence analysis or spectroscopy.

Analytical x-ray system - A group of local and remote components utilizing x-rays to determine the elemental composition or to examine the microstructure of materials. Local components include those that are struck by x-rays such as radiation source housings, port and shutter assemblies, collimators, sample holders, cameras, goniometers, detectors and shielding. Remote components include power supplies, transformers, amplifiers, readout devices, and control panels.

Fail-safe characteristics - A design feature which causes beam port shutters to close or otherwise prevents emergence of the primary beam, upon the failure of a safety or warning device.

Local components - Part of an analytical x-ray system and include areas exposed to x-rays, such as radiation source housings, port and shutter assemblies, collimators, sample holders, cameras, goniometers, detectors and shielding, but does not include power supplies, transformers, amplifiers, readout devices and control panels.

Normal operating procedures - Operating procedures for conditions suitable for analytical purposes with shielding and barriers in place. These do not include maintenance but do include routine alignment procedures. Routine and emergency radiation safety considerations are part of these procedures.

Open-beam configuration - An analytical x-ray system in which an individual could accidentally place some part of his/her body in the primary beam path during normal operation.

RH-2901. (Cont'd)

Primary beam - Ionizing radiation which passes through an aperture of the source housing by a direct path from the x-ray tube located in the radiation source housing.

RH-2902. **Equipment Requirements**.

a. **Safety device**.

A device which prevents the entry of any portion of an individual's body into the primary x-ray beam path or which causes the beam to be shut off upon entry into its path shall be provided on all open-beam configurations. A registrant may apply to the Department for an exemption from the requirement of a safety device. Such application shall include:

1. A description of the various safety devices that have been evaluated;

2. The reason each of these devices cannot be used; and

3. A description of the alternative methods that will be employed to minimize the possibility of an accidental exposure, including procedures to assure that operators and others in the area will be informed of the absence of safety devices.

b. **Warning devices**.

1. Open-beam configurations shall be provided with a readily discernible indication of:

A. X-ray tube status **(ON-OFF)** located near the radiation source housing, if the primary beam is controlled in this manner; and/or

B. Shutter status **(OPEN-CLOSED)** located near each port on the radiation source housings, if the primary beam is controlled in this manner.

2. Warning devices shall be labeled so that their purpose is easily identified. On equipment installed after January 1, 1979, warning devices shall have fail-safe characteristics.

c. **Ports**.

Unused ports on radiation machine source housings shall be secured in the closed position in a manner which will prevent casual opening.

d. **Labeling**.

All analytical x-ray equipment shall be labeled with a readily discernible sign or signs bearing the radiation symbol and the words:

1. "**CAUTION - HIGH INTENSITY X-RAY BEAM**," or words having a similar intent, on the x-ray source housing; and

2. "**CAUTION RADIATION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED**," or words having a similar intent, near any switch that energizes an x-ray tube.

e. **Shutters**.

On open-beam configurations installed after January 1, 1979, each port on the radiation source housing shall be equipped with a shutter that cannot be opened unless a collimator or a coupling has been connected to the port.

f. **Warning lights**.

1. An easily visible warning light labeled with the words "**X-RAY ON**" or words having a similar intent, shall be located near any switch that energizes an x-ray tube and shall be illuminated only when the tube is energized.

2. On equipment installed after January 1, 1979, warning lights shall have fail-safe characteristics.

g. **Radiation source housing**.

Each radiation source housing shall be subject to the following requirements:

1. Each x-ray tube housing shall be equipped with an interlock that shuts off the tube if it is removed from the radiation source housing or if the housing is disassembled.

RH-2902. (Cont'd)

h. **Generator cabinet**.

Each x-ray generator shall be supplied with a protective cabinet which limits leakage radiation measured at a distance of 5 centimeters from its surface such that it is not capable of producing a dose in excess of 0.25 millirem in one hour.

RH-2903. **Area Requirements**.

a. **Radiation levels**.

The local components of an analytical x-ray system shall be located and arranged and shall include sufficient shielding or access control such that no radiation levels exist in any area surrounding the local component group which could result in a dose to an individual present therein in excess of the dose limits given in RH-1208. These levels shall be met at any specified tube rating.

b. **Surveys**.

1. Radiation surveys, as required by RH-1300., of all analytical x-ray systems sufficient to show compliance with RH-2903.a. shall be performed:

A. Upon installation of the equipment;

B. Following any change in the initial arrangement, number or type of local components in the system;

C. Following any maintenance requiring the disassembly or removal of a local component in the system;

D. During the performance of maintenance and alignment procedures, if the procedures require the presence of a primary x-ray beam when any local component in the system is disassembled or removed;

E. Any time a visual inspection of the local components in the system reveals an abnormal condition; and

F. Whenever personnel monitoring devices show a significant increase over the previous monitoring period or the readings are approaching the limits specified in RH-1200.

RH-2903.b. (Cont'd)

2. Radiation survey measurements shall not be required if a registrant can demonstrate compliance to the satisfaction of the Department with RH-2903.a. in some other manner.

c. **Posting**.

Each area or room containing analytical x-ray equipment shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words "**CAUTION - X-RAY EQUIPMENT**" or words having a similar intent.

RH-2904. **Operating Requirements**.

a. **Procedures**.

Normal operating procedures shall be written and available to all analytical x-ray equipment workers. No person shall be permitted to operate analytical x-ray equipment in any manner other than that specified in the procedures unless such person has obtained written approval of the Radiation Safety Officer.

b. **Bypassing**.

No person shall bypass a safety device unless such person has obtained the approval of the Radiation Safety Officer. When a safety device has been bypassed, a readily discernible sign bearing the words "**SAFETY DEVICE NOT WORKING**," or words having a similar intent, shall be placed on the radiation source housing.

c. **Repair or modification of x-ray tube systems**.

Except as specified in RH-2904.b., no operation involving removal of covers, shielding materials or tube housings or modifications to shutters, collimators or beam stops shall be performed without ascertaining that the tube is off and will remain off until safe conditions have been restored. The main switch, rather than interlocks, shall be used for routine shutdown in preparation for repairs.

RH-2905. **Personnel Requirements**.

a. **Instruction**.

1. No person shall be permitted to operate or maintain analytical x-ray equipment unless such person has received instruction in and demonstrated competence as to:

A. Identification of radiation hazards associated with the use of the equipment;

B. Significance of the various radiation warning and safety devices incorporated into the equipment or the reasons they have not been installed on certain pieces of equipment and the extra precautions required in such cases;

C. Proper operating procedures for the equipment;

D. Symptoms of an acute localized exposure; and

E. Proper procedures for reporting an actual or suspected exposure.

b. **Personnel monitoring**.

1. Finger or wrist dosimetric devices shall be provided to and shall be used by:

A. Analytical x-ray equipment workers using systems having an open-beam configuration and not equipped with a safety device; and

B. Personnel maintaining analytical x-ray equipment if the maintenance procedures require the presence of a primary x-ray beam when any local component in the analytical x-ray system is disassembled or removed.

2. Reported dose values shall not be used for the purpose of determining compliance with RH-1200. and RH-1208. unless evaluated by a qualified expert.

RH-2906.- RH-2999. Reserved.

APPENDIX A TO SECTION 3

Deleted. (See Appendix G to Section 3.)

APPENDIX B TO SECTION 3

Deleted. (For RH-409.h. purposes, see Appendix E to Section 2. For RH-1303.b.5. purposes, see Appendix H to Section 3.)

APPENDIX C TO SECTION 3

Deleted. (For "Determination of A_1 and A_2 Quantities," see Appendix A to Section 4.)

APPENDIX D TO SECTION 3

NATIONALLY TRACKED SOURCE THRESHOLDS

(for use with RH-1513.)

The Terabecquerel (TBq) values are the regulatory standard. The curie (Ci) values specified are obtained by converting from the TBq value. The curie values are provided for practical usefulness only and are rounded after conversion.

Radioactive material	Category 1 (TBq)	Category 1 (Ci)	Category 2 (TBq)	Category 2 (Ci)
Actinium-227	20	540	0.2	5.4
Americium-241	60	1,600	0.6	16
Americium-241/Be	60	1,600	0.6	16
Californium-252	20	540	0.2	5.4
Cobalt-60	30	810	0.3	8.1
Curium-244	50	1,400	0.5	14
Cesium-137	100	2,700	1	27
Gadolinium-153	1,000	27,000	10	270
Iridium-192	80	2,200	0.8	22
Plutonium-238	60	1,600	0.6	16
Plutonium-239/Be	60	1,600	0.6	16
Polonium-210	60	1,600	0.6	16
Promethium-147	40,000	1,100,000	400	11,000
Radium-226	40	1,100	0.4	11
Selenium-75	200	5,400	2	54
Strontium-90	1,000	27,000	10	270
Thorium-228	20	540	0.2	5.4
Thorium-229	20	540	0.2	5.4
Thulium-170	20,000	540,000	200	5,400
Ytterbium-169	300	8,100	3	81

APPENDIX E TO SECTION 3

ASSIGNED PROTECTION FACTORS FOR RESPIRATORS [a/]

RESPIRATOR TYPE	OPERATING MODE	ASSIGNED PROTECTION FACTOR
I. Air Purifying Respirators [Particulate [b/] only][c/]		
Filtering facepiece disposable [d/]	Negative Pressure	([d/])
Facepiece, half [e/]	Negative Pressure	10
Facepiece, full	Negative Pressure	100
Facepiece, half	Powered air-purifying respirators	50
Facepiece, full	Powered air-purifying respirator	1000
Helmet/hood	Powered air-purifying respirator	1000
Facepiece, loose-fitting	Powered air-purifying respirator	25
II. Atmosphere supplying respirators [particulate, gases and vapors [f/]]		
1. Air-line respirators		
Facepiece, half	Demand	10
Facepiece, half	Continuous flow	50
Facepiece, half	Pressure demand	50
Facepiece, full	Demand	100
Facepiece, full	Continuous flow	1000
Facepiece, full	Pressure demand	1000
Helmet/hood	Continuous flow	1000
Facepiece, loose-fitting	Continuous flow	25
Suit	Continuous flow	([g/])
2. Self-contained breathing apparatus (SCBA)		
Facepiece, full	Demand	100 [h/]
Facepiece, full	Pressure demand	10,000 [j/]
Facepiece, full	Demand, re-circulating	100 [h/]
Facepiece, full	Positive pressure re-circulating	10,000 [j/]
III. Combination Respirators		
Any combination of air-purifying and atmosphere-supplying respirators	Assigned protection factor for type and mode of operation as listed above	

Footnotes for Appendix E to Section 3:

a/ These assigned protection factors apply only in a respiratory protection program that meets the requirements of this Section. They are applicable only to airborne radiological hazards and may not be appropriate to circumstances when chemical or other respiratory hazards exist instead of, or in addition to, radioactive hazards. Selection and use of respirators for such circumstances must also comply with Department of Labor regulations. Radioactive contaminants for which the concentration values in Table I, Column 3 of Appendix G to Section 3 are based on internal dose due to inhalation may, in addition, present external exposure hazards at higher concentrations. Under these circumstances, limitation on occupancy may have to be governed by external dose limits.

b/ Air purifying respirators with APF <100 must be equipped with particulate filters that are at least ninety-five percent (95%) efficient. Air purifying respirators with APF = 100 must be equipped with particulate filters that are at least ninety-nine percent (99%) efficient. Air purifying respirators with APFs > 100 must be equipped with particulate filters that are at least 99.97 percent (99.97%) efficient.

c/ The licensee may apply to the Department for the use of an APF greater than one (1) for sorbent cartridges as protection against airborne radioactive gases and vapors (e.g., radioiodine).

d/ Licensees may permit individuals to use this type of respirator who have not been medically screened or fit tested on the device provided that no credit be taken for their use in estimating intake or dose. It is also recognized that it is difficult to perform an effective positive or negative pressure pre-use seal check on this type of device. All other respiratory protection program requirements listed in RH-1303.f. apply. An assigned protection factor has not been assigned for these devices. However, an APF equal to ten (10) may be used if the licensee can demonstrate a fit factor of at least 100 by use of a validated or evaluated, qualitative or quantitative fit test.

e/ Under-chin type only. No distinction is made in this Appendix between elastomeric half-masks with replaceable cartridges and those designed with the filter medium as an integral part of the facepiece (e.g., disposable or reusable disposable). Both types are acceptable so long as the seal area of the latter contains some substantial type of seal-enhancing material such as rubber or plastic, the two or more suspension straps are adjustable, the filter medium is at least ninety-five percent (95%) efficient and all other requirement of this Part are met.

f/ The assigned protection factors for gases and vapors are not applicable to radioactive contaminants that present an absorption or submersion hazard. For tritium oxide vapor, approximately one-third of the intake occurs by absorption through the skin so that an overall protection factor of three (3) is appropriate when atmosphere-supplying respirators are used to protect against tritium oxide. Exposure to radioactive noble gases is not considered a significant respiratory hazard, and protective actions for these contaminants should be based on external (submersion) dose considerations.

g/ No NIOSH approval schedule is currently available for atmosphere supplying suits. This equipment may be used in an acceptable respiratory protection program as long as all the other minimum program requirements, with the exception of fit testing, are met (i.e., RH-1303.f.).

h/ The licensee should implement institutional controls to assure that these devices are not used in areas immediately dangerous to life or health (IDLH).

Footnotes for Appendix E to Section 3 (Cont'd):

i/ This type of respirator may be used as an emergency device in unknown concentrations for protection against inhalation hazards. External radiation hazards and other limitation to permitted exposure such as skin absorption shall be taken into account in these circumstances. This device may not be used by any individual who experiences perceptible outward leakage of breathing gas while wearing the device.

APPENDIX F TO SECTION 3

LIST OF ELEMENTS FOR USE WITH APPENDIX G TO SECTION 3

Name	Symbol	Atomic number	Name	Symbol	Atomic number
Actinium	Ac	89	Iodine	I	53
Aluminum	Al	13	Iridium	Ir	77
Americium	Am	95	Iron	Fe	26
Antimony	Sb	51	Krypton	Kr	36
Argon	Ar	18	Lanthanum	La	57
Arsenic	As	33	Lead	Pb	82
Astatine	At	85	Lutetium	Lu	71
Barium	Ba	56	Magnesium	Mg	12
Berkelium	Bk	97	Manganese	Mn	25
Beryllium	Be	4	Mendelevium	Md	101
Bismuth	Bi	83	Mercury	Hg	80
Bromine	Br	35	Molybdenum	Mo	42
Cadmium	Cd	48	Neodymium	Nd	60
Calcium	Ca	20	Neptunium	Np	93
Californium	Cf	98	Nickel	Ni	28
Carbon	C	6	Niobium	Nb	41
Cerium	Ce	58	Nitrogen	N	7
Cesium	Cs	55	Osmium	Os	76
Chlorine	Cl	17	Oxygen	O	8
Chromium	Cr	24	Palladium	Pd	46
Cobalt	Co	27	Phosphorus	P	15
Copper	Cu	29	Platinum	Pt	78
Curium	Cm	96	Plutonium	Pu	94
Dysprosium	Dy	66	Polonium	Po	84
Einsteinium	Es	99	Potassium	K	19
Erbium	Er	68	Praseodymium	Pr	59
Europium	Eu	63	Promethium	Pm	61
Fermium	Fm	100	Protactinium	Pa	91
Fluorine	F	9	Radium	Ra	88
Francium	Fr	87	Radon	Rn	86
Gadolinium	Gd	64	Rhenium	Re	75
Gallium	Ga	31	Rhodium	Rh	45
Germanium	Ge	32	Rubidium	Rb	37
Gold	Au	79	Ruthenium	Ru	44
Hafnium	Hf	72	Samarium	Sm	62
Holmium	Ho	67	Scandium	Sc	21
Hydrogen	H	1	Selenium	Se	34
Indium	In	49	Silicon	Si	14

Name	Symbol	Atomic number
Silver	Ag	47
Sodium	Na	11
Strontium	Sr	38
Sulfur	S	16
Tantalum	Ta	73
Technetium	Tc	43
Tellurium	Te	52
Terbium	Tb	65
Thallium	Tl	81
Thorium	Th	90
Thulium	Tm	69
Tin	Sn	50
Titanium	Ti	22
Tungsten	W	74
Uranium	U	92
Vanadium	V	23
Xenon	Xe	54
Ytterbium	Yb	70
Yttrium	Y	39
Zinc	Zn	30
Zirconium	Zr	40

APPENDIX G TO SECTION 3

ANNUAL LIMITS ON INTAKE (ALIs) AND DERIVED AIR CONCENTRATIONS (DACs) OF RADIONUCLIDES FOR OCCUPATIONAL EXPOSURE; EFFLUENT CONCENTRATIONS; CONCENTRATIONS FOR RELEASE TO SEWERAGE

Introduction

For each radionuclide, Table I indicates the chemical form which is to be used for selecting the appropriate ALI or DAC value. The ALIs and DACs for inhalation are given for an aerosol with an activity median aerodynamic diameter (AMAD) of 1 μm (micron), and for three classes (D,W,Y) of radioactive material, which refer to their retention (approximately days, weeks or years) in the pulmonary region of the lung. This classification applies to a range of clearance half-times for D if less than 10 days, for W from 10 to 100 days, and for Y greater than 100 days. The class (D, W, or Y) given in the column headed "Class" applies only to the inhalation ALIs and DACs given in Table I, column 2 and 3. Table II provides concentration limits for airborne and liquid effluents released to the general environment. Table III provides concentration limits for discharges to sanitary sewerage.

Note: The values in Tables I, II, and III are presented in the computer "E" notation. In this notation a value of 6E-02 represents a value of 6×10^{-2} or 0.06, 6E+2 represents 6×10^{2} or 600, and 6E+0 represents 6×10^{0} or 6.

Table I: Occupational Values

Note that the columns in Table I of this appendix captioned "Oral Ingestion ALI," "Inhalation ALI," and "DAC," are applicable to occupational exposure to radioactive material.

The ALIs in this appendix are the annual intakes of given radionuclide by "Reference man" which would result in either (1) a committed effective dose equivalent of 0.05 sievert (5 rem), stochastic ALI, or (2) a committed dose equivalent of 0.5 sievert (50 rem) to an organ or tissue, non-stochastic ALI. The stochastic ALIs were derived to result in a risk, due to irradiation of organs and tissues, comparable to the risk associated with deep dose equivalent to the whole body of 0.05 sievert (5 rem). The derivation includes multiplying the committed dose equivalent to an organ or tissue by a weighting factor, w_T. This weighting factor is the proportion of the risk of stochastic effects resulting from irradiation of the organ or tissue, T, to the total risk of stochastic effects when the whole body is irradiated uniformly. The values of w_T are listed under the definition of weighting factor in RH-1100. The non-stochastic ALIs were derived to avoid non-stochastic effects, such as prompt damage to tissue or reduction in organ function.

A value of $w_T = 0.06$ is applicable to each of the 5 organs or tissues in the "remainder" category receiving the highest dose equivalents, and the dose equivalents of all other remaining tissues may be disregarded. The following portions of the GI tract – stomach, small intestine, upper large intestine, and lower large intestine – are to be treated as 4 separate organs.

Note that the dose equivalents for an extremity, skin and lens of the eye are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

When an ALI is defined by the stochastic dose limit, this value alone is given. When an ALI is determined by the non-stochastic dose limit to an organ, the organ or tissue to which the limit applies is shown, and the ALI for the stochastic limit is shown in parentheses. Abbreviated organ or tissue designations are used:

LLI wall = lower large intestine wall;
St. wall = stomach wall;
Blad wall = bladder wall; and
Bone surf = bone surface.

The use of the ALIs listed first, the more limiting of the stochastic and non-stochastic ALIs, will ensure that non-stochastic effects are avoided and that the risk of stochastic effects is limited to an acceptably low value. If, in a particular situation involving a radionuclide for which the non-stochastic ALI is limiting, use of that non-stochastic ALI is considered unduly conservative, the licensee may use the stochastic ALI to determine the committed effective dose equivalent. However, the licensee shall also ensure that the 0.5 sievert (50 rem) dose equivalent limit for any organ or tissue is not exceeded by the sum of the external deep dose equivalent plus the internal committed dose equivalent to that organ, not the effective dose. For the case where there is no external dose contribution, this would be demonstrated if the sum of the fractions of the nonstochastic ALIs (ALI_{ns}) that contribute to the committed dose equivalent to the organ receiving the highest dose does not exceed unity, that is, $\sum$ (intake (in μCi) of each radionuclide/ALI_{ns}) <1.0. If there is an external deep dose equivalent contribution of H_d, then this sum must be less than 1 - (H_d/50), instead of < 1.0.

Note that the dose equivalents for an extremity, skin, and lens of the eye are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

The derived air concentration (DAC) values are derived limits intended to control chronic occupational exposures. The relationship between the DAC and the ALI is given by:

DAC = ALI(in μCi)/(2000 hours per working year x 60 minutes/hour x 2 x 10^4 ml per minute) = [ALI/2.4 x 10^9] μCi/ml,

where 2 x 10^4 ml is the volume of air breathed per minute at work by "Reference man" under working conditions of "light work."

The DAC values relate to 1 of 2 modes of exposure: either external submersion or the internal committed dose equivalents resulting from inhalation of radioactive materials. DACs based upon submersion are for immersion in a semi-infinite cloud of uniform concentration and apply to each radionuclide separately.

Appendix G to Section 3 (Cont'd)

The ALI and DAC values include contributions to exposure by the single radionuclide named and any in-growth of daughter radionuclides produced in the body by decay of the parent. However, intakes that include both the parent and daughter radionuclides should be treated by the general method appropriate for mixtures.

The values of ALI and DAC do not apply directly when the individual both ingests and inhales a radionuclide, when the individual is exposed to a mixture of radionuclides by either inhalation or ingestion or both, or when the individual is exposed to both internal and external irradiation. See RH-1201. When an individual is exposed to radioactive materials which fall under several of the translocation classifications of the same radionuclide, such as Class D, Class W, or Class Y, the exposure may be evaluated as if it were a mixture of different radionuclides.

It should be noted that the classification of a compound as Class D, W, or Y is based on the chemical form of the compound and does not take into account the radiological half-life of different radionuclides. For this reason, values are given for Class D, W, and Y compounds, even for very short-lived radionuclides.

Table II : Effluent Concentrations

The columns in Table II of this appendix captioned "Effluents," "Air" and "Water" are applicable to the assessment and control of dose to the public, particularly in the implementation of the provisions of RH-1209. The concentration values given in Columns 1 and 2 of Table II are equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 0.5 millisievert (0.05 rem).

Consideration of non-stochastic limits has not been included in deriving the air and water effluent concentration limits because non-stochastic effects are presumed not to occur at or below the dose levels established for individual members of the public. For radionuclides, where the non-stochastic limit was governing in deriving the occupational DAC, the stochastic ALI was used in deriving the corresponding airborne effluent limit in Table II. For this reason, the DAC and airborne effluent limits are not always proportional as was the case in Appendix B to 10 CFR Part 20.1-20.601.

The air concentration values listed in Table II, Column 1 were derived by one of two methods. For those radionuclides for which the stochastic limit is governing, the occupational stochastic inhalation ALI was divided by 2.4×10^9 (ml), relating the inhalation ALI to the DAC, as explained above, and then divided by a factor of 300. The factor of 300 includes the following components: a factor of 50 to relate the 0.05 sievert (5 rem) annual occupational dose limit to the 1 millisievert (0.1 rem) limit for members of the public, a factor of 3 to adjust for the difference in exposure time and the inhalation rate for a worker and that for members of the public; and a factor of 2 to adjust the occupational values, derived for adults, so that they are applicable to other age groups.

For those radionuclides for which submersion, that is external dose, is limiting, the occupational DAC in Table I, Column 3 was divided by 219. The factor of 219 is composed of a factor of 50, as described above, and a factor of 4.38 relating occupational exposure for 2,000 hours per year to full-time exposure (8,760 hours per year). Note that an additional factor of 2 for age considerations is not warranted in the submersion case.

The water concentrations were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^7. The factor of 7.3×10^7 (ml) includes the following components: the factors of 50 and 2 described above and a factor of 7.3×10^5 (ml) which is the annual water intake of "Reference man."

Note 2 of this appendix provides groupings of radionuclides which are applicable to unknown mixtures of radionuclides. These groupings, including occupational inhalation ALIs and DACs, air and water effluent concentrations and releases to sewer, require demonstrating that the most limiting radionuclides in successive classes are absent. The limit for the unknown mixture is defined when the presence of one of the listed radionuclides cannot be definitely excluded as being present either from knowledge of the radionuclide composition of the source or from actual measurements.

Table III: Releases to Sewers

The monthly average concentrations for release to sanitary sewers are applicable to the provisions in RH-1402. The concentration values were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^6 (ml). The factor of 7.3×10^6 (ml) is composed of a factor of 7.3×10^5 (ml), the annual water intake by "Reference Man," and a factor of 10, such that the concentrations, if the sewage released by the licensee were the only source of water ingested by a reference man during a year, would result in a committed effective dose equivalent of 0.5 rem.

Appendix G to Section 3 (Cont'd)

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
1	Hydrogen-3	Water, DAC includes skin absorption	8E+4	8E+4	2E-5	1E-7	1E-3	1E-2
		Gas (HT or T_2) Submersion[a/]: Use above values as HT and T_2 oxidize in air and in the body to HTO.						
4	Beryllium-7	W, all compounds except those given for Y	4E+4	2E+4	9E-6	3E-8	6E-4	6E-3
		Y, oxides, halides, and nitrates	–	2E+4	8E-6	3E-8	–	–
4	Beryllium-10	W, see ^{7}Be	1E+3	2E+2	6E-8	2E-10	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{7}Be	–	1E+1	6E-9	2E-11	–	–
6	Carbon-11[b/]	Monoxide	–	1E+6	5E-4	2E-6	–	–
		Dioxide	–	6E+5	3E-4	9E-7	–	–
		Compounds	4E+5	4E+5	2E-4	6E-7	6E-3	6E-2
6	Carbon-14	Monoxide	–	2E+6	7E-4	2E-6	–	–
		Dioxide	–	2E+5	9E-5	3E-7	–	–
		Compounds	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4
7	Nitrogen-13[b/]	Submersion[a/]	–	–	4E-6	2E-8	–	–
8	Oxygen-15[b/]	Submersion[a/]	–	–	4E-6	2E-8	–	–
9	Fluorine-18[b/]	D, fluorides of H, Li, Na, K, Rb, Cs, and Fr	5E+4	7E+4	3E-5	1E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
		W, fluorides of Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, As, Sb, Bi, Fe, Ru, Os, Co, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, V, Nb, Ta, Mn, Tc, and Re	–	9E+4	4E-5	1E-7	–	–
		Y, lanthanum fluoride	–	8E+4	3E-5	1E-7	–	–
11	Sodium-22	D, all compounds	4E+2	6E+2	3E-7	9E-10	6E-6	6E-5
11	Sodium-24	D, all compounds	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
12	Magnesium-28	D, all compounds except those given for W	7E+2	2E+3	7E-7	2E-9	9E-6	9E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	–	1E+3	5E-7	2E-9	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
13	Aluminum-26	D, all compounds except those given for W	4E+2	6E+1	3E-8	9E-11	6E-6	6E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	–	9E+1	4E-8	1E-10	–	–
14	Silicon-31	D, all compounds except those given for W and Y	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, oxides, hydroxides, carbides, and nitrates	–	3E+4	1E-5	5E-8	–	–
		Y, aluminosilicate glass	–	3E+4	1E-5	4E-8	–	–
14	Silicon-32	D, see ^{31}Si	2E+3	2E+2	1E-7	3E-10	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
		W, see ^{31}Si	–	1E+2	5E-8	2E-10	–	–
		Y, see ^{31}Si	–	5E+0	2E-9	7E-12	–	–
15	Phosphorus-32	D, all compounds except phosphates given for W	6E+2	9E+2	4E-7	1E-9	9E-6	9E-5
		W, phosphates of Zn^{2+}, S^{3+}, Mg^{2+}, Fe^{3+}, Bi^{3+}, and lanthanides	–	4E+2	2E-7	5E-10	–	–
15	Phosphorus-33	D, see ^{32}P	6E+3	8E+3	4E-6	1E-8	8E-5	8E-4
		W, see ^{32}P	–	3E+3	1E-6	4E-9	–	–
16	Sulfur-35	Vapor	–	1E+4	6E-6	2E-8	–	–
		D, sulfides and sulfates except those given for W	1E+4	2E+4	7E-6	2E-8	–	–
			LLI wall (8E+3)	–	–	–	1E-4	1E-3
		W, elemental sulfur, sulfides of Sr, Ba, Ge, Sn, Pb, As, Sb, Bi, Cu, Ag, Au, Zn, Cd, Hg, W, and Mo. Sulfates of Ca, Sr, Ba, Ra, As, Sb, and Bi	6E+3 –	2E+3	9E-7	3E-9	–	–
17	Chlorine-36	D, chlorides of H, Li, Na, K, Rb, Cs, and Fr	2E+3	2E+3	1E-6	3E-9	2E-5	2E-4
		W, chlorides of lanthanides, Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, Ge, Sn, Pb, As, Sb, Bi, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Tc, and Re	–	2E+2	1E-7	3E-10	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
17	Chlorine-38[b/]	D, see ^{36}Cl	2E+4	4E+4	2E-5	6E-8	–	–
			St wall (3E+4)	–	–	–	3E-4	3E-3
		W, see ^{36}Cl	–	5E+4	2E-5	6E-8	–	–
17	Chlorine-39[b/]	D, see ^{36}Cl	2E+4	5E+4	2E-5	7E-8	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
		W, see ^{36}Cl	–	6E+4	2E-5	8E-8	–	–
18	Argon-37	Submersion[a/]	–	–	1E+0	6E-3	–	–
18	Argon-39	Submersion[a/]	–	–	2E-4	8E-7	–	–
18	Argon-41	Submersion[a/]	–	–	3E-6	1E-8	–	–
19	Potassium-40	D, all compounds	3E+2	4E+2	2E-7	6E-10	4E-6	4E-5
19	Potassium-42	D, all compounds	5E+3	5E+3	2E-6	7E-9	6E-5	6E-4
19	Potassium-43	D, all compounds	6E+3	9E+3	4E-6	1E-8	9E-5	9E-4
19	Potassium-44[b/]	D, all compounds	2E+4	7E+4	3E-5	9E-8	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
19	Potassium-45[b/]	D, all compounds	3E+4	1E+5	5E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
20	Calcium-41	W, all compounds	3E+3	4E+3	2E-6	–	–	–
			Bone surf (4E+3)	Bone surf (4E+3)	–	5E-9	6E-5	6E-4
20	Calcium-45	W, all compounds	2E+3	8E+2	4E-7	1E-9	2E-5	2E-4
20	Calcium-47	W, all compounds	8E+2	9E+2	4E-7	1E-9	1E-5	1E-4
21	Scandium-43	Y, all compounds	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
21	Scandium-44m	Y, all compounds	5E+2	7E+2	3E-7	1E-9	7E-6	7E-5
21	Scandium-44	Y, all compounds	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
21	Scandium-46	Y, all compounds	9E+2	2E+2	1E-7	3E-10	1E-5	1E-4
21	Scandium-47	Y, all compounds	2E+3	3E+3	1E-6	4E-9	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
21	Scandium-48	Y, all compounds	8E+2	1E+3	6E-7	2E-9	1E-5	1E-4

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
21	Scandium-49[b/]	Y, all compounds	2E+4	5E+4	2E-5	8E-8	3E-4	3E-3
22	Titanium-44	D, all compounds except those given for W and Y	3E+2	1E+1	5E-9	2E-11	4E-6	4E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	–	3E+1	1E-8	4E-11	–	–
		Y, SrTi0	–	6E+0	2E-9	8E-12	–	–
22	Titanium-45	D, see ^{44}Ti	9E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{44}Ti	–	4E+4	1E-5	5E-8	–	–
		Y, see ^{44}Ti	–	3E+4	1E-5	4E-8	–	–
23	Vanadium-47[b/]	D, all compounds except those given for W	3E+4	8E+4	3E-5	1E-7	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
		W, oxides, hydroxides, carbides, and halides	–	1E+5	4E-5	1E-7	–	–
23	Vanadium-48	D, see ^{47}V	6E+2	1E+3	5E-7	2E-9	9E-6	9E-5
		W, see ^{47}V	–	6E+2	3E-7	9E-10	–	–
23	Vanadium-49	D, see ^{47}V	7E+4	3E+4	1E-5	–	–	–
			LLI wall (9E+4)	Bone surf (3E+4)	–	5E-8	1E-3	1E-2
		W, see ^{47}V	–	2E+4	8E-6	2E-8	–	–
24	Chromium-48	D, all compounds except those given for W and Y	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, halides and nitrates	–	7E+3	3E-6	1E-8	–	–
		Y, oxides and hydroxides	–	7E+3	3E-6	1E-8	–	–
24	Chromium-49[b/]	D, see ^{48}Cr	3E+4	8E+4	4E-5	1E-7	4E-4	4E-3
		W, see ^{48}Cr	–	1E+5	4E-5	1E-7	–	–
		Y, see ^{48}Cr	–	9E+4	4E-5	1E-7	–	–
24	Chromium-51	D, see ^{48}Cr	4E+4	5E+4	2E-5	6E-8	5E-4	5E-3
		W, see ^{48}Cr	–	2E+4	1E-5	3E-8	–	–
		Y, see ^{48}Cr	–	2E+4	8E-6	3E-8	–	–
25	Manganese-51[b/]	D, all compounds except those given for W	2E+4	5E+4	2E-5	7E-8	3E-4	3E-3
		W, oxides, hydroxides, halides, and nitrates	–	6E+4	3E-5	8E-8	–	–
25	Manganese-52m[b/]	D, see ^{51}Mn	3E+4	9E+4	4E-5	1E-7	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
		W, see ^{51}Mn	–	1E+5	4E-5	1E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
25	Manganese-52	D, see ^{51}Mn	7E+2	1E+3	5E-7	2E-9	1E-5	1E-4
		W, see ^{51}Mn	–	9E+2	4E-7	1E-9	–	–
25	Manganese-53	D, see ^{51}Mn	5E+4	1E+4	5E-6	–	7E-4	7E-3
			–	Bone surf (2E+4)	-	3E-8	–	–
		W, see ^{51}Mn	–	1E+4	5E-6	2E-8	–	–
25	Manganese-54	D, see ^{51}Mn	2E+3	9E+2	4E-7	1E-9	3E-5	3E-4
		W, see ^{51}Mn	–	8E+2	3E-7	1E-9	–	–
25	Manganese-56	D, see ^{51}Mn	5E+3	2E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{51}Mn	–	2E+4	9E-6	3E-8	–	–
26	Iron-52	D, all compounds except those given for W	9E+2	3E+3	1E-6	4E-9	1E-5	1E-4
		W, oxides, hydroxides, and halides	–	2E+3	1E-6	3E-9	–	–
26	Iron-55	D, see ^{52}Fe	9E+3	2E+3	8E-7	3E-9	1E-4	1E-3
		W, see ^{52}Fe	–	4E+3	2E-6	6E-9	–	–
26	Iron-59	D, see ^{52}Fe	8E+2	3E+2	1E-7	5E-10	1E-5	1E-4
		W, see ^{52}Fe	–	5E+2	2E-7	7E-10	–	–
26	Iron-60	D, see ^{52}Fe	3E+1	6E+0	3E-9	9E-12	4E-7	4E-6
		W, see ^{52}Fe	–	2E+1	8E-9	3E-11	–	–
27	Cobalt-55	W, all compounds except those given for Y	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, oxides, hydroxides, halides, and nitrates	–	3E+3	1E-6	4E-9	–	–
27	Cobalt-56	W, see ^{55}Co	5E+2	3E+2	1E-7	4E-10	6E-6	6E-5
		Y, see ^{55}Co	4E+2	2E+2	8E-8	3E-10	–	–
27	Cobalt-57	W, see ^{55}Co	8E+3	3E+3	1E-6	4E-9	6E-5	6E-4
		Y, see ^{55}Co	4E+3	7E+2	3E-7	9E-10	–	–
27	Cobalt-58m	W, see ^{55}Co	6E+4	9E+4	4E-5	1E-7	8E-4	8E-3
		Y, see ^{55}Co	–	6E+4	3E-5	9E-8	–	–
27	Cobalt-58	W, see ^{55}Co	2E+3	1E+3	5E-7	2E-9	2E-5	2E-4
		Y, see ^{55}Co	1E+3	7E+2	3E-7	1E-9	–	–
27	Cobalt-60m[b/]	W, see ^{55}Co	1E+6	4E+6	2E-3	6E-6	–	–
			St wall (1E+6)	–	–	–	2E-2	2E-1
		Y, see ^{55}Co	–	3E+6	1E-3	4E-6	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
27	Cobalt-60	W, see ^{55}Co	5E+2	2E+2	7E-8	2E-10	3E-6	3E-5
		Y, see ^{55}Co	2E+2	3E+1	1E-8	5E-11	–	–
27	Cobalt-61[b/]	W, see ^{55}Co	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		Y, see ^{55}Co	2E+4	6E+4	2E-5	8E-8	–	–
27	Cobalt-62m[b/]	W, see ^{55}Co	4E+4	2E+5	7E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
		Y, see ^{55}Co	–	2E+5	6E-5	2E-7	–	–
28	Nickel-56	D, all compounds except those given for W	1E+3	2E+3	8E-7	3E-9	2E-5	2E-4
		W, oxides, hydroxides, and carbides	–	1E+3	5E-7	2E-9	–	–
		Vapor	–	1E+3	5E-7	2E-9	–	–
28	Nickel-57	D, see ^{56}Ni	2E+3	5E+3	2E-6	7E-9	2E-5	2E-4
		W, see ^{56}Ni	–	3E+3	1E-6	4E-9	–	–
		Vapor	–	6E+3	3E-6	9E-9	–	–
28	Nickel-59	D, see ^{56}Ni	2E+4	4E+3	2E-6	5E-9	3E-4	3E-3
		W, see ^{56}Ni	–	7E+3	3E-6	1E-8	–	–
		Vapor	–	2E+3	8E-7	3E-9	–	–
28	Nickel-63	D, see ^{56}Ni	9E+3	2E+3	7E-7	2E-9	1E-4	1E-3
		W, see ^{56}Ni	–	3E+3	1E-6	4E-9	–	–
		Vapor	–	8E+2	3E-7	1E-9	–	–
28	Nickel-65	D, see ^{56}Ni	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{56}Ni	–	3E+4	1E-5	4E-8	–	–
		Vapor	–	2E+4	7E-6	2E-8	–	–
28	Nickel-66	D, see ^{56}Ni	4E+2	2E+3	7E-7	2E-9	–	–
			LLI wall (5E+2)	–	–	–	6E-6	6E-5
		W, see ^{56}Ni	–	6E+2	3E-7	9E-10	–	–
		Vapor	–	3E+3	1E-6	4E-9	–	–
29	Copper-60[b/]	D, all compounds except those given for W and Y	3E+4	9E+4	4E-5	1E-7	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
		W, sulfides, halides, and nitrates	–	1E+5	5E-5	2E-7	–	–
		Y, oxides and hydroxides	–	1E+5	4E-5	1E-7	–	–
29	Copper-61	D, see ^{60}Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{60}Cu	–	4E+4	2E-5	6E-8	–	–
		Y, see ^{60}Cu	–	4E+4	1E-5	5E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
29	Copper-64	D, see ^{60}Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{60}Cu	–	2E+4	1E-5	3E-8	–	–
		Y, see ^{60}Cu	–	2E+4	9E-6	3E-8	–	–
29	Copper-67	D, see ^{60}Cu	5E+3	8E+3	3E-6	1E-8	6E-5	6E-4
		W, see ^{60}Cu	–	5E+3	2E-6	7E-9	–	–
		Y, see ^{60}Cu	–	5E+3	2E-6	6E-9	–	–
30	Zinc-62	Y, all compounds	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
30	Zinc-63[b/]	Y, all compounds	2E+4	7E+4	3E-5	9E-8	–	–
			St wall (3E+4)	–	–	–	3E-4	3E-3
30	Zinc-65	Y, all compounds	4E+2	3E+2	1E-7	4E-10	5E-6	5E-5
30	Zinc-69m	Y, all compounds	4E+3	7E+3	3E-6	1E-8	6E-5	6E-4
30	Zinc-69[b/]	Y, all compounds	6E+4	1E+5	6E-5	2E-7	8E-4	8E-3
30	Zinc-71m	Y, all compounds	6E+3	2E+4	7E-6	2E-8	8E-5	8E-4
30	Zinc-72	Y, all compounds	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
31	Gallium-65[b/]	D, all compounds except those given for W	5E+4	2E+5	7E-5	2E-7	–	–
			St wall (6E+4)	–	–	–	9E-4	9E-3
		W, oxides, hydroxides, carbides, halides, and nitrates	–	2E+5	8E-5	3E-7	–	–
31	Gallium-66	D, see ^{65}Ga	1E+3	4E+3	1E-6	5E-9	1E-5	1E-4
		W, see ^{65}Ga	–	3E+3	1E-6	4E-9	–	–
31	Gallium-67	D, see ^{65}Ga	7E+3	1E+4	6E-6	2E-8	1E-4	1E-3
		W, see ^{65}Ga	–	1E+4	4E-6	1E-8	–	–
31	Gallium-68[b/]	D, see ^{65}Ga	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{65}Ga	–	5E+4	2E-5	7E-8	–	–
31	Gallium-70[b/]	D, see ^{65}Ga	5E+4	2E+5	7E-5	2E-7	–	–
			St wall (7E+4)	–	–	–	1E-3	1E-2
		W, see ^{65}Ga	–	2E+5	8E-5	3E-7	–	–
31	Gallium-72	D, see ^{65}Ga	1E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{65}Ga	–	3E+3	1E-6	4E-9	–	–
31	Gallium-73	D, see ^{65}Ga	5E+3	2E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{65}Ga	–	2E+4	6E-6	2E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
32	Germanium-66	D, all compounds except those given for W	2E+4	3E+4	1E-5	4E-8	3E-4	3E-3
		W, oxides, sulfides, and halides	–	2E+4	8E-6	3E-8	–	–
32	Germanium-67[b/]	D, see ^{66}Ge	3E+4	9E+4	4E-5	1E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
		W, see ^{66}Ge	–	1E+5	4E-5	1E-7	–	–
32	Germanium-68	D, see ^{66}Ge	5E+3	4E+3	2E-6	5E-9	6E-5	6E-4
		W, see ^{66}Ge	–	1E+2	4E-8	1E-10	–	–
32	Germanium-69	D, see ^{66}Ge	1E+4	2E+4	6E-6	2E-8	2E-4	2E-3
		W, see ^{66}Ge	–	8E+3	3E-6	1E-8	–	–
32	Germanium-71	D, see ^{66}Ge	5E+5	4E+5	2E-4	6E-7	7E-3	7E-2
		W, see ^{66}Ge	–	4E+4	2E-5	6E-8	–	–
32	Germanium-75[b/]	D, see ^{66}Ge	4E+4	8E+4	3E-5	1E-7	–	–
			St wall (7E+4)	–	–	–	9E-4	9E-3
		W, see ^{66}Ge	–	8E+4	4E-5	1E-7	–	–
32	Germanium-77	D, see ^{66}Ge	9E+3	1E+4	4E-6	1E-8	1E-4	1E-3
		W, see ^{66}Ge	–	6E+3	2E-6	8E-9	–	–
32	Germanium-78[b/]	D, see ^{66}Ge	2E+4	2E+4	9E-6	3E-8	–	–
			St wall (2E+4)	–	–	–	3E-4	3E-3
		W, see ^{66}Ge	–	2E+4	9E-6	3E-8	–	–
33	Arsenic-69[b/]	W, all compounds	3E+4	1E+5	5E-5	2E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
33	Arsenic-70[b/]	W, all compounds	1E+4	5E+4	2E-5	7E-8	2E-4	2E-3
33	Arsenic-71	W, all compounds	4E+3	5E+3	2E-6	6E-9	5E-5	5E-4
33	Arsenic-72	W, all compounds	9E+2	1E+3	6E-7	2E-9	1E-5	1E-4
33	Arsenic-73	W, all compounds	8E+3	2E+3	7E-7	2E-9	1E-4	1E-3
33	Arsenic-74	W, all compounds	1E+3	8E+2	3E-7	1E-9	2E-5	2E-4
33	Arsenic-76	W, all compounds	1E+3	1E+3	6E-7	2E-9	1E-5	1E-4

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
33	Arsenic-77	W, all compounds	4E+3	5E+3	2E-6	7E-9	–	–
			LLI wall (5E+3)	–	–	–	6E-5	6E-4
33	Arsenic-78[b/]	W, all compounds	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
34	Selenium-70[b/]	D, all compounds except those given for W	2E+4	4E+4	2E-5	5E-8	1E-4	1E-3
		W, oxides, hydroxides, carbides, and elemental Se	1E+4	4E+4	2E-5	6E-8	–	–
34	Selenium-73m[b/]	D, see ^{70}Se	6E+4	2E+5	6E-5	2E-7	4E-4	4E-3
		W, see ^{70}Se	3E+4	1E+5	6E-5	2E-7	–	–
34	Selenium-73	D, see ^{70}Se	3E+3	1E+4	5E-6	2E-8	4E-5	4E-4
		W, see ^{70}Se	–	2E+4	7E-6	2E-8	–	–
34	Selenium-75	D, see ^{70}Se	5E+2	7E+2	3E-7	1E-9	7E-6	7E-5
		W, see ^{70}Se	–	6E+2	3E-7	8E-10	–	–
34	Selenium-79	D, see ^{70}Se	6E+2	8E+2	3E-7	1E-9	8E-6	8E-5
		W, see ^{70}Se	–	6E+2	2E-7	8E-10	–	–
34	Selenium-81m[b/]	D, see ^{70}Se	4E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		W, see ^{70}Se	2E+4	7E+4	3E-5	1E-7	–	–
34	Selenium-81[b/]	D, see ^{70}Se	6E+4	2E+5	9E-5	3E-7	–	–
			St wall (8E+4)	–	–	–	1E-3	1E-2
		W, see ^{70}Se	–	2E+5	1E-4	3E-7	-	-
34	Selenium-83[b/]	D, see ^{70}Se	4E+4	1E+5	5E-5	2E-7	4E-4	4E-3
		W, see ^{70}Se	3E+4	1E+5	5E-5	2E-7	–	–
35	Bromine-74m[b/]	D, bromides of H, Li, Na, K, Rb, Cs, and Fr	1E+4	4E+4	2E-5	5E-8	–	–
			St wall (2E+4)	–	–	–	3E-4	3E-3
		W, bromides of lanthanides, Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, Ge, Sn, Pb, As, Sb, Bi, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Mn, Tc, and Re	–	4E+4	2E-5	6E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
35	Bromine-74[b/]	D, see ^{74m}Br	2E+4	7E+4	3E-5	1E-7	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
		W, see ^{74m}Br	–	8E+4	4E-5	1E-7	–	–
35	Bromine-75[b/]	D, see ^{74m}Br	3E+4	5E+4	2E-5	7E-8	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
		W, see ^{74m}Br	–	5E+4	2E-5	7E-8	–	–
35	Bromine-76	D, see ^{74m}Br	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
		W, see ^{74m}Br	–	4E+3	2E-6	6E-9	–	–
35	Bromine-77	D, see ^{74m}Br	2E+4	2E+4	1E-5	3E-8	2E-4	2E-3
		W, see ^{74m}Br	–	2E+4	8E-6	3E-8	–	–
35	Bromine-80m	D, see ^{74m}Br	2E+4	2E+4	7E-6	2E-8	3E-4	3E-3
		W, see ^{74m}Br	–	1E+4	6E-6	2E-8	–	–
35	Bromine-80[b/]	D, see ^{74m}Br	5E+4	2E+5	8E-5	3E-7	–	–
			St wall (9E+4)	–	–	–	1E-3	1E-2
		W, see ^{74m}Br	–	2E+5	9E-5	3E-7	–	–
35	Bromine-82	D, see ^{74m}Br	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
		W, see ^{74m}Br	–	4E+3	2E-6	5E-9	–	–
35	Bromine-83	D, see ^{74m}Br	5E+4	6E+4	3E-5	9E-8	–	–
			St wall (7E+4)	–	–	–	9E-4	9E-3
		W, see ^{74m}Br	–	6E+4	3E-5	9E-8	–	–
35	Bromine-84[b/]	D, see ^{74m}Br	2E+4	6E+4	2E-5	8E-8	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
		W, see ^{74m}Br	–	6E+4	3E-5	9E-8	–	–
36	Krypton-74[b/]	Submersion[a/]	–	–	3E-6	1E-8	–	–
36	Krypton-76	Submersion[a/]	–	–	9E-6	4E-8	–	–
36	Krypton-77[b/]	Submersion[a/]	–	–	4E-6	2E-8	–	–
36	Krypton-79	Submersion[a/]	–	–	2E-5	7E-8	–	–
36	Krypton-81	Submersion[a/]	–	–	7E-4	3E-6	–	–
36	Krypton-83m[b/]	Submersion[a/]	–	–	1E-2	5E-5	–	–
36	Krypton-85m	Submersion[a/]	–	–	2E-5	1E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
36	Krypton-85	Submersion[a/]	–	–	1E-4	7E-7	–	–
36	Krypton-87[b/]	Submersion[a/]	–	–	5E-6	2E-8	–	–
36	Krypton-88	Submersion[a/]	–	–	2E-6	9E-9	–	–
37	Rubidium-79[b/]	D, all compounds	4E+4	1E+5	5E-5	2E-7	–	–
			St wall (6E+4)	–	–	–	8E-4	8E-3
37	Rubidium-81m[b/]	D, all compounds	2E+5	3E+5	1E-4	5E-7	–	–
			St wall (3E+5)	–	–	–	4E-3	4E-2
37	Rubidium-81	D, all compounds	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
37	Rubidium-82m	D, all compounds	1E+4	2E+4	7E-6	2E-8	2E-4	2E-3
37	Rubidium-83	D, all compounds	6E+2	1E+3	4E-7	1E-9	9E-6	9E-5
37	Rubidium-84	D, all compounds	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-86	D, all compounds	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-87	D, all compounds	1E+3	2E+3	6E-7	2E-9	1E-5	1E-4
37	Rubidium-88[b/]	D, all compounds	2E+4	6E+4	3E-5	9E-8	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
37	Rubidium-89[b/]	D, all compounds	4E+4	1E+5	6E-5	2E-7	–	–
			St wall (6E+4)	–	–	–	9E-4	9E-3
38	Strontium-80[b/]	D, all soluble compounds except $SrTiO_3$	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		Y, all insoluble compounds and $SrTi0_3$	–	1E+4	5E-6	2E-8	–	–
38	Strontium-81[b/]	D, see ^{80}Sr	3E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		Y, see ^{80}Sr	2E+4	8E+4	3E-5	1E-7	–	–
38	Strontium-82	D, see ^{80}Sr	3E+2	4E+2	2E-7	6E-10	–	–
			LLI wall (2E+2)	–	–	–	3E-6	3E-5
		Y, see ^{80}Sr	2E+2	9E+1	4E-8	1E-10	–	–
38	Strontium-83	D, see ^{80}Sr	3E+3	7E+3	3E-6	1E-8	3E-5	3E-4
		Y, see ^{80}Sr	2E+3	4E+3	1E-6	5E-9	–	–
38	Strontium-85m[b/]	D, see ^{80}Sr	2E+5	6E+5	3E-4	9E-7	3E-3	3E-2
		Y, see ^{80}Sr	–	8E+5	4E-4	1E-6	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
38	Strontium-85	D, see ^{80}Sr	3E+3	3E+3	1E-6	4E-9	4E-5	4E-4
		Y, see ^{80}Sr	–	2E+3	6E-7	2E-9	–	–
38	Strontium-87m	D, see ^{80}Sr	5E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		Y, see ^{80}Sr	4E+4	2E+5	6E-5	2E-7	–	–
38	Strontium-89	D, see ^{80}Sr	6E+2	8E+2	4E-7	1E-9	–	–
			LLI wall (6E+2)	–	–	–	8E-6	8E-5
		Y, see ^{80}Sr	5E+2	1E+2	6E-8	2E-10	–	–
38	Strontium-90	D, see ^{80}Sr	3E+1	2E+1	8E-9	–	–	–
			Bone surf (4E+1)	Bone surf (2E+1)	–	3E-11	5E-7	5E-6
		Y, see ^{80}Sr	–	4E+0	2E-9	6E-12	–	–
38	Strontium-91	D, see ^{80}Sr	2E+3	6E+3	2E-6	8E-9	2E-5	2E-4
		Y, see ^{80}Sr	–	4E+3	1E-6	5E-9	–	–
38	Strontium-92	D, see ^{80}Sr	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{80}Sr	–	7E+3	3E-6	9E-9	–	–
39	Yttrium-86m[b/]	W, all compounds except those given for Y	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
		Y, oxides and hydroxides	–	5E+4	2E-5	8E-8	–	–
39	Yttrium-86	W, see ^{86m}Y	1E+3	3E+3	1E-6	5E-9	2E-5	2E-4
		Y, see ^{86m}Y	–	3E+3	1E-6	5E-9	–	–
39	Yttrium-87	W, see ^{86m}Y	2E+3	3E+3	1E-6	5E-9	3E-5	3E-4
		Y, see ^{86m}Y	–	3E+3	1E-6	5E-9	–	–
39	Yttrium-88	W, see ^{86m}Y	1E+3	3E+2	1E-7	3E-10	1E-5	1E-4
		Y, see ^{86m}Y	–	2E+2	1E-7	3E-10	–	–
39	Yttrium-90m	W, see ^{86m}Y	8E+3	1E+4	5E-6	2E-8	1E-4	1E-3
		Y, see ^{86m}Y	–	1E+4	5E-6	2E-8	–	–
39	Yttrium-90	W, see ^{86m}Y	4E+2	7E+2	3E-7	9E-10	–	–
			LLI wall (5E+2)	–	–	–	7E-6	7E-5
		Y, see ^{86m}Y	–	6E+2	3E-7	9E-10	–	–
39	Yttrium-91m[b/]	W, see ^{86m}Y	1E+5	2E+5	1E-4	3E-7	2E-3	2E-2
		Y, see ^{86m}Y	–	2E+5	7E-5	2E-7	–	–
39	Yttrium-91	W, see ^{86m}Y	5E+2	2E+2	7E-8	2E-10	–	–
			LLI wall (6E+2)	–	–	–	8E-6	8E-5
		Y, see ^{86m}Y	–	1E+2	5E-8	2E-10	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
39	Yttrium-92	W, see ^{86m}Y	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{86m}Y	–	8E+3	3E-6	1E-8	–	–
39	Yttrium-93	W, see ^{86m}Y	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, see ^{86m}Y	–	2E+3	1E-6	3E-9	–	–
39	Yttrium-94[b/]	W, see ^{86m}Y	2E+4 St wall (3E+4)	8E+4	3E-5	1E-7	–	–
				–	–	–	4E-4	4E-3
		Y, see ^{86m}Y	–	8E+4	3E-5	1E-7	–	–
39	Yttrium-95[b/]	W, see ^{86m}Y	4E+4 St wall (5E+4)	2E+5	6E-5	2E-7	–	–
				–	–	–	7E-4	7E-3
		Y, see ^{86m}Y	–	1E+5	6E-5	2E-7	–	–
40	Zirconium-86	D, all compounds except those given for W and Y	1E+3	4E+3	2E-6	6E-9	2E-5	2E-4
		W, oxides, hydroxides, halides, and nitrates	–	3E+3	1E-6	4E-9	–	–
		Y, carbide	–	2E+3	1E-6	3E-9	–	–
40	Zirconium-88	D, see ^{86}Zr	4E+3	2E+2	9E-8	3E-10	5E-5	5E-4
		W, see ^{86}Zr	–	5E+2	2E-7	7E-10	–	–
		Y, see ^{86}Zr	–	3E+2	1E-7	4E-10	–	–
40	Zirconium-89	D, see ^{86}Zr	2E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{86}Zr	–	2E+3	1E-6	3E-9	–	–
		Y, see ^{86}Zr	–	2E+3	1E-6	3E-9	–	–
40	Zirconium-93	D, see ^{86}Zr	1E+3 Bone surf (3E+3)	6E+0 Bone surf (2E+1)	3E-9	–	–	–
					–	2E-11	4E-5	4E-4
		W, see ^{86}Zr	–	2E+1	1E-8	–	–	–
			–	Bone surf (6E+1)	–	9E-11	–	–
		Y, see ^{86}Zr	–	6E+1	2E-8	–	–	–
			–	Bone surf (7E+1)	–	9E-11	–	–
40	Zirconium-95	D, see ^{86}Zr	1E+3	1E+2	5E-8	–	2E-5	2E-4
			–	Bone surf (3E+2)	–	4E-10	–	–
		W, see ^{86}Zr	–	4E+2	2E-7	5E-10	–	–
		Y, see ^{86}Zr	–	3E+2	1E-7	4E-10	–	–
40	Zirconium-97	D, see ^{86}Zr	6E+2	2E+3	8E-7	3E-9	9E-6	9E-5
		W, see ^{86}Zr	–	1E+3	6E-7	2E-9	–	–
		Y, see ^{86}Zr	–	1E+3	5E-7	2E-9	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
41	Niobium-88[b/]	W, all compounds except those given for Y	5E+4	2E+5	9E-5	3E-7	–	–
			St wall (7E+4)	–	–	–	1E-3	1E-2
		Y, oxides and hydroxides	–	2E+5	9E-5	3E-7	–	–
41	Niobium-89[b/] (66 min)	W, see ^{88}Nb	1E+4	4E+4	2E-5	6E-8	1E-4	1E-3
		Y, see ^{88}Nb	–	4E+4	2E-5	5E-8	–	–
41	Niobium-89 (122 min)	W, see ^{88}Nb	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		Y, see ^{88}Nb	–	2E+4	6E-6	2E-8	–	–
41	Niobium-90	W, see ^{88}Nb	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		Y, see ^{88}Nb	–	2E+3	1E-6	3E-9	–	–
41	Niobium-93m	W, see ^{88}Nb	9E+3	2E+3	8E-7	3E-9	–	–
			LLI wall (1E+4)	–	–	–	2E-4	2E-3
		Y, see ^{88}Nb	–	2E+2	7E-8	2E-10	–	–
41	Niobium-94	W, see ^{88}Nb	9E+2	2E+2	8E-8	3E-10	1E-5	1E-4
		Y, see ^{88}Nb	–	2E+1	6E-9	2E-11	–	–
41	Niobium-95m	W, see ^{88}Nb	2E+3	3E+3	1E-6	4E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
		Y, see ^{88}Nb	–	2E+3	9E-7	3E-9	–	–
41	Niobium-95	W, see ^{88}Nb	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
		Y, see ^{88}Nb	–	1E+3	5E-7	2E-9	–	–
41	Niobium-96	W, see ^{88}Nb	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, see ^{88}Nb	–	2E+3	1E-6	3E-9	–	–
41	Niobium-97[b/]	W, see ^{88}Nb	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		Y, see ^{88}Nb	–	7E+4	3E-5	1E-7	–	–
41	Niobium-98[b/]	W, see ^{88}Nb	1E+4	5E+4	2E-5	8E-8	2E-4	2E-3
		Y, see ^{88}Nb	–	5E+4	2E-5	7E-8	–	–
42	Molybdenum-90	D, all compounds except those given for Y	4E+3	7E+3	3E-6	1E-8	3E-5	3E-4
		Y, oxides, hydroxides, and MoS_2	2E+3	5E+3	2E-6	6E-9	–	–
42	Molybdenum-93m	D, see ^{90}Mo	9E+3	2E+4	7E-6	2E-8	6E-5	6E-4
		Y, see ^{90}Mo	4E+3	1E+4	6E-6	2E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
42	Molybdenum-93	D, see ^{90}Mo	4E+3	5E+3	2E-6	8E-9	5E-5	5E-4
		Y, see ^{90}Mo	2E+4	2E+2	8E-8	2E-10	–	–
42	Molybdenum-99	D, see ^{90}Mo	2E+3	3E+3	1E-6	4E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{90}Mo	1E+3	1E+3	6E-7	2E-9	–	–
42	Molybdenum-101[b/]	D, see ^{90}Mo	4E+4	1E+5	6E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
		Y, see ^{90}Mo	–	1E+5	6E-5	2E-7	–	–
43	Technetium-93m[b/]	D, all compounds except those given for W	7E+4	2E+5	6E-5	2E-7	1E-3	1E-2
		W, oxides, hydroxides, halides, and nitrates	–	3E+5	1E-4	4E-7	–	–
43	Technetium-93	D, see ^{93m}Tc	3E+4	7E+4	3E-5	1E-7	4E-4	4E-3
		W, see ^{93m}Tc	–	1E+5	4E-5	1E-7	–	–
43	Technetium-94m[b/]	D, see ^{93m}Tc	2E+4	4E+4	2E-5	6E-8	3E-4	3E-3
		W, see ^{93m}Tc	–	6E+4	2E-5	8E-8	–	–
43	Technetium-94	D, see ^{93m}Tc	9E+3	2E+4	8E-6	3E-8	1E-4	1E-3
		W, see ^{93m}Tc	–	2E+4	1E-5	3E-8	–	–
43	Technetium-95m	D, see ^{93m}Tc	4E+3	5E+3	2E-6	8E-9	5E-5	5E-4
		W, see ^{93m}Tc	–	2E+3	8E-7	3E-9	–	–
43	Technetium-95	D, see ^{93m}Tc	1E+4	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{93m}Tc	–	2E+4	8E-6	3E-8	–	–
43	Technetium-96m[b/]	D, see ^{93m}Tc	2E+5	3E+5	1E-4	4E-7	2E-3	2E-2
		W, see ^{93m}Tc	–	2E+5	1E-4	3E-7	–	–
43	Technetium-96	D, see ^{93m}Tc	2E+3	3E+3	1E-6	5E-9	3E-5	3E-4
		W, see ^{93m}Tc	–	2E+3	9E-7	3E-9	–	–
43	Technetium-97m	D, see ^{93m}Tc	5E+3	7E+3	3E-6	–	6E-5	6E-4
			–	St wall (7E+3)	–	1E-8	–	–
		W, see ^{93m}Tc	–	1E+3	5E-7	2E-9	–	–
43	Technetium-97	D, see ^{93m}Tc	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
		W, see ^{93m}Tc	–	6E+3	2E-6	8E-9	–	–
43	Technetium-98	D, see ^{93m}Tc	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
		W, see ^{93m}Tc	–	3E+2	1E-7	4E-10	–	–
43	Technetium-99m	D, see ^{93m}Tc	8E+4	2E+5	6E-5	2E-7	1E-3	1E-2
		W, see ^{93m}Tc	–	2E+5	1E-4	3E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
43	Technetium-99	D, see ^{93m}Tc	4E+3	5E+3	2E-6	–	6E-5	6E-4
			–	St wall (6E+3)	–	8E-9	–	–
		W, see ^{93m}Tc	–	7E+2	3E-7	9E-10	–	–
43	Technetium-101[b/]	D, see ^{93m}Tc	9E+4	3E+5	1E-4	5E-7	–	–
			St wall (1E+5)	–	–	–	2E-3	2E-2
		W, see ^{93m}Tc	–	4E+5	2E-4	5E-7	–	–
43	Technetium-104[b/]	D, see ^{93m}Tc	2E+4	7E+4	3E-5	1E-7	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
		W, see ^{93m}Tc	–	9E+4	4E-5	1E-7	–	–
44	Ruthenium-94[b/]	D, all compounds except those given for W and Y	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, halides	–	6E+4	3E-5	9E-8	–	–
		Y, oxides and hydroxides	–	6E+4	2E-5	8E-8	–	–
44	Ruthenium-97	D, see ^{94}Ru	8E+3	2E+4	8E-6	3E-8	1E-4	1E-3
		W, see ^{94}Ru	–	1E+4	5E-6	2E-8	–	–
		Y, see ^{94}Ru	–	1E+4	5E-6	2E-8	–	–
44	Ruthenium-103	D, see ^{94}Ru	2E+3	2E+3	7E-7	2E-9	3E-5	3E-4
		W, see ^{94}Ru	–	1E+3	4E-7	1E-9	–	–
		Y, see ^{94}Ru	–	6E+2	3E-7	9E-10	–	–
44	Ruthenium-105	D, see ^{94}Ru	5E+3	1E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{94}Ru	–	1E+4	6E-6	2E-8	–	–
		Y, see ^{94}Ru	–	1E+4	5E-6	2E-8	–	–
44	Ruthenium-106	D, see ^{94}Ru	2E+2	9E+1	4E-8	1E-10	–	–
			LLI wall (2E+2)	–	–	–	3E-6	3E-5
		W, see ^{94}Ru	–	5E+1	2E-8	8E-11	–	–
		Y, see ^{94}Ru	–	1E+1	5E-9	2E-11	–	–
45	Rhodium-99m	D, all compounds except those given for W and Y	2E+4	6E+4	2E-5	8E-8	2E-4	2E-3
		W, halides	–	8E+4	3E-5	1E-7	–	–
		Y, oxides and hydroxides	–	7E+4	3E-5	9E-8	–	–
45	Rhodium-99	D, see ^{99m}Rh	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{99m}Rh	–	2E+3	9E-7	3E-9	–	–
		Y, see ^{99m}Rh	–	2E+3	8E-7	3E-9	–	–
45	Rhodium-100	D, see ^{99m}Rh	2E+3	5E+3	2E-6	7E-9	2E-5	2E-4
		W, see ^{99m}Rh	–	4E+3	2E-6	6E-9	–	–
		Y, see ^{99m}Rh	–	4E+3	2E-6	5E-9	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (µCi)	Table I Occupational Values Col. 2 Inhalation ALI (µCi)	Table I Occupational Values Col. 3 Inhalation DAC (µCi/ml)	Table II Effluent Concentrations Col. 1 Air (µCi/ml)	Table II Effluent Concentrations Col. 2 Water (µCi/ml)	Table III Releases to Sewers Monthly Average Concentration (µCi/ml)
45	Rhodium-101m	D, see ^{99m}Rh	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, see ^{99m}Rh	–	8E+3	4E-6	1E-8	–	–
		Y, see ^{99m}Rh	–	8E+3	3E-6	1E-8	–	–
45	Rhodium-101	D, see ^{99m}Rh	2E+3	5E+2	2E-7	7E-10	3E-5	3E-4
		W, see ^{99m}Rh	–	8E+2	3E-7	1E-9	–	–
		Y, see ^{99m}Rh	–	2E+2	6E-8	2E-10	–	–
45	Rhodium-102m	D, see ^{99m}Rh	1E+3	5E+2	2E-7	7E-10	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		W, see ^{99m}Rh	–	4E+2	2E-7	5E-10	–	–
		Y, see ^{99m}Rh	–	1E+2	5E-8	2E-10	–	–
45	Rhodium-102	D, see ^{99m}Rh	6E+2	9E+1	4E-8	1E-10	8E-6	8E-5
		W, see ^{99m}Rh	–	2E+2	7E-8	2E-10	–	–
		Y, see ^{99m}Rh	–	6E+1	2E-8	8E-11	–	–
45	Rhodium-103m[b/]	D, see ^{99m}Rh	4E+5	1E+6	5E-4	2E-6	6E-3	6E-2
		W, see ^{99m}Rh	–	1E+6	5E-4	2E-6	–	–
		Y, see ^{99m}Rh	–	1E+6	5E-4	2E-6	–	–
45	Rhodium-105	D, see ^{99m}Rh	4E+3	1E+4	5E-6	2E-8	–	–
			LLI wall (4E+3)	–	–	–	5E-5	5E-4
		W, see ^{99m}Rh	–	6E+3	3E-6	9E-9	–	–
		Y, see ^{99m}Rh	–	6E+3	2E-6	8E-9	–	–
45	Rhodium-106m	D, see ^{99m}Rh	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, see ^{99m}Rh	–	4E+4	2E-5	5E-8	–	–
		Y, see ^{99m}Rh	–	4E+4	1E-5	5E-8	–	–
45	Rhodium-107[b/]	D, see ^{99m}Rh	7E+4	2E+5	1E-4	3E-7	–	–
			St wall (9E+4)	–	–	–	1E-3	1E-2
		W, see ^{99m}Rh	–	3E+5	1E-4	4E-7	–	–
		Y, see ^{99m}Rh	–	3E+5	1E-4	3E-7	–	–
46	Palladium-100	D, all compound44s except those given for W and4 Y	1E+3	1E+3	6E-7	2E-9	2E-5	2E-4
		W, nitrates	–	1E+3	5E-7	2E-9	–	–
		Y, oxides and hydroxides	–	1E+3	6E-7	2E-9	–	–
46	Palladium-101	D, see ^{100}Pd	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{100}Pd	–	3E+4	1E-5	5E-8	–	–
		Y, see ^{100}Pd	–	3E+4	1E-5	4E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
46	Palladium-103	D, see ^{100}Pd	6E+3	6E+3	3E-6	9E-9	–	–
			LLI wall					
			(7E+3)	–	–	–	1E-4	1E-3
		W, see ^{100}Pd	–	4E+3	2E-6	6E-9	–	–
		Y, see ^{100}Pd	–	4E+3	1E-6	5E-9	–	–
46	Palladium-107	D, see ^{100}Pd	3E+4	2E+4	9E-6	–	–	–
			LLI wall	Kidneys				
			(4E+4)	(2E+4)	–	3E-8	5E-4	5E-3
		W, see ^{100}Pd	–	7E+3	3E-6	1E-8	–	–
		Y, see ^{100}Pd	–	4E+2	2E-7	6E-10	–	–
46	Palladium-109	D, see ^{100}Pd	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
		W, see ^{100}Pd	–	5E+3	2E-6	8E-9	–	–
		Y, see ^{100}Pd	–	5E+3	2E-6	6E-9	–	–
47	Silver-102[b/]	D, all compounds except those given for W and Y	5E+4	2E+5	8E-5	2E-7	–	–
			St wall					
			(6E+4)	–	–	–	9E-4	9E-3
		W, nitrates and sulfides	–	2E+5	9E-5	3E-7	–	–
		Y, oxides and hydroxides	–	2E+5	8E-5	3E-7	–	–
47	Silver-103[b/]	D, see ^{102}Ag	4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
		W, see ^{102}Ag	–	1E+5	5E-5	2E-7	–	–
		Y, see ^{102}Ag	–	1E+5	5E-5	2E-7	–	–
47	Silver-104m[b/]	D, see ^{102}Ag	3E+4	9E+4	4E-5	1E-7	4E-4	4E-3
		W, see ^{102}Ag	–	1E+5	5E-5	2E-7	–	–
		Y, see ^{102}Ag	–	1E+5	5E-5	2E-7	–	–
47	Silver-104[b/]	D, see ^{102}Ag	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{102}Ag	–	1E+5	6E-5	2E-7	–	–
		Y, see ^{102}Ag	–	1E+5	6E-5	2E-7	–	–
47	Silver-105	D, see ^{102}Ag	3E+3	1E+3	4E-7	1E-9	4E-5	4E-4
		W, see ^{102}Ag	–	2E+3	7E-7	2E-9	–	–
		Y, see ^{102}Ag	–	2E+3	7E-7	2E-9	–	–
47	Silver-106m	D, see ^{102}Ag	8E+2	7E+2	3E-7	1E-9	1E-5	1E-4
		W, see ^{102}Ag	–	9E+2	4E-7	1E-9	–	–
		Y, see ^{102}Ag	–	9E+2	4E-7	1E-9	–	–
47	Silver-106[b/]	D, see ^{102}Ag	6E+4	2E+5	8E-5	3E-7	–	–
			St wall					
			(6E+4)	–	–	–	9E-4	9E-3
		W, see ^{102}Ag	–	2E+5	9E-5	3E-7	–	–
		Y, see ^{102}Ag	–	2E+5	8E-5	3E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
47	Silver-108m	D, see ^{102}Ag	6E+2	2E+2	8E-8	3E-10	9E-6	9E-5
		W, see ^{102}Ag	–	3E+2	1E-7	4E-10	–	–
		Y, see ^{102}Ag	–	2E+1	1E-8	3E-11	–	–
47	Silver-110m	D, see ^{102}Ag	5E+2	1E+2	5E-8	2E-10	6E-6	6E-5
		W, see ^{102}Ag	–	2E+2	8E-8	3E-10	–	–
		Y, see ^{102}Ag	–	9E+1	4E-8	1E-10	–	–
47	Silver-111	D, see ^{102}Ag	9E+2	2E+3	6E-7	–	–	–
			LLI wall	Liver				
			(1E+3)	(2E+3)	–	2E-9	2E-5	2E-4
		W, see ^{102}Ag	–	9E+2	4E-7	1E-9	–	–
		Y, see ^{102}Ag	–	9E+2	4E-7	1E-9	–	–
47	Silver-112	D, see ^{102}Ag	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{102}Ag	–	1E+4	4E-6	1E-8	–	–
		Y, see ^{102}Ag	–	9E+3	4E-6	1E-8	–	–
47	Silver-115[b/]	D, see ^{102}Ag	3E+4	9E+4	4E-5	1E-7	–	–
			St wall					
			(3E+4)	–	–	–	4E-4	4E-3
		W, see ^{102}Ag	–	9E+4	4E-5	1E-7	–	–
		Y, see ^{102}Ag	–	8E+4	3E-5	1E-7	–	–
48	Cadmium-104[b/]	D, all compounds except those given for W and Y	2E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		W, sulfides, halides, and nitrates	–	1E+5	5E-5	2E-7	–	–
		Y, oxides and hydroxides	–	1E+5	5E-5	2E-7	–	–
48	Cadmium-107	D, see ^{104}Cd	2E+4	5E+4	2E-5	8E-8	3E-4	3E-3
		W, see ^{104}Cd	–	6E+4	2E-5	8E-8	–	–
		Y, see ^{104}Cd	–	5E+4	2E-5	7E-8	–	–
48	Cadmium-109	D, see ^{104}Cd	3E+2	4E+1	1E-8	–	–	–
			Kidneys	Kidneys				
			(4E+2)	(5E+1)	–	7E-11	6E-6	6E-5
		W, see ^{104}Cd	–	1E+2	5E-8	–	–	–
				Kidneys				
			–	(1E+2)	–	2E-10	–	–
		Y, see ^{104}Cd	–	1E+2	5E-8	2E-10	–	–
48	Cadmium-113m	D, see ^{104}Cd	2E+1	2E+0	1E-9	–	–	–
			Kidneys	Kidneys				
			(4E+1)	(4E+0)	–	5E-12	5E-7	5E-6
		W, see ^{104}Cd	–	8E+0	4E-9	–	–	–
				Kidneys				
			–	(1E+1)	–	2E-11	–	–
		Y, see ^{104}Cd	–	1E+1	5E-9	2E-11	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
48	Cadmium-113	D, see ^{104}Cd	2E+1 Kidneys	2E+0 Kidneys	9E-10	–	–	–
			(3E+1)	(3E+0)	–	5E-12	4E-7	4E-6
		W, see ^{104}Cd	–	8E+0 Kidneys	3E-9	–	–	–
			–	(1E+1)	–	2E-11	–	–
		Y, see ^{104}Cd	–	1E+1	6E-9	2E-11	–	–
48	Cadmium-115m	D, see ^{104}Cd	3E+2	5E+1	2E-8	–	4E-6	4E-5
			–	Kidneys (8E+1)	–	1E-10	–	–
		W, see ^{104}Cd	–	1E+2	5E-8	2E-10	–	–
		Y, see ^{104}Cd	–	1E+2	6E-8	2E-10	–	–
48	Cadmium-115	D, see ^{104}Cd	9E+2 LLI wall	1E+3	6E-7	2E-9	–	–
			(1E+3)	–	–	–	1E-5	1E-4
		W, see ^{104}Cd	–	1E+3	5E-7	2E-9	–	–
		Y, see ^{104}Cd	–	1E+3	6E-7	2E-9	–	–
48	Cadmium-117m	D, see ^{104}Cd	5E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		W, see ^{104}Cd	–	2E+4	7E-6	2E-8	–	–
		Y, see ^{104}Cd	–	1E+4	6E-6	2E-8	–	–
48	Cadmium-117	D, see ^{104}Cd	5E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		W, see ^{104}Cd	–	2E+4	7E-6	2E-8	–	–
		Y, see ^{104}Cd	–	1E+4	6E-6	2E-8	–	–
49	Indium-109	D, all compounds except those given for W	2E+4	4E+4	2E-5	6E-8	3E-4	3E-3
		W, oxides, hydroxides, halides, and nitrates	–	6E+4	3E-5	9E-8	–	–
49	Indium-110[b/] (69.1 min)	D, see ^{109}In	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{109}In	–	6E+4	2E-5	8E-8	–	–
49	Indium-110 (4.9 h)	D, see ^{109}In	5E+3	2E+4	7E-6	2E-8	7E-5	7E-4
		W, see ^{109}In	–	2E+4	8E-6	3E-8	–	–
49	Indium-111	D, see ^{109}In	4E+3	6E+3	3E-6	9E-9	6E-5	6E-4
		W, see ^{109}In	–	6E+3	3E-6	9E-9	–	–
49	Indium-112[b/]	D, see ^{109}In	2E+5	6E+5	3E-4	9E-7	2E-3	2E-2
		W, see ^{109}In	–	7E+5	3E-4	1E-6	–	–
49	Indium-113m[b/]	D, see ^{109}In	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
		W, see ^{109}In	–	2E+5	8E-5	3E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
49	Indium-114m	D, see ^{109}In	3E+2	6E+1	3E-8	9E-11	–	–
			LLI wall (4E+2)	–	–	–	5E-6	5E-5
		W, see ^{109}In	–	1E+2	4E-8	1E-10	–	–
49	Indium-115m	D, see ^{109}In	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{109}In	–	5E+4	2E-5	7E-8	–	–
49	Indium-115	D, see ^{109}In	4E+1	1E+0	6E-10	2E-12	5E-7	5E-6
		W, see ^{109}In	–	5E+0	2E-9	8E-12	–	–
49	Indium-116m[b/]	D, see ^{109}In	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{109}In	–	1E+5	5E-5	2E-7	–	–
49	Indium-117m[b/]	D, see ^{109}In	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{109}In	–	4E+4	2E-5	6E-8	–	–
49	Indium-117[b/]	D, see ^{109}In	6E+4	2E+5	7E-5	2E-7	8E-4	8E-3
		W, see ^{109}In	–	2E+5	9E-5	3E-7	–	–
49	Indium-119m[b/]	D, see ^{109}In	4E+4	1E+5	5E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	7E-4	7E-3
		W, see ^{109}In	–	1E+5	6E-5	2E-7	–	–
50	Tin-110	D, all compounds except those given for W	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
		W, sulfides, oxides, hydroxides, halides, nitrates, and stannic phosphate	–	1E+4	5E-6	2E-8	–	–
50	Tin-111[b/]	D, see ^{110}Sn	7E+4	2E+5	9E-5	3E-7	1E-3	1E-2
		W, see ^{110}Sn	–	3E+5	1E-4	4E-7	–	–
50	Tin-113	D, see ^{110}Sn	2E+3	1E+3	5E-7	2E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
		W, see ^{110}Sn	–	5E+2	2E-7	8E-10	–	–
50	Tin-117m	D, see ^{110}Sn	2E+3	1E+3	5E-7	–	–	–
			LLI wall (2E+3)	Bone surf (2E+3)	–	3E-9	3E-5	3E-4
		W, see ^{110}Sn	–	1E+3	6E-7	2E-9	–	–
50	Tin-119m	D, see ^{110}Sn	3E+3	2E+3	1E-6	3E-9	–	–
			LLI wall (4E+3)	–	–	–	6E-5	6E-4
		W, see ^{110}Sn	–	1E+3	4E-7	1E-9	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
50	Tin-121m	D, see ^{110}Sn	3E+3	9E+2	4E-7	1E-9	–	–
			LLI wall (4E+3)	–	–	–	5E-5	5E-4
		W, see ^{110}Sn	–	5E+2	2E-7	8E-10	–	–
50	Tin-121	D, see ^{110}Sn	6E+3	2E+4	6E-6	2E-8	–	–
			LLI wall (6E+3)	–	–	–	8E-5	8E-4
		W, see ^{110}Sn	–	1E+4	5E-6	2E-8	–	–
50	Tin-123m[b/]	D, see ^{110}Sn	5E+4	1E+5	5E-5	2E-7	7E-4	7E-3
		W, see ^{110}Sn	–	1E+5	6E-5	2E-7	–	–
50	Tin-123	D, see ^{110}Sn	5E+2	6E+2	3E-7	9E-10	–	–
			LLI wall (6E+2)	–	–	–	9E-6	9E-5
		W, see ^{110}Sn	–	2E+2	7E-8	2E-10	–	–
50	Tin-125	D, see ^{110}Sn	4E+2	9E+2	4E-7	1E-9	–	–
			LLI wall (5E+2)	–	–	–	6E-6	6E-5
		W, see ^{110}Sn	–	4E+2	1E-7	5E-10	–	–
50	Tin-126	D, see ^{110}Sn	3E+2	6E+1	2E-8	8E-11	4E-6	4E-5
		W, see ^{110}Sn	–	7E+1	3E-8	9E-11	–	–
50	Tin-127	D, see ^{110}Sn	7E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		W, see ^{110}Sn	–	2E+4	8E-6	3E-8	–	–
50	Tin-128[b/]	D, see ^{110}Sn	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, see ^{110}Sn	–	4E+4	1E-5	5E-8	–	–
51	Antimony-115[b/]	D, all compounds except those given for W	8E+4	2E+5	1E-4	3E-7	1E-3	1E-2
		W, oxides, hydroxides, halides, sulfides, sulfates, and nitrates	–	3E+5	1E-4	4E-7	–	–
51	Antimony-116m[b/]	D, see ^{115}Sb	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{115}Sb	–	1E+5	6E-5	2E-7	–	–
51	Antimony-116[b/]	D, see ^{115}Sb	7E+4	3E+5	1E-4	4E-7	–	–
			St wall (9E+4)	–	–	–	1E-3	1E-2
		W, see ^{115}Sb	–	3E+5	1E-4	5E-7	–	–
51	Antimony-117	D, see ^{115}Sb	7E+4	2E+5	9E-5	3E-7	9E-4	9E-3
		W, see ^{115}Sb	–	3E+5	1E-4	4E-7	–	–
51	Antimony-118m	D, see ^{115}Sb	6E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		W, see ^{115}Sb	5E+3	2E+4	9E-6	3E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
51	Antimony-119	D, see ^{115}Sb	2E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{115}Sb	2E+4	3E+4	1E-5	4E-8	–	–
51	Antimony-120[b/] (16 min)	D, see ^{115}Sb	1E+5	4E+5	2E-4	6E-7	–	–
			St wall (2E+5)	–	–	–	2E-3	2E-2
		W, see ^{115}Sb	–	5E+5	2E-4	7E-7	–	–
51	Antimony-120 (5.76 d)	D, see ^{115}Sb	1E+3	2E+3	9E-7	3E-9	1E-5	1E-4
		W, see ^{115}Sb	9E+2	1E+3	5E-7	2E-9	–	–
51	Antimony-122	D, see ^{115}Sb	8E+2	2E+3	1E-6	3E-9	–	–
			LLI wall (8E+2)	–	–	–	1E-5	1E-4
		W, see ^{115}Sb	7E+2	1E+3	4E-7	2E-9	–	–
51	Antimony-124m[b/]	D, see ^{115}Sb	3E+5	8E+5	4E-4	1E-6	3E-3	3E-2
		W, see ^{115}Sb	2E+5	6E+5	2E-4	8E-7	–	–
51	Antimony-124	D, see ^{115}Sb	6E+2	9E+2	4E-7	1E-9	7E-6	7E-5
		W, see ^{115}Sb	5E+2	2E+2	1E-7	3E-10	–	–
51	Antimony-125	D, see ^{115}Sb	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4
		W, see ^{115}Sb	–	5E+2	2E-7	7E-10	–	–
51	Antimony-126m[b/]	D, see ^{115}Sb	5E+4	2E+5	8E-5	3E-7	–	–
			St wall (7E+4)	–	–	–	9E-4	9E-3
		W, see ^{115}Sb	–	2E+5	8E-5	3E-7	–	–
51	Antimony-126	D, see ^{115}Sb	6E+2	1E+3	5E-7	2E-9	7E-6	7E-5
		W, see ^{115}Sb	5E+2	5E+2	2E-7	7E-10	–	–
51	Antimony-127	D, see ^{115}Sb	8E+2	2E+3	9E-7	3E-9	–	–
			LLI wall (8E+2)	–	–	–	1E-5	1E-4
		W, see ^{115}Sb	7E+2	9E+2	4E-7	1E-9	–	–
51	Antimony-128[b/] (10.4 min)	D, see ^{115}Sb	8E+4	4E+5	2E-4	5E-7	–	–
			St wall (1E+5)	–	–	–	1E-3	1E-2
		W, see ^{115}Sb	–	4E+5	2E-4	6E-7	–	–
51	Antimony-128 (9.01 h)	D, see ^{115}Sb	1E+3	4E+3	2E-6	6E-9	2E-5	2E-4
		W, see ^{115}Sb	–	3E+3	1E-6	5E-9	–	–
51	Antimony-129	D, see ^{115}Sb	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		W, see ^{115}Sb	–	9E+3	4E-6	1E-8	–	–
51	Antimony-130[b/]	D, see ^{115}Sb	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		W, see ^{115}Sb	–	8E+4	3E-5	1E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
51	Antimony-131[b/]	D, see ^{115}Sb	1E+4 Thyroid (2E+4)	2E+4 Thyroid (4E+4)	1E-5 –	– 6E-8	– 2E-4	– 2E-3
		W, see ^{115}Sb	- -	2E+4 Thyroid (4E+4)	1E-5 –	– 6E-8	– –	– –
52	Tellurium-116	D, all compounds except those given for W	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, oxides, hydroxides, and nitrates	-	3E+4	1E-5	4E-8	–	–
52	Tellurium-121m	D, see ^{116}Te	5E+2 Bone surf (7E+2)	2E+2 Bone surf (4E+2)	8E-8 –	– 5E-10	– 1E-5	– 1E-4
		W, see ^{116}Te	–	4E+2	2E-7	6E-10	–	–
52	Tellurium-121	D, see ^{116}Te	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
		W, see ^{116}Te	–	3E+3	1E-6	4E-9	–	–
52	Tellurium-123m	D, see ^{116}Te	6E+2 Bone surf (1E+3)	2E+2 Bone surf (5E+2)	9E-8 –	– 8E-10	– 1E-5	– 1E-4
		W, see ^{116}Te	–	5E+2	2E-7	8E-10	–	–
52	Tellurium-123	D, see ^{116}Te	5E+2 Bone surf (1E+3)	2E+2 Bone surf (5E+2)	8E-8 –	– 7E-10	– 2E-5	– 2E-4
		W, see ^{116}Te	– –	4E+2 Bone surf (1E+3)	2E-7 –	– 2E-9	– –	– –
52	Tellurium-125m	D, see ^{116}Te	1E+3 Bone surf (1E+3)	4E+2 Bone surf (1E+3)	2E-7 –	– 1E-9	– 2E-5	– 2E-4
		W, see ^{116}Te	–	7E+2	3E-7	1E-9	–	–
52	Tellurium-127m	D, see ^{116}Te	6E+2 –	3E+2 Bone surf (4E+2)	1E-7 –	– 6E-10	9E-6 –	9E-5 –
		W, see ^{116}Te	–	3E+2	1E-7	4E-10	–	–
52	Tellurium-127	D, see ^{116}Te	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{116}Te	–	2E+4	7E-6	2E-8	–	–
52	Tellurium-129m	D, see ^{116}Te	5E+2	6E+2	3E-7	9E-10	7E-6	7E-5
		W, see ^{116}Te	–	2E+2	1E-7	3E-10	–	–
52	Tellurium-129[b/]	D, see ^{116}Te	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
		W, see ^{116}Te	–	7E+4	3E-5	1E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
52	Tellurium-131m	D, see ^{116}Te	3E+2 Thyroid (6E+2)	4E+2 Thyroid (1E+3)	2E-7 –	– 2E-9	– 8E-6	– 8E-5
		W, see ^{116}Te	– –	4E+2 Thyroid (9E+2)	2E-7 –	– 1E-9	– –	– –
52	Tellurium-131[b/]	D, see ^{116}Te	3E+3 Thyroid (6E+3)	5E+3 Thyroid (1E+4)	2E-6 –	– 2E-8	– 8E-5	– 8E-4
		W, see ^{116}Te	– –	5E+3 Thyroid (1E+4)	2E-6 –	– 2E-8	– –	– –
52	Tellurium-132	D, see ^{116}Te	2E+2 Thyroid (7E+2)	2E+2 Thyroid (8E+2)	9E-8 –	– 1E-9	– 9E-6	– 9E-5
		W, see ^{116}Te	– –	2E+2 Thyroid (6E+2)	9E-8 –	– 9E-10	– –	– –
52	Tellurium-133m[b/]	D, see ^{116}Te	3E+3 Thyroid (6E+3)	5E+3 Thyroid (1E+4)	2E-6 –	– 2E-8	– 9E-5	– 9E-4
		W, see ^{116}Te	– –	5E+3 Thyroid (1E+4)	2E-6 –	– 2E-8	– –	– –
52	Tellurium-133[b/]	D, see ^{116}Te	1E+4 Thyroid (3E+4)	2E+4 Thyroid (6E+4)	9E-6 –	– 8E-8	– 4E-4	– 4E-3
		W, see ^{116}Te	– –	2E+4 Thyroid (6E+4)	9E-6 –	– 8E-8	– –	– –
52	Tellurium-134[b/]	D, see ^{116}Te	2E+4 Thyroid (2E+4)	2E+4 Thyroid (5E+4)	1E-5 –	– 7E-8	– 3E-4	– 3E-3
		W, see ^{116}Te	– –	2E+4 Thyroid (5E+4)	1E-5 –	– 7E-8	– –	– –
53	Iodine-120m[b/]	D, all compounds	1E+4 Thyroid (1E+4)	2E+4 –	9E-6 –	3E-8 –	– 2E-4	– 2E-3
53	Iodine-120[b/]	D, all compounds	4E+3 Thyroid (8E+3)	9E+3 Thyroid (1E+4)	4E-6 –	– 2E-8	– 1E-4	– 1E-3

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
53	Iodine-121	D, all compounds	1E+4 Thyroid (3E+4)	2E+4 Thyroid (5E+4)	8E-6 –	– 7E-8	– 4E-4	– 4E-3
53	Iodine-123	D, all compounds	3E+3 Thyroid (1E+4)	6E+3 Thyroid (2E+4)	3E-6 –	– 2E-8	– 1E-4	– 1E-3
53	Iodine-124	D, all compounds	5E+1 Thyroid (2E+2)	8E+1 Thyroid (3E+2)	3E-8 –	– 4E-10	– 2E-6	– 2E-5
53	Iodine-125	D, all compounds	4E+1 Thyroid (1E+2)	6E+1 Thyroid (2E+2)	3E-8 –	– 3E-10	– 2E-6	– 2E-5
53	Iodine-126	D, all compounds	2E+1 Thyroid (7E+1)	4E+1 Thyroid (1E+2)	1E-8 –	– 2E-10	– 1E-6	– 1E-5
53	Iodine-128[b/]	D, all compounds	4E+4 St wall (6E+4)	1E+5 –	5E-5 –	2E-7 –	– 8E-4	– 8E-3
53	Iodine-129	D, all compounds	5E+0 Thyroid (2E+1)	9E+0 Thyroid (3E+1)	4E-9 –	– 4E-11	– 2E-7	– 2E-6
53	Iodine-130	D, all compounds	4E+2 Thyroid (1E+3)	7E+2 Thyroid (2E+3)	3E-7 –	– 3E-9	– 2E-5	– 2E-4
53	Iodine-131	D, all compounds	3E+1 Thyroid (9E+1)	5E+1 Thyroid (2E+2)	2E-8 –	– 2E-10	– 1E-6	– 1E-5
53	Iodine-132m[b/]	D, all compounds	4E+3 Thyroid (1E+4)	8E+3 Thyroid (2E+4)	4E-6 –	– 3E-8	– 1E-4	– 1E-3
53	Iodine-132	D, all compounds	4E+3 Thyroid (9E+3)	8E+3 Thyroid (1E+4)	3E-6 –	– 2E-8	– 1E-4	– 1E-3
53	Iodine-133	D, all compounds	1E+2 Thyroid (5E+2)	3E+2 Thyroid (9E+2)	1E-7 –	– 1E-9	– 7E-6	– 7E-5
53	Iodine-134[b/]	D, all compounds	2E+4 Thyroid (3E+4)	5E+4 –	2E-5 –	6E-8 –	– 4E-4	– 4E-3

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
53	Iodine-135	D, all compounds	8E+2 Thyroid (3E+3)	2E+3 Thyroid (4E+3)	7E-7 –	– 6E-9	– 3E-5	– 3E-4
54	Xenon-120[b/]	Submersion[a/]	–	–	1E-5	4E-8	–	–
54	Xenon-121[b/]	Submersion[a/]	–	–	2E-6	1E-8	–	–
54	Xenon-122	Submersion[a/]	–	–	7E-5	3E-7	–	–
54	Xenon-123	Submersion[a/]	–	–	6E-6	3E-8	–	–
54	Xenon-125	Submersion[a/]	–	–	2E-5	7E-8	–	–
54	Xenon-127	Submersion[a/]	–	–	1E-5	6E-8	–	–
54	Xenon-129m	Submersion[a/]	–	–	2E-4	9E-7	–	–
54	Xenon-131m	Submersion[a/]	–	–	4E-4	2E-6	–	–
54	Xenon-133m	Submersion[a/]	–	–	1E-4	6E-7	–	–
54	Xenon-133	Submersion[a/]	–	–	1E-4	5E-7	–	–
54	Xenon-135m[b/]	Submersion[a/]	–	–	9E-6	4E-8	–	–
54	Xenon-135	Submersion[a/]	–	–	1E-5	7E-8	–	–
54	Xenon-138[b/]	Submersion[a/]	–	–	4E-6	2E-8	–	–
55	Cesium-125[b/]	D, all compounds	5E+4 St wall (9E+4)	1E+5 –	6E-5 –	2E-7 –	– 1E-3	– 1E-2
55	Cesium-127	D, all compounds	6E+4	9E+4	4E-5	1E-7	9E-4	9E-3
55	Cesium-129	D, all compounds	2E+4	3E+4	1E-5	5E-8	3E-4	3E-3
55	Cesium-130[b/]	D, all compounds	6E+4 St wall (1E+5)	2E+5 –	8E-5 –	3E-7 –	– 1E-3	– 1E-2
55	Cesium-131	D, all compounds	2E+4	3E+4	1E-5	4E-8	3E-4	3E-3
55	Cesium-132	D, all compounds	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
55	Cesium-134m	D, all compounds	1E+5 St wall (1E+5)	1E+5 –	6E-5 –	2E-7 –	– 2E-3	– 2E-2
55	Cesium-134	D, all compounds	7E+1	1E+2	4E-8	2E-10	9E-7	9E-6

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
55	Cesium-135m[b/]	D, all compounds	1E+5	2E+5	8E-5	3E-7	1E-3	1E-2
55	Cesium-135	D, all compounds	7E+2	1E+3	5E-7	2E-9	1E-5	1E-4
55	Cesium-136	D, all compounds	4E+2	7E+2	3E-7	9E-10	6E-6	6E-5
55	Cesium-137	D, all compounds	1E+2	2E+2	6E-8	2E-10	1E-6	1E-5
55	Cesium-138[b/]	D, all compounds	2E+4	6E+4	2E-5	8E-8	–	–
			St wall (3E+4)	–	–	–	4E-4	4E-3
56	Barium-126[b/]	D, all compounds	6E+3	2E+4	6E-6	2E-8	8E-5	8E-4
56	Barium-128	D, all compounds	5E+2	2E+3	7E-7	2E-9	7E-6	7E-5
56	Barium-131m[b/]	D, all compounds	4E+5	1E+6	6E-4	2E-6	–	–
			St wall (5E+5)	–	–	–	7E-3	7E-2
56	Barium-131	D, all compounds	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
56	Barium-133m	D, all compounds	2E+3	9E+3	4E-6	1E-8	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
56	Barium-133	D, all compounds	2E+3	7E+2	3E-7	9E-10	2E-5	2E-4
56	Barium-135m	D, all compounds	3E+3	1E+4	5E-6	2E-8	4E-5	4E-4
56	Barium-139[b/]	D, all compounds	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
56	Barium-140	D, all compounds	5E+2	1E+3	6E-7	2E-9	–	–
			LLI wall (6E+2)	–	–	–	8E-6	8E-5
56	Barium-141[b/]	D, all compounds	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
56	Barium-142[b/]	D, all compounds	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
57	Lanthanum-131[b/]	D, all compounds except those given for W	5E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		W, oxides and hydroxides	–	2E+5	7E-5	2E-7	–	–
57	Lanthanum-132	D, see ^{131}La	3E+3	1E+4	4E-6	1E-8	4E-5	4E-4
		W, see ^{131}La	–	1E+4	5E-6	2E-8	–	–
57	Lanthanum-135	D, see ^{131}La	4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
		W, see ^{131}La	–	9E+4	4E-5	1E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
57	Lanthanum-137	D, see ^{131}La	1E+4	6E+1	3E-8	–	2E-4	2E-3
			–	Liver (7E+1)	–	1E-10	–	–
		W, see ^{131}La	–	3E+2	1E-7	–	–	–
			–	Liver (3E+2)	–	4E-10	–	–
57	Lanthanum-138	D, see ^{131}La	9E+2	4E+0	1E-9	5E-12	1E-5	1E-4
		W, see ^{131}La	–	1E+1	6E-9	2E-11	–	–
57	Lanthanum-140	D, see ^{131}La	6E+2	1E+3	6E-7	2E-9	9E-6	9E-5
		W, see ^{131}La	–	1E+3	5E-7	2E-9	–	–
57	Lanthanum-141	D, see ^{131}La	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
		W, see ^{131}La	–	1E+4	5E-6	2E-8	–	–
57	Lanthanum-142[b/]	D, see ^{131}La	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{131}La	–	3E+4	1E-5	5E-8	–	–
57	Lanthanum-143[b/]	D, see ^{131}La	4E+4	1E+5	4E-5	1E-7	–	–
			St wall (4E+4)	–	–	–	5E-4	5E-3
		W, see ^{131}La	–	9E+4	4E-5	1E-7	–	–
58	Cerium-134	W, all compounds except those given for Y	5E+2	7E+2	3E-7	1E-9	–	–
			LLI wall (6E+2)	–	–	–	8E-6	8E-5
		Y, oxides, hydroxides, and fluorides	–	7E+2	3E-7	9E-10	–	–
58	Cerium-135	W, see ^{134}Ce	2E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		Y, see ^{134}Ce	–	4E+3	1E-6	5E-9	–	–
58	Cerium-137m	W, see ^{134}Ce	2E+3	4E+3	2E-6	6E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
		Y, see ^{134}Ce	–	4E+3	2E-6	5E-9	–	–
58	Cerium-137	W, see ^{134}Ce	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
		Y, see ^{134}Ce	–	1E+5	5E-5	2E-7	–	–
58	Cerium-139	W, see ^{134}Ce	5E+3	8E+2	3E-7	1E-9	7E-5	7E-4
		Y, see ^{134}Ce	–	7E+2	3E-7	9E-10	–	–
58	Cerium-141	W, see ^{134}Ce	2E+3	7E+2	3E-7	1E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
		Y, see ^{134}Ce	–	6E+2	2E-7	8E-10	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
58	Cerium-143	W, see ^{134}Ce	1E+3	2E+3	8E-7	3E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{134}Ce	–	2E+3	7E-7	2E-9	–	–
58	Cerium-144	W, see ^{134}Ce	2E+2	3E+1	1E-8	4E-11	–	–
			LLI wall (3E+2)	–	–	–	3E-6	3E-5
		Y, see ^{134}Ce	–	1E+1	6E-9	2E-11	–	–
59	Praseodymium-136[b/]	W, all compounds except those given for Y	5E+4	2E+5	1E-4	3E-7	–	–
			St wall (7E+4)	–	–	–	1E-3	1E-2
		Y, oxides, hydroxides, carbides, and fluorides	–	2E+5	9E-5	3E-7	–	–
59	Praseodymium-137[b/]	W, see ^{136}Pr	4E+4	2E+5	6E-5	2E-7	5E-4	5E-3
		Y, see ^{136}Pr	–	1E+5	6E-5	2E-7	–	–
59	Praseodymium-138m	W, see ^{136}Pr	1E+4	5E+4	2E-5	8E-8	1E-4	1E-3
		Y, see ^{136}Pr	–	4E+4	2E-5	6E-8	–	–
59	Praseodymium-139	W, see ^{136}Pr	4E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		Y, see ^{136}Pr	–	1E+5	5E-5	2E-7	–	–
59	Praseodymium-142m[b/]	W, see ^{136}Pr	8E+4	2E+5	7E-5	2E-7	1E-3	1E-2
		Y, see ^{136}Pr	–	1E+5	6E-5	2E-7	–	–
59	Praseodymium-142	W, see ^{136}Pr	1E+3	2E+3	9E-7	3E-9	1E-5	1E-4
		Y, see ^{136}Pr	–	2E+3	8E-7	3E-9	–	–
59	Praseodymium-143	W, see ^{136}Pr	9E+2	8E+2	3E-7	1E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{136}Pr	–	7E+2	3E-7	9E-10	–	–
59	Praseodymium-144[b/]	W, see ^{136}Pr	3E+4	1E+5	5E-5	2E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
		Y, see ^{136}Pr	–	1E+5	5E-5	2E-7	–	–
59	Praseodymium-145	W, see ^{136}Pr	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{136}Pr	–	8E+3	3E-6	1E-8	–	–
59	Praseodymium-147[b/]	W, see ^{136}Pr	5E+4	2E+5	8E-5	3E-7	–	–
			St wall (8E+4)	–	–	–	1E-3	1E-2
		Y, see ^{136}Pr	–	2E+5	8E-5	3E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
60	Neodymium-136[b/]	W, all compounds except those given for Y	1E+4	6E+4	2E-5	8E-8	2E-4	2E-3
		Y, oxides, hydroxides, carbides, and fluorides	–	5E+4	2E-5	8E-8	–	–
60	Neodymium-138	W, see ^{136}Nd	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
		Y, see ^{136}Nd	-	5E+3	2E-6	7E-9	-	-
60	Neodymium-139m	W, see ^{136}Nd	5E+3	2E+4	7E-6	2E-8	7E-5	7E-4
		Y, see ^{136}Nd	–	1E+4	6E-6	2E-8	–	–
60	Neodymium-139[b/]	W, see ^{136}Nd	9E+4	3E+5	1E-4	5E-7	1E-3	1E-2
		Y, see ^{136}Nd	–	3E+5	1E-4	4E-7	–	–
60	Neodymium-141	W, see ^{136}Nd	2E+5	7E+5	3E-4	1E-6	2E-3	2E-2
		Y, see ^{136}Nd	–	6E+5	3E-4	9E-7	–	–
60	Neodymium-147	W, see ^{136}Nd	1E+3	9E+2	4E-7	1E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{136}Nd	–	8E+2	4E-7	1E-9	–	–
60	Neodymium-149[b/]	W, see ^{136}Nd	1E+4	3E+4	1E-5	4E-8	1E-4	1E-3
		Y, see ^{136}Nd	–	2E+4	1E-5	3E-8	–	–
60	Neodymium-151[b/]	W, see ^{136}Nd	7E+4	2E+5	8E-5	3E-7	9E-4	9E-3
		Y, see ^{136}Nd	–	2E+5	8E-5	3E-7	–	–
61	Promethium-141[b/]	W, all compounds except those given for Y	5E+4	2E+5	8E-5	3E-7	–	–
			St wall (6E+4)	–	–	–	8E-4	8E-3
		Y, oxides, hydroxides, carbides, and fluorides	–	2E+5	7E-5	2E-7	–	–
61	Promethium-143	W, see ^{141}Pm	5E+3	6E+2	2E-7	8E-10	7E-5	7E-4
		Y, see ^{141}Pm	–	7E+2	3E-7	1E-9	–	–
61	Promethium-144	W, see ^{141}Pm	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		Y, see ^{141}Pm	–	1E+2	5E-8	2E-10	–	–
61	Promethium-145	W, see ^{141}Pm	1E+4	2E+2	7E-8	–	1E-4	1E-3
			–	Bone surf (2E+2)	–	3E-10	–	–
		Y, see ^{141}Pm	–	2E+2	8E-8	3E-10	–	–
61	Promethium-146	W, see ^{141}Pm	2E+3	5E+1	2E-8	7E-11	2E-5	2E-4
		Y, see ^{141}Pm	–	4E+1	2E-8	6E-11	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
61	Promethium-147	W, see ^{141}Pm	4E+3	1E+2	5E-8	–	–	–
			LLI wall	Bone surf				
			(5E+3)	(2E+2)	–	3E-10	7E-5	7E-4
		Y, see ^{141}Pm	–	1E+2	6E-8	2E-10	–	–
61	Promethium-148m	W, see ^{141}Pm	7E+2	3E+2	1E-7	4E-10	1E-5	1E-4
		Y, see ^{141}Pm	–	3E+2	1E-7	5E-10	–	–
61	Promethium-148	W, see ^{141}Pm	4E+2	5E+2	2E-7	8E-10	–	–
			LLI wall					
			(5E+2)	–	–	–	7E-6	7E-5
		Y, see ^{141}Pm	–	5E+2	2E-7	7E-10	–	–
61	Promethium-149	W, see ^{141}Pm	1E+3	2E+3	8E-7	3E-9	–	–
			LLI wall					
			(1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{141}Pm	–	2E+3	8E-7	2E-9	–	–
61	Promethium-150	W, see ^{141}Pm	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		Y, see ^{141}Pm	–	2E+4	7E-6	2E-8	–	–
61	Promethium-151	W, see ^{141}Pm	2E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		Y, see ^{141}Pm	–	3E+3	1E-6	4E-9	–	–
62	Samarium-141m[b/]	W, all compounds	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
62	Samarium-141[b/]	W, all compounds	5E+4	2E+5	8E-5	2E-7	–	–
			St wall					
			(6E+4)	–	–	–	8E-4	8E-3
62	Samarium-142[b/]	W, all compounds	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3
62	Samarium-145	W, all compounds	6E+3	5E+2	2E-7	7E-10	8E-5	8E-4
62	Samarium-146	W, all compounds	1E+1	4E-2	1E-11	–	–	–
			Bone surf	Bone surf				
			(3E+1)	(6E-2)	–	9E-14	3E-7	3E-6
62	Samarium-147	W, all compounds	2E+1	4E-2	2E-11	–	–	–
			Bone surf	Bone surf				
			(3E+1)	(7E-2)	–	1E-13	4E-7	4E-6
62	Samarium-151	W, all compounds	1E+4	1E+2	4E-8	–	–	–
			LLI wall	Bone surf				
			(1E+4)	(2E+2)	–	2E-10	2E-4	2E-3
62	Samarium-153	W, all compounds	2E+3	3E+3	1E-6	4E-9	–	–
			LLI wall					
			(2E+3)	–	–	–	3E-5	3E-4

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
62	Samarium-155[b/]	W, all compounds	6E+4	2E+5	9E-5	3E-7	–	–
			St wall (8E+4)	–	–	–	1E-3	1E-2
62	Samarium-156	W, all compounds	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
63	Europium-145	W, all compounds	2E+3	2E+3	8E-7	3E-9	2E-5	2E-4
63	Europium-146	W, all compounds	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
63	Europium-147	W, all compounds	3E+3	2E+3	7E-7	2E-9	4E-5	4E-4
63	Europium-148	W, all compounds	1E+3	4E+2	1E-7	5E-10	1E-5	1E-4
63	Europium-149	W, all compounds	1E+4	3E+3	1E-6	4E-9	2E-4	2E-3
63	Europium-150 (12.62 h)	W, all compounds	3E+3	8E+3	4E-6	1E-8	4E-5	4E-4
63	Europium-150 (34.2 y)	W, all compounds	8E+2	2E+1	8E-9	3E-11	1E-5	1E-4
63	Europium-152m	W, all compounds	3E+3	6E+3	3E-6	9E-9	4E-5	4E-4
63	Europium-152	W, all compounds	8E+2	2E+1	1E-8	3E-11	1E-5	1E-4
63	Europium-154	W, all compounds	5E+2	2E+1	8E-9	3E-11	7E-6	7E-5
63	Europium-155	W, all compounds	4E+3	9E+1	4E-8	–	5E-5	5E-4
			–	Bone surf (1E+2)	–	2E-10	–	–
63	Europium-156	W, all compounds	6E+2	5E+2	2E-7	6E-10	8E-6	8E-5
63	Europium-157	W, all compounds	2E+3	5E+3	2E-6	7E-9	3E-5	3E-4
63	Europium-158[b/]	W, all compounds	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
64	Gadolinium-145[b/]	D, all compounds except those given for W	5E+4	2E+5	6E-5	2E-7	–	–
			St wall (5E+4)	–	–	–	6E-4	6E-3
		W, oxides, hydroxides, and fluorides	–	2E+5	7E-5	2E-7	–	–
64	Gadolinium-146	D, see ^{145}Gd	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		W, see ^{145}Gd	–	3E+2	1E-7	4E-10	–	–
64	Gadolinium-147	D, see ^{145}Gd	2E+3	4E+3	2E-6	6E-9	3E-5	3E-4
		W, see ^{145}Gd	–	4E+3	1E-6	5E-9	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
64	Gadolinium-148	D, see ^{145}Gd	1E+1 Bone surf (2E+1)	8E+3 Bone surf (2E-2)	3E-12 –	– 2E-14	– 3E-7	– 3E-6
		W, see ^{145}Gd	– –	3E-2 Bone surf (6E-2)	1E-11 –	– 8E-14	– –	– –
64	Gadolinium-149	D, see ^{145}Gd	3E+3	2E+3	9E-7	3E-9	4E-5	4E-4
		W, see ^{145}Gd	–	2E+3	1E-6	3E-9	–	–
64	Gadolinium-151	D, see ^{145}Gd	6E+3	4E+2 Bone surf (6E+2)	2E-7 –	– 9E-10	9E-5 –	9E-4 –
		W, see ^{145}Gd	–	1E+3	5E-7	2E-9	–	–
64	Gadolinium-152	D, see ^{145}Gd	2E+1 Bone surf (3E+1)	1E-2 Bone surf (2E-2)	4E-12 –	– 3E-14	– 4E-7	– 4E-6
		W, see ^{145}Gd	– –	4E-2 Bone surf (8E-2)	2E-11 –	– 1E-13	– –	– –
64	Gadolinium-153	D, see ^{145}Gd	5E+3	1E+2 Bone surf (2E+2)	6E-8 –	– 3E-10	6E-5 –	6E-4 –
		W, see ^{145}Gd	–	6E+2	2E-7	8E-10	–	–
64	Gadolinium-159	D, see ^{145}Gd	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{145}Gd	–	6E+3	2E-6	8E-9	–	–
65	Terbium-147[b/]	W, all compounds	9E+3	3E+4	1E-5	5E-8	1E-4	1E-3
65	Terbium-149	W, all compounds	5E+3	7E+2	3E-7	1E-9	7E-5	7E-4
65	Terbium-150	W, all compounds	5E+3	2E+4	9E-6	3E-8	7E-5	7E-4
65	Terbium-151	W, all compounds	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
65	Terbium-153	W, all compounds	5E+3	7E+3	3E-6	1E-8	7E-5	7E-4
65	Terbium-154	W, all compounds	2E+3	4E+3	2E-6	6E-9	2E-5	2E-4
65	Terbium-155	W, all compounds	6E+3	8E+3	3E-6	1E-8	8E-5	8E-4
65	Terbium-156m (5.0 h)	W, all compounds	2E+4	3E+4	1E-5	4E-8	2E-4	2E-3
65	Terbium-156m (24.4 h)	W, all compounds	7E+3	8E+3	3E-6	1E-8	1E-4	1E-3
65	Terbium-156	W, all compounds	1E+3	1E+3	6E-7	2E-9	1E-5	1E-4

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
65	Terbium-157	W, all compounds	5E+4	3E+2	1E-7	–	–	–
			LLI wall (5E+4)	Bone surf (6E+2)	–	8E-10	7E-4	7E-3
65	Terbium-158	W, all compounds	1E+3	2E+1	8E-9	3E-11	2E-5	2E-4
65	Terbium-160	W, all compounds	8E+2	2E+2	9E-8	3E-10	1E-5	1E-4
65	Terbium-161	W, all compounds	2E+3	2E+3	7E-7	2E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
66	Dysprosium-155	W, all compounds	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
66	Dysprosium-157	W, all compounds	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
66	Dysprosium-159	W, all compounds	1E+4	2E+3	1E-6	3E-9	2E-4	2E-3
66	Dysprosium-165	W, all compounds	1E+4	5E+4	2E-5	6E-8	2E-4	2E-3
66	Dysprosium-166	W, all compounds	6E+2	7E+2	3E-7	1E-9	–	–
			LLI wall (8E+2)	–	–	–	1E-5	1E-4
67	Holmium-155[b/]	W, all compounds	4E+4	2E+5	6E-5	2E-7	6E-4	6E-3
67	Holmium-157[b/]	W, all compounds	3E+5	1E+6	6E-4	2E-6	4E-3	4E-2
67	Holmium-159[b/]	W, all compounds	2E+5	1E+6	4E-4	1E-6	3E-3	3E-2
67	Holmium-161	W, all compounds	1E+5	4E+5	2E-4	6E-7	1E-3	1E-2
67	Holmium-162m[b/]	W, all compounds	5E+4	3E+5	1E-4	4E-7	7E-4	7E-3
67	Holmium-162[b/]	W, all compounds	5E+5	2E+6	1E-3	3E-6	–	–
			St wall (8E+5)	–	–	–	1E-2	1E-1
67	Holmium-164m[b/]	W, all compounds	1E+5	3E+5	1E-4	4E-7	1E-3	1E-2
67	Holmium-164[b/]	W, all compounds	2E+5	6E+5	3E-4	9E-7	–	–
			St wall (2E+5)	–	–	–	3E-3	3E-2
67	Holmium-166m	W, all compounds	6E+2	7E+0	3E-9	9E-12	9E-6	9E-5
67	Holmium-166	W, all compounds	9E+2	2E+3	7E-7	2E-9	–	–
			LLI wall (9E+2)	–	–	–	1E-5	1E-4
67	Holmium-167	W, all compounds	2E+4	6E+4	2E-5	8E-8	2E-4	2E-3

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
68	Erbium-161	W, all compounds	2E+4	6E+4	3E-5	9E-8	2E-4	2E-3
68	Erbium-165	W, all compounds	6E+4	2E+5	8E-5	3E-7	9E-4	9E-3
68	Erbium-169	W, all compounds	3E+3	3E+3	1E-6	4E-9	–	-
			LLI wall (4E+3)	–	–	–	5E-5	5E-4
68	Erbium-171	W, all compounds	4E+3	1E+4	4E-6	1E-8	5E-5	5E-4
68	Erbium-172	W, all compounds	1E+3	1E+3	6E-7	2E-9	–	-
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
69	Thulium-162[b/]	W, all compounds	7E+4	3E+5	1E-4	4E-7	–	-
			St wall (7E+4)	–	–	–	1E-3	1E-2
69	Thulium-166	W, all compounds	4E+3	1E+4	6E-6	2E-8	6E-5	6E-4
69	Thulium-167	W, all compounds	2E+3	2E+3	8E-7	3E-9	–	-
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
69	Thulium-170	W, all compounds	8E+2	2E+2	9E-8	3E-10	–	-
			LLI wall (1E+3)	–	–	–	1E-5	1E-4
69	Thulium-171	W, all compounds	1E+4	3E+2	1E-7	–	–	-
			LLI wall (1E+4)	Bone surf (6E+2)	–	8E-10	2E-4	2E-3
69	Thulium-172	W, all compounds	7E+2	1E+3	5E-7	2E-9	–	-
			LLI wall (8E+2)	–	–	–	1E-5	1E-4
69	Thulium-173	W, all compounds	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
69	Thulium-175[b/]	W, all compounds	7E+4	3E+5	1E-4	4E-7	–	-
			St wall (9E+4)	–	–	–	1E-3	1E-2
70	Ytterbium-162[b/]	W, all compounds except those given for Y	7E+4	3E+5	1E-4	4E-7	1E-3	1E-2
		Y, oxides, hydroxides, and fluorides	–	3E+5	1E-4	4E-7	–	-
70	Ytterbium-166	W, see ^{162}Yb	1E+3	2E+3	8E-7	3E-9	2E-5	2E-4
		Y, see ^{162}Yb	–	2E+3	8E-7	3E-9	–	-

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
70	Ytterbium-167[b/]	W, see ^{162}Yb	3E+5	8E+5	3E-4	1E-6	4E-3	4E-2
		Y, see ^{162}Yb	–	7E+5	3E-4	1E-6	–	–
70	Ytterbium-169	W, see ^{162}Yb	2E+3	8E+2	4E-7	1E-9	2E-5	2E-4
		Y, see ^{162}Yb	–	7E+2	3E-7	1E-9	–	–
70	Ytterbium-175	W, see ^{162}Yb	3E+3	4E+3	1E-6	5E-9	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
		Y, see ^{162}Yb	–	3E+3	1E-6	5E-9	–	–
70	Ytterbium-177[b/]	W, see ^{162}Yb	2E+4	5E+4	2E-5	7E-8	2E-4	2E-3
		Y, see ^{162}Yb	–	5E+4	2E-5	6E-8	–	–
70	Ytterbium-178[b/]	W, see ^{162}Yb	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		Y, see ^{162}Yb	–	4E+4	2E-5	5E-8	–	–
71	Lutetium-169	W, all compounds except those given for Y	3E+3	4E+3	2E-6	6E-9	3E-5	3E-4
		Y, oxides, hydroxides, and fluorides	–	4E+3	2E-6	6E-9	–	–
71	Lutetium-170	W, see ^{169}Lu	1E+3	2E+3	9E-7	3E-9	2E-5	2E-4
		Y, see ^{169}Lu	–	2E+3	8E-7	3E-9	–	–
71	Lutetium-171	W, see ^{169}Lu	2E+3	2E+3	8E-7	3E-9	3E-5	3E-4
		Y, see ^{169}Lu	–	2E+3	8E-7	3E-9	–	–
71	Lutetium-172	W, see ^{169}Lu	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
		Y, see ^{169}Lu	–	1E+3	5E-7	2E-9	–	–
71	Lutetium-173	W, see ^{169}Lu	5E+3	3E+2	1E-7	–	7E-5	7E-4
			–	Bone surf (5E+2)	-	6E-10	–	–
		Y, see ^{169}Lu	–	3E+2	1E-7	4E-10	–	–
71	Lutetium-174m	W, see ^{169}Lu	2E+3	2E+2	1E-7	–	–	–
			LLI wall (3E+3)	Bone surf (3E+2)	–	5E-10	4E-5	4E-4
		Y, see ^{169}Lu	–	2E+2	9E-8	3E-10	–	–
71	Lutetium-174	W, see ^{169}Lu	5E+3	1E+2	5E-8	–	7E-5	7E-4
			–	Bone surf (2E+2)	–	3E-10	–	–
		Y, see ^{169}Lu	–	2E+2	6E-8	2E-10	–	–
71	Lutetium-176m	W, see ^{169}Lu	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		Y, see ^{169}Lu	–	2E+4	9E-6	3E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation		Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
71	Lutetium-176	W, see ^{169}Lu	7E+2	5E+0	2E-9	–	1E-5	1E-4
			–	Bone surf (1E+1)	–	2E-11	–	–
		Y, see ^{169}Lu	–	8E+0	3E-9	1E-11	–	–
71	Lutetium-177m	W, see ^{169}Lu	7E+2	1E+2	5E-8	–	1E-5	1E-4
			–	Bone surf (1E+2)	–	2E-10	–	–
		Y, see ^{169}Lu	–	8E+1	3E-8	1E-10	–	–
71	Lutetium-177	W, see ^{169}Lu	2E+3	2E+3	9E-7	3E-9	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
		Y, see ^{169}Lu	–	2E+3	9E-7	3E-9	–	–
71	Lutetium-178m[b/]	W, see ^{169}Lu	5E+4	2E+5	8E-5	3E-7	–	–
			St wall (6E+4)	–	–	–	8E-4	8E-3
		Y, see ^{169}Lu	–	2E+5	7E-5	2E-7	–	–
71	Lutetium-178[b/]	W, see ^{169}Lu	4E+4	1E+5	5E-5	2E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
		Y, see ^{169}Lu	–	1E+5	5E-5	2E-7	–	–
71	Lutetium-179	W, see ^{169}Lu	6E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		Y, see ^{169}Lu	–	2E+4	6E-6	3E-8	–	–
72	Hafnium-170	D, all compounds except those given for W	3E+3	6E+3	2E-6	8E-9	4E-5	4E-4
		W, oxides, hydroxides, carbides, and nitrates	–	5E+3	2E-6	6E-9	–	–
72	Hafnium-172	D, see ^{170}Hf	1E+3	9E+0	4E-9	–	2E-5	2E-4
			–	Bone surf (2E+1)	–	3E-11	–	–
		W, see ^{170}Hf	–	4E+1	2E-8	–	–	–
			–	Bone surf (6E+1)	–	8E-11	–	–
72	Hafnium-173	D, see ^{170}Hf	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{170}Hf	–	1E+4	5E-6	2E-8	–	–
72	Hafnium-175	D, see ^{170}Hf	3E+3	9E+2	4E-7	–	4E-5	4E-4
			–	Bone surf (1E+3)	–	1E-9	–	–
		W, see ^{170}Hf	–	1E+3	5E-7	2E-9	–	–
72	Hafnium-177m[b/]	D, see ^{170}Hf	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
		W, see ^{170}Hf	–	9E+4	4E-5	1E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
72	Hafnium-178m	D, see ^{170}Hf	3E+2	1E+0	5E-10	–	3E-6	3E-5
			–	Bone surf (2E+0)	–	3E-12	–	–
		W, see ^{170}Hf	–	5E+0	2E-9	–	–	–
			–	Bone surf (9E+0)	–	1E-11	–	–
72	Hafnium-179m	D, see ^{170}Hf	1E+3	3E+2	1E-7	–	1E-5	1E-4
			–	Bone surf (6E+2)	–	8E-10	–	–
		W, see ^{170}Hf	–	6E+2	3E-7	8E-10	–	–
72	Hafnium-180m	D, see ^{170}Hf	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{170}Hf	–	3E+4	1E-5	4E-8	–	–
72	Hafnium-181	D, see ^{170}Hf	1E+3	2E+2	7E-8	–	2E-5	2E-4
			–	Bone surf (4E+2)	–	6E-10	–	–
		W, see ^{170}Hf	–	4E+2	2E-7	6E-10	–	–
72	Hafnium-182m[b/]	D, see ^{170}Hf	4E+4	9E+4	4E-5	1E-7	5E-4	5E-3
		W, see ^{170}Hf	–	1E+5	6E-5	2E-7	–	–
72	Hafnium-182	D, see ^{170}Hf	2E+2 Bone surf (4E+2)	8E-1 Bone surf (2E+0)	3E-10 –	– 2E-12	– 5E-6	– 5E-5
		W, see ^{170}Hf	–	3E+0	1E-9	–	–	–
			–	Bone surf (7E+0)	–	1E-11	–	–
72	Hafnium-183[b/]	D, see ^{170}Hf	2E+4	5E+4	2E-5	6E-8	3E-4	3E-3
		W, see ^{170}Hf	–	6E+4	2E-5	8E-8	–	–
72	Hafnium-184	D, see ^{170}Hf	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		W, see ^{170}Hf	–	6E+3	3E-6	9E-9	–	–
73	Tantalum-172[b/]	W, all compounds except those given for Y	4E+4	1E+5	5E-5	2E-7	5E-4	5E-3
		Y, elemental Ta, oxides, hydroxides, halides, carbides, nitrates, and nitrides	–	1E+5	4E-5	1E-7	–	–
73	Tantalum-173	W, see ^{172}Ta	7E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		Y, see ^{172}Ta	–	2E+4	7E-6	2E-8	–	–
73	Tantalum-174[b/]	W, see ^{172}Ta	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
		Y, see ^{172}Ta	–	9E+4	4E-5	1E-7	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
73	Tantalum-175	W, see ^{172}Ta	6E+3	2E+4	7E-6	2E-8	8E-5	8E-4
		Y, see ^{172}Ta	–	1E+4	6E-6	2E-8	–	–
73	Tantalum-176	W, see ^{172}Ta	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
		Y, see ^{172}Ta	–	1E+4	5E-6	2E-8	–	–
73	Tantalum-177	W, see ^{172}Ta	1E+4	2E+4	8E-6	3E-8	2E-4	2E-3
		Y, see ^{172}Ta	–	2E+4	7E-6	2E-8	–	–
73	Tantalum-178	W, see ^{172}Ta	2E+4	9E+4	4E-5	1E-7	2E-4	2E-3
		Y, see ^{172}Ta	–	7E+4	3E-5	1E-7	–	–
73	Tantalum-179	W, see ^{172}Ta	2E+4	5E+3	2E-6	8E-9	3E-4	3E-3
		Y, see ^{172}Ta	–	9E+2	4E-7	1E-9	–	–
73	Tantalum-180m	W, see ^{172}Ta	2E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		Y, see ^{172}Ta	–	6E+4	2E-5	8E-8	–	–
73	Tantalum-180	W, see ^{172}Ta	1E+3	4E+2	2E-7	6E-10	2E-5	2E-4
		Y, see ^{172}Ta	–	2E+1	1E-8	3E-11	–	–
73	Tantalum-182m[b/]	W, see ^{172}Ta	2E+5	5E+5	2E-4	8E-7	–	–
			St wall (2E+5)	–	–	–	3E-3	3E-2
		Y, see ^{172}Ta	–	4E+5	2E-4	6E-7	–	–
73	Tantalum-182	W, see ^{172}Ta	8E+2	3E+2	1E-7	5E-10	1E-5	1E-4
		Y, see ^{172}Ta	–	1E+2	6E-8	2E-10	–	–
73	Tantalum-183	W, see ^{172}Ta	9E+2	1E+3	5E-7	2E-9	–	–
			LLI wall (1E+3)	–	–	–	2E-5	2E-4
		Y, see ^{172}Ta	–	1E+3	4E-7	1E-9	–	–
73	Tantalum-184	W, see ^{172}Ta	2E+3	5E+3	2E-6	8E-9	3E-5	3E-4
		Y, see ^{172}Ta	–	5E+3	2E-6	7E-9	–	–
73	Tantalum-185[b/]	W, see ^{172}Ta	3E+4	7E+4	3E-5	1E-7	4E-4	4E-3
		Y, see ^{172}Ta	–	6E+4	3E-5	9E-8	–	–
73	Tantalum-186[b/]	W, see ^{172}Ta	5E+4	2E+5	1E-4	3E-7	–	–
			St wall (7E+4)	–	–	–	1E-3	1E-2
		Y, see ^{172}Ta	–	2E+5	9E-5	3E-7	–	–
74	Tungsten-176	D, all compounds	1E+4	5E+4	2E-5	7E-8	1E-4	1E-3
74	Tungsten-177	D, all compounds	2E+4	9E+4	4E-5	1E-7	3E-4	3E-3
74	Tungsten-178	D, all compounds	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
74	Tungsten-179[b/]	D, all compounds	5E+5	2E+6	7E-4	2E-6	7E-3	7E-2
74	Tungsten-181	D, all compounds	2E+4	3E+4	1E-5	5E-8	2E-4	2E-3
74	Tungsten-185	D, all compounds	2E+3	7E+3	3E-6	9E-9	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
74	Tungsten-187	D, all compounds	2E+3	9E+3	4E-6	1E-8	3E-5	3E-4
74	Tungsten-188	D, all compounds	4E+2	1E+3	5E-7	2E-9	–	–
			LLI wall (5E+2)	–	–	–	7E-6	7E-5
75	Rhenium-177[b/]	D, all compounds except those given for W	9E+4	3E+5	1E-4	4E-7	–	–
			St wall (1E+5)	–	–	–	2E-3	2E-2
		W, oxides, hydroxides, and nitrates	–	4E+5	1E-4	5E-7	–	–
75	Rhenium-178[b/]	D, see ^{177}Re	7E+4	3E+5	1E-4	4E-7	–	–
			St wall (1E+5)	–	–	–	1E-3	1E-2
		W, see ^{177}Re	–	3E+5	1E-4	4E-7	–	–
75	Rhenium-181	D, see ^{177}Re	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
		W, see ^{177}Re	–	9E+3	4E-6	1E-8	–	–
75	Rhenium-182 (12.7 h)	D, see ^{177}Re	7E+3	1E+4	5E-6	2E-8	9E-5	9E-4
		W, see ^{177}Re	–	2E+4	6E-6	2E-8	–	–
75	Rhenium-182 (64.0 h)	D, see ^{177}Re	1E+3	2E+3	1E-6	3E-9	2E-5	2E-4
		W, see ^{177}Re	–	2E+3	9E-7	3E-9	–	–
75	Rhenium-184m	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{177}Re	–	4E+2	2E-7	6E-10	–	–
75	Rhenium-184	D, see ^{177}Re	2E+3	4E+3	1E-6	5E-9	3E-5	3E-4
		W, see ^{177}Re	–	1E+3	6E-7	2E-9	–	–
75	Rhenium-186m	D, see ^{177}Re	1E+3	2E+3	7E-7	–	–	–
			St wall (2E+3)	St wall (2E+3)	–	3E-9	2E-5	2E-4
		W, see ^{177}Re	–	2E+2	6E-8	2E-10	–	–
75	Rhenium-186	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{177}Re	–	2E+3	7E-7	2E-9	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
75	Rhenium-187	D, see ^{177}Re	6E+5	8E+5	4E-4	–	8E-3	8E-2
			–	St wall (9E+5)	–	1E-6	–	–
		W, see ^{177}Re	–	1E+5	4E-5	1E-7	–	–
75	Rhenium-188m[b/]	D, see ^{177}Re	8E+4	1E+5	6E-5	2E-7	1E-3	1E-2
		W, see ^{177}Re	–	1E+5	6E-5	2E-7	–	–
75	Rhenium-188	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		W, see ^{177}Re	–	3E+3	1E-6	4E-9	–	–
75	Rhenium-189	D, see ^{177}Re	3E+3	5E+3	2E-6	7E-9	4E-5	4E-4
		W, see ^{177}Re	–	4E+3	2E-6	6E-9	–	–
76	Osmium-180[b/]	D, all compounds except those given for W and Y	1E+5	4E+5	2E-4	5E-7	1E-3	1E-2
		W, halides and nitrates	–	5E+5	2E-4	7E-7	–	–
		Y, oxides and hydroxides	–	5E+5	2E-4	6E-7	–	–
76	Osmium-181[b/]	D, see ^{180}Os	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{180}Os	–	5E+4	2E-5	6E-8	–	–
		Y, see ^{180}Os	–	4E+4	2E-5	6E-8	–	–
76	Osmium-182	D, see ^{180}Os	2E+3	6E+3	2E-6	8E-9	3E-5	3E-4
		W, see ^{180}Os	–	4E+3	2E-6	6E-9	–	–
		Y, see ^{180}Os	–	4E+3	2E-6	6E-9	–	–
76	Osmium-185	D, see ^{180}Os	2E+3	5E+2	2E-7	7E-10	3E-5	3E-4
		W, see ^{180}Os	–	8E+2	3E-7	1E-9	–	–
		Y, see ^{180}Os	–	8E+2	3E-7	1E-9	–	–
76	Osmium-189m	D, see ^{180}Os	8E+4	2E+5	1E-4	3E-7	1E-3	1E-2
		W, see ^{180}Os	–	2E+5	9E-5	3E-7	–	–
		Y, see ^{180}Os	–	2E+5	7E-5	2E-7	–	–
76	Osmium-191m	D, see ^{180}Os	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{180}Os	–	2E+4	8E-6	3E-8	–	–
		Y, see ^{180}Os	–	2E+4	7E-6	2E-8	–	–
76	Osmium-191	D, see ^{180}Os	2E+3	2E+3	9E-7	3E-9	–	–
			LLI wall (3E+3)	–	–	–	3E-5	3E-4
		W, see ^{180}Os	–	2E+3	7E-7	2E-9	–	–
		Y, see ^{180}Os	–	1E+3	6E-7	2E-9	–	–
76	Osmium-193	D, see ^{180}Os	2E+3	5E+3	2E-6	6E-9	–	–
			LLI wall (2E+3)	–	–	–	2E-5	2E-4
		W, see ^{180}Os	–	3E+3	1E-6	4E-9	–	–
		Y, see ^{180}Os	–	3E+3	1E-6	4E-9	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
76	Osmium-194	D, see ^{180}Os	4E+2	4E+1	2E-8	6E-11	–	–
			LLI wall (6E+2)	–	–	–	8E-6	8E-5
		W, see ^{180}Os	–	6E+1	2E-8	8E-11	–	–
		Y, see ^{180}Os	–	8E+0	3E-9	1E-11	–	–
77	Iridium-182[b/]	D, all compounds except those given for W and Y	4E+4	1E+5	6E-5	2E-7	–	–
			St wall (4E+4)	–	–	–	6E-4	6E-3
		W, halides, nitrates, and metallic iridium	–	2E+5	6E-5	2E-7	–	–
		Y, oxides and hydroxides	–	1E+5	5E-5	2E-7	–	–
77	Iridium-184	D, see ^{182}Ir	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{182}Ir	–	3E+4	1E-5	5E-8	–	–
		Y, see ^{182}Ir	–	3E+4	1E-5	4E-8	–	–
77	Iridium-185	D, see ^{182}Ir	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{182}Ir	–	1E+4	5E-6	2E-8	–	–
		Y, see ^{182}Ir	–	1E+4	4E-6	1E-8	–	–
77	Iridium-186	D, see ^{182}Ir	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		W, see ^{182}Ir	–	6E+3	3E-6	9E-9	–	–
		Y, see ^{182}Ir	–	6E+3	2E-6	8E-9	–	–
77	Iridium-187	D, see ^{182}Ir	1E+4	3E+4	1E-5	5E-8	1E-4	1E-3
		W, see ^{182}Ir	–	3E+4	1E-5	4E-8	–	–
		Y, see ^{182}Ir	–	3E+4	1E-5	4E-8	–	–
77	Iridium-188	D, see ^{182}Ir	2E+3	5E+3	2E-6	6E-9	3E-5	3E-4
		W, see ^{182}Ir	–	4E+3	1E-6	5E-9	–	–
		Y, see ^{182}Ir	–	3E+3	1E-6	5E-9	–	–
77	Iridium-189	D, see ^{182}Ir	5E+3	5E+3	2E-6	7E-9	–	–
			LLI wall (5E+3)	–	–	–	7E-5	7E-4
		W, see ^{182}Ir	–	4E+3	2E-6	5E-9	–	–
		Y, see ^{182}Ir	–	4E+3	1E-6	5E-9	–	–
77	Iridium-190m[b/]	D, see ^{182}Ir	2E+5	2E+5	8E-5	3E-7	2E-3	2E-2
		W, see ^{182}Ir	–	2E+5	9E-5	3E-7	–	–
		Y, see ^{182}Ir	–	2E+5	8E-5	3E-7	–	–
77	Iridium-190	D, see ^{182}Ir	1E+3	9E+2	4E-7	1E-9	1E-5	1E-4
		W, see ^{182}Ir	–	1E+3	4E-7	1E-9	–	–
		Y, see ^{182}Ir	–	9E+2	4E-7	1E-9	–	–
77	Iridium-192m	D, see ^{182}Ir	3E+3	9E+1	4E-8	1E-10	4E-5	4E-4
		W, see ^{182}Ir	–	2E+2	9E-8	3E-10	–	–
		Y, see ^{182}Ir	–	2E+1	6E-9	2E-11	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
77	Iridium-192	D, see ^{182}Ir	9E+2	3E+2	1E-7	4E-10	1E-5	1E-4
		W, see ^{182}Ir	–	4E+2	2E-7	6E-10	–	–
		Y, see ^{182}Ir	–	2E+2	9E-8	3E-10	–	–
77	Iridium-194m	D, see ^{182}Ir	6E+2	9E+1	4E-8	1E-10	9E-6	9E-5
		W, see ^{182}Ir	–	2E+2	7E-8	2E-10	–	–
		Y, see ^{182}Ir	–	1E+2	4E-8	1E-10	–	–
77	Iridium-194	D, see ^{182}Ir	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		W, see ^{182}Ir	–	2E+3	9E-7	3E-9	–	–
		Y, see ^{182}Ir	–	2E+3	8E-7	3E-9	–	–
77	Iridium-195m	D, see ^{182}Ir	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{182}Ir	–	3E+4	1E-5	4E-8	–	–
		Y, see ^{182}Ir	–	2E+4	9E-6	3E-8	–	–
77	Iridium-195	D, see ^{182}Ir	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{182}Ir	–	5E+4	2E-5	7E-8	–	–
		Y, see ^{182}Ir	–	4E+4	2E-5	6E-8	–	–
78	Platinum-186	D, all compounds	1E+4	4E+4	2E-5	5E-8	2E-4	2E-3
78	Platinum-188	D, all compounds	2E+3	2E+3	7E-7	2E-9	2E-5	2E-4
78	Platinum-189	D, all compounds	1E+4	3E+4	1E-5	4E-8	1E-4	1E-3
78	Platinum-191	D, all compounds	4E+3	8E+3	4E-6	1E-8	5E-5	5E-4
78	Platinum-193m	D, all compounds	3E+3	6E+3	3E-6	8E-9	–	–
			LLI wall (3E+4)	–	–	–	4E-5	4E-4
78	Platinum-193	D, all compounds	4E+4	2E+4	1E-5	3E-8	–	–
			LLI wall (5E+4)	–	–	–	6E-4	6E-3
78	Platinum-195m	D, all compounds	2E+3	4E+3	2E-6	6E-9	–	–
			LLI wall (2E+3)	–	–	–	3E-5	3E-4
78	Platinum-197m[b/]	D, all compounds	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
78	Platinum-197	D, all compounds	3E+3	1E+4	4E-6	1E-8	4E-5	4E-4
78	Platinum-199[b/]	D, all compounds	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
78	Platinum-200	D, all compounds	1E+3	3E+3	1E-6	5E-9	2E-5	2E-4

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
79	Gold-193	D, all compounds except those given for W and Y	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, halides and nitrates	–	2E+4	9E-6	3E-8	–	–
		Y, oxides and hydroxides	–	2E+4	8E-6	3E-8	–	–
79	Gold-194	D, see ^{193}Au	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{193}Au	–	5E+3	2E-6	8E-9	–	–
		Y, see ^{193}Au	–	5E+3	2E-6	7E-9	–	–
79	Gold-195	D, see ^{193}Au	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{193}Au	–	1E+3	6E-7	2E-9	–	–
		Y, see ^{193}Au	–	4E+2	2E-7	6E-10	–	–
79	Gold-198m	D, see ^{193}Au	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		W, see ^{193}Au	–	1E+3	5E-7	2E-9	–	–
		Y, see ^{193}Au	–	1E+3	5E-7	2E-9	–	–
79	Gold-198	D, see ^{193}Au	1E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		W, see ^{193}Au	–	2E+3	8E-7	3E-9	–	–
		Y, see ^{193}Au	–	2E+3	7E-7	2E-9	–	–
79	Gold-199	D, see ^{193}Au	3E+3	9E+3	4E-6	1E-8	–	–
			LLI wall (3E+3)	–	–	–	4E-5	4E-4
		W, see ^{193}Au	–	4E+3	2E-6	6E-9	–	–
		Y, see ^{193}Au	–	4E+3	2E-6	5E-9	–	–
79	Gold-200m	D, see ^{193}Au	1E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{193}Au	–	3E+3	1E-6	4E-9	–	–
		Y, see ^{193}Au	–	2E+4	1E-6	3E-9	–	–
79	Gold-200[b/]	D, see ^{193}Au	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
		W, see ^{193}Au	–	8E+4	3E-5	1E-7	–	–
		Y, see ^{193}Au	–	7E+4	3E-5	1E-7	–	–
79	Gold-201[b/]	D, see ^{193}Au	7E+4	2E+5	9E-5	3E-7	–	–
			St wall (9E+4)	–	–	–	1E-3	1E-2
		W, see ^{193}Au	–	2E+5	1E-4	3E-7	–	–
		Y, see ^{193}Au	–	2E+5	9E-5	3E-7	–	–
80	Mercury-193m	Vapor	–	8E+3	4E-6	1E-8	–	–
		Organic D	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		D, sulfates	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		W, oxides, hydroxides, halides, nitrates, and sulfides	–	8E+3	3E-6	1E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
80	Mercury-193	Vapor	–	3E+4	1E-5	4E-8	–	–
		Organic D	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		D, see ^{193m}Hg	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{193m}Hg	–	4E+4	2E-5	6E-8	–	–
80	Mercury-194	Vapor	–	3E+1	1E-8	4E-11	–	–
		Organic D	2E+1	3E+1	1E-8	4E-11	2E-7	2E-6
		D, see ^{193m}Hg	8E+2	4E+1	2E-8	6E-11	1E-5	1E-4
		W, see ^{193m}Hg	–	1E+2	5E-8	2E-10	–	–
80	Mercury-195m	Vapor	–	4E+3	2E-6	6E-9	–	–
		Organic D	3E+3	6E+3	3E-6	8E-9	4E-5	4E-4
		D, see ^{193m}Hg	2E+3	5E+3	2E-6	7E-9	3E-5	3E-4
		W, see ^{193m}Hg	–	4E+3	2E-6	5E-9	–	–
80	Mercury-195	Vapor	–	3E+4	1E-5	4E-8	–	–
		Organic D	2E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		D, see ^{193m}Hg	1E+4	4E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{193m}Hg	–	3E+4	1E-5	5E-8	–	–
80	Mercury-197m	Vapor	–	5E+3	2E-6	7E-9	–	–
		Organic D	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
		D, see ^{193m}Hg	3E+3	7E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{193m}Hg	–	5E+3	2E-6	7E-9	–	–
80	Mercury-197	Vapor	–	8E+3	4E-6	1E-8	–	–
		Organic D	7E+3	1E+4	6E-6	2E-8	9E-5	9E-4
		D, see ^{193m}Hg	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, see ^{193m}Hg	–	9E+3	4E-6	1E-8	–	–
80	Mercury-199m[b/]	Vapor	–	8E+4	3E-5	1E-7	–	–
		Organic D	6E+4	2E+5	7E-5	2E-7	–	–
			St wall (1E+5)	–	–	–	1E-3	1E-2
		D, see ^{193m}Hg	6E+4	1E+5	6E-5	2E-7	8E-4	8E-3
		W, see ^{193m}Hg	–	2E+5	7E-5	2E-7	–	–
80	Mercury-203	Vapor	–	8E+2	4E-7	1E-9	–	–
		Organic D	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
		D, see ^{193m}Hg	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
		W, see ^{193m}Hg	–	1E+3	5E-7	2E-9	–	–
81	Thallium-194m[b/]	D, all compounds	5E+4	2E+5	6E-5	2E-7	–	–
			St wall (7E+4)	–	–	–	1E-3	1E-2
81	Thallium-194[b/]	D, all compounds	3E+5	6E+5	2E-4	8E-7	–	–
			St wall (3E+5)	–	–	–	4E-3	4E-2
81	Thallium-195[b/]	D, all compounds	6E+4	1E+5	5E-5	2E-7	9E-4	9E-3

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
81	Thallium-197	D, all compounds	7E+4	1E+5	5E-5	2E-7	1E-3	1E-2
81	Thallium-198m[b/]	D, all compounds	3E+4	5E+4	2E-5	8E-8	4E-4	4E-3
81	Thallium-198	D, all compounds	2E+4	3E+4	1E-5	5E-8	3E-4	3E-3
81	Thallium-199	D, all compounds	6E+4	8E+4	4E-5	1E-7	9E-4	9E-3
81	Thallium-200	D, all compounds	8E+3	1E+4	5E-6	2E-8	1E-4	1E-3
81	Thallium-201	D, all compounds	2E+4	2E+4	9E-6	3E-8	2E-4	2E-3
81	Thallium-202	D, all compounds	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
81	Thallium-204	D, all compounds	2E+3	2E+3	9E-7	3E-9	2E-5	2E-4
82	Lead-195m[b/]	D, all compounds	6E+4	2E+5	8E-5	3E-7	8E-4	8E-3
82	Lead-198	D, all compounds	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
82	Lead-199[b/]	D, all compounds	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
82	Lead-200	D, all compounds	3E+3	6E+3	3E-6	9E-9	4E-5	4E-4
82	Lead-201	D, all compounds	7E+3	2E+4	8E-6	3E-8	1E-4	1E-3
82	Lead-202m	D, all compounds	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
82	Lead-202	D, all compounds	1E+2	5E+1	2E-8	7E-11	2E-6	2E-5
82	Lead-203	D, all compounds	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
82	Lead-205	D, all compounds	4E+3	1E+3	6E-7	2E-9	5E-5	5E-4
82	Lead-209	D, all compounds	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
82	Lead-210	D, all compounds	6E-1 Bone surf (1E+0)	2E-1 Bone surf (4E-1)	1E-10 –	– 6E-13	– 1E-8	– 1E-7
82	Lead-211[b/]	D, all compounds	1E+4	6E+2	3E-7	9E-10	2E-4	2E-3
82	Lead-212	D, all compounds	8E+1 Bone surf (1E+2)	3E+1 –	1E-8 –	5E-11 –	– 2E-6	– 2E-5
82	Lead-214[b/]	D, all compounds	9E+3	8E+2	3E-7	1E-9	1E-4	1E-3
83	Bismuth-200[b/]	D, nitrates W, all other compounds	3E+4 –	8E+4 1E+5	4E-5 4E-5	1E-7 1E-7	4E-4 –	4E-3 –

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
83	Bismuth-201[b/]	D, see ^{200}Bi	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{200}Bi	–	4E+4	2E-5	5E-8	–	–
83	Bismuth-202[b/]	D, see ^{200}Bi	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{200}Bi	–	8E+4	3E-5	1E-7	–	–
83	Bismuth-203	D, see ^{200}Bi	2E+3	7E+3	3E-6	9E-9	3E-5	3E-4
		W, see ^{200}Bi	–	6E+3	3E-6	9E-9	–	–
83	Bismuth-205	D, see ^{200}Bi	1E+3	3E+3	1E-6	3E-9	2E-5	2E-4
		W, see ^{200}Bi	–	1E+3	5E-7	2E-9	–	–
83	Bismuth-206	D, see ^{200}Bi	6E+2	1E+3	6E-7	2E-9	9E-6	9E-5
		W, see ^{200}Bi	–	9E+2	4E-7	1E-9	–	–
83	Bismuth-207	D, see ^{200}Bi	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
		W, see ^{200}Bi	–	4E+2	1E-7	5E-10	–	–
83	Bismuth-210m	D, see ^{200}Bi	4E+1 Kidneys	5E+0 Kidneys	2E-9	–	–	–
			(6E+1)	(6E+0)	–	9E-12	8E-7	8E-6
		W, see ^{200}Bi	–	7E-1	3E-10	9E-13	–	–
83	Bismuth-210	D, see ^{200}Bi	8E+2	2E+2	1E-7	–	1E-5	1E-4
			–	Kidneys				
			–	(4E+2)	–	5E-10	–	–
		W, see ^{200}Bi	–	3E+1	1E-8	4E-11	–	–
83	Bismuth-212[b/]	D, see ^{200}Bi	5E+3	2E+2	1E-7	3E-10	7E-5	7E-4
		W, see ^{200}Bi	–	3E+2	1E-7	4E-10	–	–
83	Bismuth-213[b/]	D, see ^{200}Bi	7E+3	3E+2	1E-7	4E-10	1E-4	1E-3
		W, see ^{200}Bi	–	4E+2	1E-7	5E-10	–	–
83	Bismuth-214[b/]	D, see ^{200}Bi	2E+4	8E+2	3E-7	1E-9	–	–
			St wall					
			(2E+4)	–	–	–	3E-4	3E-3
		W, see ^{200}Bi	–	9E-2	4E-7	1E-9	–	–
84	Polonium-203[b/]	D, all compounds except those given for W	3E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		W, oxides, hydroxides, and nitrates	–	9E+4	4E-5	1E-7	–	–
84	Polonium-205[b/]	D, see ^{203}Po	2E+4	4E+4	2E-5	5E-8	3E-4	3E-3
		W, see ^{203}Po	–	7E+4	3E-5	1E-7	–	–
84	Polonium-207	D, see ^{203}Po	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{203}Po	–	3E+4	1E-5	4E-8	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
84	Polonium-210	D, see ^{203}Po	3E+0	6E-1	3E-10	9E-13	4E-8	4E-7
		W, see ^{203}Po	–	6E-1	3E-10	9E-13	–	–
85	Astatine-207[b/]	D, halides	6E+3	3E+3	1E-6	4E-9	8E-5	8E-4
		W	–	2E+3	9E-7	3E-9	–	–
85	Astatine-211	D, halides	1E+2	8E+1	3E-8	1E-10	2E-6	2E-5
		W	–	5E+1	2E-8	8E-11	–	–
86	Radon-220	With daughters removed	–	2E+4	7E-6	2E-8	–	–
		With daughters present	–	2E+1 (or 12 WLM)	9E-9 (or 1.0 WL)	3E-11	–	–
86	Radon-222	With daughters removed	–	1E+4	4E-6	1E-8	–	–
		With daughters present	–	1E+2 (or 4 WLM)	3E-8 (or 0.33 WL)	1E-10	–	–
87	Francium-222[b/]	D, all compounds	2E+3	5E+2	2E-7	6E-10	3E-5	3E-4
87	Francium-223[b/]	D, all compounds	6E+2	8E+2	3E-7	1E-9	8E-6	8E-5
88	Radium-223	W, all compounds	5E+0	7E-1	3E-10	9E-13	–	–
			Bone surf (9E+0)	–	–	–	1E-7	1E-6
88	Radium-224	W, all compounds	8E+0	2E+0	7E-10	2E-12	–	–
			Bone surf (2E+1)	–	–	–	2E-7	2E-6
88	Radium-225	W, all compounds	8E+0	7E-1	3E-10	9E-13	–	–
			Bone surf (2E+1)	–	–	–	2E-7	2E-6
88	Radium-226	W, all compounds	2E+0	6E-1	3E-10	9E-13	–	–
			Bone surf (5E+0)	–	–	–	6E-8	6E-7
88	Radium-227[b/]	W, all compounds	2E+4	1E+4	6E-6	–	–	–
			Bone surf (2E+4)	Bone surf (2E+4)	–	3E-8	3E-4	3E-3
88	Radium-228	W, all compounds	2E+0	1E+0	5E-10	2E-12	–	–
			Bone surf (4E+0)	–	–	–	6E-8	6E-7

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values: Col. 1 Oral Ingestion ALI (µCi)	Table I Occupational Values: Inhalation Col. 2 ALI (µCi)	Table I Occupational Values: Inhalation Col. 3 DAC (µCi/ml)	Table II Effluent Concentrations: Col. 1 Air (µCi/ml)	Table II Effluent Concentrations: Col. 2 Water (µCi/ml)	Table III Releases to Sewers: Monthly Average Concentration (µCi/ml)
89	Actinium-224	D, all compounds except those given for W and Y	2E+3	3E+1	1E-8	–	–	–
			LLI wall (2E+3)	Bone surf (4E+1)	–	5E-11	3E-5	3E-4
		W, halides and nitrates	–	5E+1	2E-8	7E-11	–	–
		Y, oxides and hydroxides	–	5E+1	2E-8	6E-11	–	–
89	Actinium-225	D, see ^{224}Ac	5E+1	3E-1	1E-10	–	–	–
			LLI wall (5E+1)	Bone surf (5E-1)	-	7E-13	7E-7	7E-6
		W, see ^{224}Ac	–	6E-1	3E-10	9E-13	–	–
		Y, see ^{224}Ac	–	6E-1	3E-10	9E-13	–	–
89	Actinium-226	D, see ^{224}Ac	1E+2	3E+0	1E-9	–	–	–
			LLI wall (1E+2)	Bone surf (4E+0)	–	5E-12	2E-6	2E-5
		W, see ^{224}Ac	–	5E+0	2E-9	7E-12	–	–
		Y, see ^{224}Ac	–	5E+0	2E-9	6E-12	–	–
89	Actinium-227	D, see ^{224}Ac	2E-1	4E-4	2E-13	–	–	–
			Bone surf (4E-1)	Bone surf (8E-4)	–	1E-15	5E-9	5E-8
		W, see ^{224}Ac	–	2E-3	7E-13	–	–	–
			–	Bone surf (3E-3)	–	4E-15	–	–
		Y, see ^{224}Ac	–	4E-3	2E-12	6E-15	–	–
89	Actinium-228	D, see ^{224}Ac	2E+3	9E+0	4E-9	–	3E-5	3E-4
			–	Bone surf (2E+1)	–	2E-11	–	–
		W, see ^{224}Ac	–	4E+1	2E-8	–	–	–
			–	Bone surf (6E+1)	–	8E-11	–	–
		Y, see ^{224}Ac	–	4E+1	2E-8	6E-11	–	–
90	Thorium-226[b/]	W, all compounds except those given for Y	5E+3	2E+2	6E-8	2E-10	–	–
			St wall (5E+3)	–	–	–	7E-5	7E-4
		Y, oxides and hydroxides	–	1E+2	6E-8	2E-10	–	–
90	Thorium-227	W, see ^{226}Th	1E+2	3E-1	1E-10	5E-13	2E-6	2E-5
		Y, see ^{226}Th	–	3E-1	1E-10	5E-13	–	–
90	Thorium-228	W, see ^{226}Th	6E+0	1E-2	4E-12	–	–	–
			Bone surf (1E+1)	Bone surf (2E-2)	–	3E-14	2E-7	2E-6
		Y, see ^{226}Th	–	2E-2	7E-12	2E-14	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
90	Thorium-229	W, see ^{226}Th	6E-1 Bone surf	9E-4 Bone surf	4E-13	–	–	–
			(1E+0)	(2E-3)	–	3E-15	2E-8	2E-7
		Y, see ^{226}Th	–	2E-3 Bone surf	1E-12	–	–	–
			–	(3E-3)	–	4E-15	–	–
90	Thorium-230	W, see ^{226}Th	4E+0 Bone surf	6E-3 Bone surf	3E-12	–	–	–
			(9E+0)	(2E-2)	–	2E-14	1E-7	1E-6
		Y, see ^{226}Th	–	2E-2 Bone surf	6E-12	–	–	–
			–	(2E-2)	–	3E-14	–	–
90	Thorium-231	W, see ^{226}Th	4E+3	6E+3	3E-6	9E-9	5E-5	5E-4
		Y, see ^{226}Th	–	6E+3	3E-6	9E-9	–	–
90	Thorium-232	W, see ^{226}Th	7E-1 Bone surf	1E-3 Bone surf	5E-13	–	–	–
			(2E+0)	(3E-3)	–	4E-15	3E-8	3E-7
		Y, see ^{226}Th	–	3E-3 Bone sur	1E-12	–	–	–
			–	(4E-3)	–	6E-15	–	–
90	Thorium-234	W, see ^{226}Th	3E+2 LLI wall	2E+2	8E-8	3E-10	–	–
			(4E+2)	–	–	–	5E-6	5E-5
		Y, see ^{226}Th	–	2E+2	6E-8	2E-10	–	–
91	Protactinium-227[b/]	W, all compounds except those given for Y	4E+3	1E+2	5E-8	2E-10	5E-5	5E-4
		Y, oxides and hydroxides	–	1E+2	4E-8	1E-10	–	–
91	Protactinium-228	W, see ^{227}Pa	1E+3	1E+1 Bone surf	5E-9	–	2E-5	2E-4
			–	(2E+1)	–	3E-11	–	–
		Y, see ^{227}Pa	–	1E+1	5E-9	2E-11	–	–
91	Protactinium-230	W, see ^{227}Pa	6E+2 Bone surf	5E+0	2E-9	7E-12	–	–
			(9E+2)	–	–	–	1E-5	1E-4
		Y, see ^{227}Pa	–	4E+0	1E-9	5E-12	–	–
91	Protactinium-231	W, see ^{227}Pa	2E-1 Bone surf	2E-3 Bone surf	6E-13	–	–	–
			(5E-1)	(4E-3)	–	6E-15	6E-9	6E-8
		Y, see ^{227}Pa	–	4E-3 Bone surf	2E-12	–	–	–
			–	(6E-3)	–	8E-15	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
91	Protactinium-232	W, see ^{227}Pa	1E+3	2E+1	9E-9	–	2E-5	2E-4
			–	Bone surf (6E+1)	–	8E-11	–	–
		Y, see ^{227}Pa	–	6E+1	2E-8	–	–	–
			–	Bone surf (7E+1)	–	1E-10	–	–
91	Protactinium-233	W, see ^{227}Pa	1E+3	7E+2	3E-7	1E-9	–	–
			LLI wall (2E+3)	–	–	–	2E-5	2E-4
		Y, see ^{227}Pa	–	6E+2	2E-7	8E-10	–	–
91	Protactinium-234	W, see ^{227}Pa	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		Y, see ^{227}Pa	–	7E+3	3E-6	9E-9	–	–
92	Uranium-230	D, UF_6, UO_2F_2, UO_2,$(NO_3)_2$	4E+0 Bone surf (6E+0)	4E-1 Bone surf (6E-1)	2E-10 –	–	–	–
						8E-13	8E-8	8E-7
		W, UO_3, UF_4, UCl_4	–	4E-1	1E-10	5E-13	–	–
		Y, UO_2, U_3O_8	–	3E-1	1E-10	4E-13	–	–
92	Uranium-231	D, see ^{230}U	5E+3	8E+3	3E-6	1E-8	–	–
			LLI wall (4E+3)	–	–	–	6E-5	6E-4
		W, see ^{230}U	–	6E+3	2E-6	8E-9	–	–
		Y, see ^{230}U	–	5E+3	2E-6	6E-9	–	–
92	Uranium-232	D, see ^{230}U	2E+0 Bone surf (4E+0)	2E-1 Bone surf (4E-1)	9E-11 –	–	–	–
						6E-13	6E-8	6E-7
		W, see ^{230}U	–	4E-1	2E-10	5E-13	–	–
		Y, see ^{230}U	–	8E-3	3E-12	1E-14	–	–
92	Uranium-233	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 –	–	–	–
						3E-12	3E-7	3E-6
		W, see ^{230}U	–	7E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	5E-14	–	–
92	Uranium-234[e/]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10 –	–	–	–
						3E-12	3E-7	3E-6
		W, see ^{230}U	–	7E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	5E-14	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
92	Uranium-235[c/]	D, see ^{230}U	1E+1	1E+0	6E-10	–	–	–
			Bone surf (2E+1)	Bone surf (2E+0)	–	3E-12	3E-7	3E-6
		W, see ^{230}U	–	8E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	6E-14	–	–
92	Uranium-236	D, see ^{230}U	1E+1	1E+0	5E-10	–	–	–
			Bone surf (2E+1)	Bone surf (2E+0)	–	3E-12	3E-7	3E-6
		W, see ^{230}U	–	8E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	6E-14	–	–
92	Uranium-237	D, see ^{230}U	2E+3	3E+3	1E-6	4E-9	–	–
			LLI wall (2E+3)	–	–	-	3E-5	3E-4
		W, see ^{230}U	–	2E+3	7E-7	2E-9	–	–
		Y, see ^{230}U	–	2E+3	6E-7	2E-9	–	–
92	Uranium-238[c/]	D, see ^{230}U	1E+1	1E+0	6E-10	–	–	–
			Bone surf (2E+1)	Bone surf (2E+0)	–	3E-12	3E-7	3E-6
		W, see ^{230}U	–	8E-1	3E-10	1E-12	–	–
		Y, see ^{230}U	–	4E-2	2E-11	6E-14	–	–
92	Uranium-239[b/]	D, see ^{230}U	7E+4	2E+5	8E-5	3E-7	9E-4	9E-3
		W, see ^{230}U	–	2E+5	7E-5	2E-7	–	–
		Y, see ^{230}U	–	2E+5	6E-5	2E-7	–	–
92	Uranium-240	D, see ^{230}U	1E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		W, see ^{230}U	–	3E+3	1E-6	4E-9	–	–
		Y, see ^{230}U	–	2E+3	1E-6	3E-9	–	–
92	Uranium-natural[c/]	D, see ^{230}U	1E+1	1E+0	5E-10	–	–	–
			Bone surf (2E+1)	Bone surf (2E+0)	–	3E-12	3E-7	3E-6
		W, see ^{230}U	–	8E-1	3E-10	9E-13	–	–
		Y, see ^{230}U	–	5E-2	2E-11	9E-14	–	–
93	Neptunium-232[b/]	W, all compounds	1E+5	2E+3	7E-7	–	2E-3	2E-2
			–	Bone surf (5E+2)	–	6E-9	–	–
93	Neptunium-233[b/]	W, all compounds	8E+5	3E+6	1E-3	4E-6	1E-2	1E-1
93	Neptunium-234	W, all compounds	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
93	Neptunium-235	W, all compounds	2E+4	8E+2	3E-7	–	–	–
			LLI wall (2E+4)	Bone surf (1E+3)	–	2E-9	3E-4	3E-3

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
93	Neptunium-236 (1.15E+5 y)	W, all compounds	3E+0	2E-2	9E-12	–	–	–
			Bone surf (6E+0)	Bone surf (5E-2)	–	8E-14	9E-8	9E-7
93	Neptunium-236 (22.5 h)	W, all compounds	3E+3	3E+1	1E-8	–	–	–
			Bone surf (4E+3)	Bone surf (7E+1)	–	1E-10	5E-5	5E-4
93	Neptunium-237	W, all compounds	5E-1	4E-3	2E-12	–	–	–
			Bone surf (1E+0)	Bone surf (1E-2)	–	1E-14	2E-8	2E-7
93	Neptunium-238	W, all compounds	1E+3	6E+1	3E-8	–	2E-5	2E-4
			–	Bone surf (2E+2)	–	2E-10	–	–
93	Neptunium-239	W, all compounds	2E+3	2E+3	9E-7	3E-9	–	–
			LLI wall (2E+3)	–	–	–	2E-5	2E-4
93	Neptunium-240[b/]	W, all compounds	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
94	Plutonium-234	W, all compounds except PuO_2	8E+3	2E+2	9E-8	3E-10	1E-4	1E-3
		Y, PuO_2	–	2E+2	8E-8	3E-10	–	–
94	Plutonium-235[b/]	W, see ^{234}Pu	9E+5	3E+6	1E-3	4E-6	1E-2	1E-1
		Y, see ^{234}Pu	–	3E+6	1E-3	3E-6	–	–
94	Plutonium-236	W, see ^{234}Pu	2E+0	2E-2	8E-12	–	–	–
			Bone surf (4E+0)	Bone surf (4E-2)	–	5E-14	6E-8	6E-7
		Y, see ^{234}Pu	–	4E-2	2E-11	6E-14	–	–
94	Plutonium-237	W, see ^{234}Pu	1E+4	3E+3	1E-6	5E-9	2E-4	2E-3
		Y, see ^{234}Pu	–	3E+3	1E-6	4E-9	–	–
94	Plutonium-238	W, see ^{234}Pu	9E-1	7E-3	3E-12	–	–	–
			Bone surf (2E+0)	Bone surf (1E-2)	–	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	–	2E-2	8E-12	2E-14	–	–
94	Plutonium-239	W, see ^{234}Pu	8E-1	6E-3	3E-12	–	–	–
			Bone surf (1E+0)	Bone surf (1E-2)	–	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	–	2E-2	7E-12	–	–	–
			–	Bone surf (2E-2)	–	2E-14	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
94	Plutonium-240	W, see ^{234}Pu	8E-1	6E-3	3E-12	–	–	–
			Bone surf (1E+0)	Bone surf (1E-2)	–	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	–	2E-2	7E-12	–	–	–
			–	Bone surf (2E-2)	–	2E-14	–	–
94	Plutonium-241	W, see ^{234}Pu	4E+1	3E-1	1E-10	–	–	–
			Bone surf (7E+1)	Bone surf (6E-1)	–	8E-13	1E-6	1E-5
		Y, see ^{234}Pu	–	8E-1	3E-10	–	–	–
			–	Bone surf (1E+0)	–	1E-12	–	–
94	Plutonium-242	W, see ^{234}Pu	8E-1	7E-3	3E-12	–	–	–
			Bone surf (1E+0)	Bone surf (1E-2)	–	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	–	2E-2	7E-12	–	–	–
			–	Bone surf (2E-2)	–	2E-14	–	–
94	Plutonium-243	W, see ^{234}Pu	2E+4	4E+4	2E-5	5E-8	2E-4	2E-3
		Y, see ^{234}Pu	–	4E+4	2E-5	5E-8	–	–
94	Plutonium-244	W, see ^{234}Pu	8E-1	7E-3	3E-12	–	–	–
			Bone surf (2E+0)	Bone surf (1E-2)	–	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	–	2E-2	7E-12	–	–	–
			–	Bone surf (2E-2)	–	2E-14	–	–
94	Plutonium-245	W, see ^{234}Pu	2E+3	5E+3	2E-6	6E-9	3E-5	3E-4
		Y, see ^{234}Pu	–	4E+3	2E-6	6E-9	–	–
94	Plutonium-246	W, see ^{234}Pu	4E+2	3E+2	1E-7	4E-10	–	–
			LLI wall (4E+2)	–	–	–	6E-6	6E-5
		Y, see ^{234}Pu	–	3E+2	1E-7	4E-10	–	–
95	Americium-237[b/]	W, all compounds	8E+4	3E+5	1E-4	4E-7	1E-3	1E-2
95	Americium-238[b/]	W, all compounds	4E+4	3E+3	1E-6	–	5E-4	5E-3
			–	Bone surf (6E+3)	–	9E-9	–	–
95	Americium-239	W, all compounds	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
95	Americium-240	W, all compounds	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
95	Americium-241	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
95	Americium-242m	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
95	Americium-242	W, all compounds	4E+3 –	8E+1 Bone surf (9E+1)	4E-8 –	– 1E-10	5E-5 –	5E-4 –
95	Americium-243	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
95	Americium-244m[b/]	W, all compounds	6E+4 St wall (8E+4)	4E+3 Bone surf (7E+3)	2E-6 –	– 1E-8	– 1E-3	– 1E-2
95	Americium-244	W, all compounds	3E+3 –	2E+2 Bone surf (3E+2)	8E-8 –	– 4E-10	4E-5 –	4E-4 –
95	Americium-245	W, all compounds	3E+4	8E+4	3E-5	1E-7	4E-4	4E-3
95	Americium-246m[b/]	W, all compounds	5E+4 St wall (6E+4)	2E+5 –	8E-5 –	3E-7 –	– 8E-4	– 8E-3
95	Americium-246[b/]	W, all compounds	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
96	Curium-238	W, all compounds	2E+4	1E+3	5E-7	2E-9	2E-4	2E-3
96	Curium-240	W, all compounds	6E+1 Bone surf (8E+1)	6E-1 Bone surf (6E-1)	2E-10 –	– 9E-13	– 1E-6	– 1E-5
96	Curium-241	W, all compounds	1E+3 –	3E+1 Bone surf (4E+1)	1E-8 –	– 5E-11	2E-5 –	2E-4 –
96	Curium-242	W, all compounds	3E+1 Bone surf (5E+1)	3E-1 Bone surf (3E-1)	1E-10 –	– 4E-13	– 7E-7	– 7E-6
96	Curium-243	W, all compounds	1E+0 Bone surf (2E+0)	9E-3 Bone surf (2E-2)	4E-12 –	– 2E-14	– 3E-8	– 3E-7

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2	Col. 3	Col. 1	Col. 2	
				Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
96	Curium-244	W, all compounds	1E+0 Bone surf (3E+0)	1E-2 Bone surf (2E-2)	5E-12 –	– 3E-14	– 3E-8	– 3E-7
96	Curium-245	W, all compounds	7E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
96	Curium-246	W, all compounds	7E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
96	Curium-247	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 –	– 2E-14	– 2E-8	– 2E-7
96	Curium-248	W, all compounds	2E-1 Bone surf (4E-1)	2E-3 Bone surf (3E-3)	7E-13 –	– 4E-15	– 5E-9	– 5E-8
96	Curium-249[b/]	W, all compounds	5E+4 –	2E+4 Bone surf (3E+4)	7E-6 –	– 4E-8	7E-4 –	7E-3 –
96	Curium-250	W, all compounds	4E-2 Bone surf (6E-2)	3E-4 Bone surf (5E-4)	1E-13 –	– 8E-16	– 9E-10	– 9E-9
97	Berkelium-245	W, all compounds	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
97	Berkelium-246	W, all compounds	3E+3	3E+3	1E-6	4E-9	4E-5	4E-4
97	Berkelium-247	W, all compounds	5E-1 Bone surf (1E+0)	4E-3 Bone surf (9E-3)	2E-12 –	– 1E-14	– 2E-8	– 2E-7
97	Berkelium-249	W, all compounds	2E+2 Bone surf (5E+2)	2E+0 Bone surf (4E+0)	7E-10 –	– 5E-12	– 6E-6	– 6E-5
97	Berkelium-250	W, all compounds	9E+3 –	3E+2 Bone surf (7E+2)	1E-7 –	– 1E-9	1E-4 –	1E-3 –
98	Californium-244[b/]	W, all compounds except those given for Y	3E+4 St wall (3E+4)	6E+2 –	2E-7 –	8E-10 –	– 4E-4	– 4E-3
		Y, oxides and hydroxides	–	6E+2	2E-7	8E-10	–	–

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3	Col. 1	Col. 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
98	Californium-246	W, see ^{244}Cf	4E+2	9E+0	4E-9	1E-11	5E-6	5E-5
		Y, see ^{244}Cf	–	9E+0	4E-9	1E-11	–	–
98	Californium-248	W, see ^{244}Cf	8E+0 Bone surf (2E+1)	6E-2 Bone surf (1E-1)	3E-11 –	– 2E-13	– 2E-7	– 2E-6
		Y, see ^{244}Cf	–	1E-1	4E-11	1E-13	–	–
98	Californium-249	W, see ^{244}Cf	5E-1 Bone surf (1E+0)	4E-3 Bone surf (9E-3)	2E-12 –	– 1E-14	– 2E-8	– 2E-7
		Y, see ^{244}Cf	– –	1E-2 Bone surf (1E-2)	4E-12 –	– 2E-14	– –	– –
98	Californium-250	W, see ^{244}Cf	1E+0 Bone surf (2E+0)	9E-3 Bone surf (2E-2)	4E-12 –	– 3E-14	– 3E-8	– 3E-7
		Y, see ^{244}Cf	–	3E-2	1E-11	4E-14	–	–
98	Californium-251	W, see ^{244}Cf	5E-1 Bone surf (1E+0)	4E-3 Bone surf (9E-3)	2E-12 –	– 1E-14	– 2E-8	– 2E-7
		Y, see ^{244}Cf	– –	1E-2 Bone surf (1E-2)	4E-12 –	– 2E-14	– –	– –
98	Californium-252	W, see ^{244}Cf	2E+0 Bone surf (5E+0)	2E-2 Bone surf (4E-2)	8E-12 –	– 5E-14	– 7E-8	– 7E-7
		Y, see ^{244}Cf	–	3E-2	1E-11	5E-14	–	–
98	Californium-253	W, see ^{244}Cf	2E+2 Bone surf (4E+2)	2E+0 –	8E-10 –	3E-12 –	– 5E-6	– 5E-5
		Y, see ^{244}Cf	–	2E+0	7E-10	2E-12	–	–
98	Californium-254	W, see ^{244}Cf	2E+0	2E-2	9E-12	3E-14	3E-8	3E-7
		Y, see ^{244}Cf	–	2E-2	7E-12	2E-14	–	–
99	Einsteinium-250	W, all compounds	4E+4 Bone surf –	5E+2 Bone surf (1E+3)	2E-7 –	– 2E-9	6E-4 –	6E-3 –
99	Einsteinium-251	W, all compounds	7E+3 Bone surf –	9E+2 Bone surf (1E+3)	4E-7 –	– 2E-9	1E-4 –	1E-3 –
99	Einsteinium-253	W, all compounds	2E+2	1E+0	6E-10	2E-12	2E-6	2E-5

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (*continued*)

Atomic No.	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col. 2 Inhalation	Col. 3 Inhalation	Col. 1	Col. 2	
			ALI (µCi)	ALI (µCi)	DAC (µCi/ml)	Air (µCi/ml)	Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
99	Einsteinium-254m	W, all compounds	3E+2	1E+1	4E-9	1E-11	–	–
			LLI wall (3E+2)	–	–	–	4E-6	4E-5
99	Einsteinium-254	W, all compounds	8E+0	7E-2	3E-11	–	–	–
			Bone surf (2E+1)	Bone surf (1E-1)	–	2E-13	2E-7	2E-6
100	Fermium-252	W, all compounds	5E+2	1E+1	5E-9	2E-11	6E-6	6E-5
100	Fermium-253	W, all compounds	1E+3	1E+1	4E-9	1E-11	1E-5	1E-4
100	Fermium-254	W, all compounds	3E+3	9E+1	4E-8	1E-10	4E-5	4E-4
100	Fermium-255	W, all compounds	5E+2	2E+1	9E-9	3E-11	7E-6	7E-5
100	Fermium-257	W, all compounds	2E+1	2E-1	7E-11	–	–	–
			Bone surf (4E+1)	Bone surf (2E-1)	–	3E-13	5E-7	5E-6
101	Mendelevium-257	W, all compounds	7E+3	8E+1	4E-8	–	1E-4	1E-3
			–	Bone surf (9E+1)	–	1E-10	–	–
101	Mendelevium-258	W, all compounds	3E+1	2E-1	1E-10	–	–	–
			Bone surf (5E+1)	Bone surf (3E-1)	–	5E-13	6E-7	6E-6
- Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours		Submersion[a/]	–	2E+2	1E-7	1E-9	–	–
- Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours		. . . .	–	2E-1	1E-10	1E-12	1E-8	1E-7
- Any single radionuclide not listed above that decays by alpha emission or spontaneous fission, or any mixture for which either the identity or the concentration of any radionuclide in the mixture is not known		. . . .	–	4E-4	2E-13	1E-15	2E-9	2E-8

Footnotes for Appendix G to Section 3:

[a/] "Submersion" means that values given are for submersion in a hemispherical semi-infinite cloud of airborne material.

[b/] These radionuclides have radiological half-lives of less than 2 hours. The total effective dose equivalent received during operations with these radionuclides might include a significant contribution from external exposure. The DAC values for all radionuclides, other than those designated Class "Submersion," are based upon the committed effective dose equivalent due to the intake of the radionuclide into the body and do NOT include potentially significant contributions to dose equivalent from external exposures. The licensee may substitute 1E-7 μCi/ml for the listed DAC to account for the submersion dose prospectively, but should use individual monitoring devices or other radiation measuring instruments that measure external exposure to demonstrate compliance with the limits. (See RH-1202.)

[c/] For soluble mixtures of U-238, U-234, and U-235 in air, chemical toxicity may be the limiting factor. (See RH-1200.e.) If the percent by weight (enrichment) of U-235 is not greater than 5, the concentration value for a 40-hour workweek is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8E-3 (SA) μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The specific activity for natural uranium is 6.77E-7 curies per gram U. The specific activity for other mixtures of U-238, U-235, and U-234, if not known, shall be:

SA = 3.6E-7 curies/gram U U-depleted

$SA = [0.4 + 0.38 (enrichment) + 0.0034 (enrichment)^2] E-6,$ enrichment ≥ 0.72

where enrichment is the percentage by weight of U-235, expressed as percent.

Note:

1. If the identity of each radionuclide in a mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the DAC for the mixture shall be the most restrictive DAC of any radionuclide in the mixture.

2. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in this appendix are not present in the mixture, the inhalation ALI, DAC, and effluent and sewage concentrations for the mixture are the lowest values specified in this appendix for any radionuclide that is not known to be absent from the mixture; or

Footnotes for Appendix G to Section 3 (Cont'd)

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage

Radionuclide	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
	Col. 1 Oral Ingestion ALI (µCi)	Col. 2 Inhalation ALI (µCi)	Col. 3 Inhalation DAC (µCi/ml)	Col. 1 Air (µCi/ml)	Col. 2 Water (µCi/ml)	Monthly Average Concentration (µCi/ml)
If it is known that Ac-227-D and Cm-250-W are not present	–	7E-4	3E-13	–	–	–
If, in addition, it is known that Ac-227-W,Y, Th-229-W,Y, Th-230-W, Th-232-W,Y, Pa-231-W,Y, Np-237-W, Pu-239-W, Pu-240-W, Pu-242-W, Am-241-W, Am-242m-W, Am-243-W, Cm-245-W, Cm-246-W, Cm-247-W, Cm-248-W, Bk-247-W, Cf-249-W, and Cf-251-W are not present	–	7E-3	3E-12	–	–	–
If, in addition, it is known that Sm-146-W, Sm-147-W, Gd-148-D,W, Gd-152-D,W, Th-228-W,Y, Th-230-Y, U-232-Y, U-233-Y, U-234-Y, U-235-Y, U-236-Y, U-238-Y, Np-236-W, Pu-236-W,Y, Pu-238-W,Y, Pu-239-Y, Pu-240-Y, Pu-242-Y, Pu-244-W,Y, Cm-243-W, Cm-244-W, Cf-248-W, Cf-249-Y, Cf-250-W,Y, Cf-251-Y, Cf-252-W,Y, and Cf-254-W,Y are not present	–	7E-2	3E-11	–	–	–
If, in addition, it is known that Pb-210-D, Bi-210m-W, Po-210-D,W, Ra-223-W, Ra-225-W, Ra-226-W, Ac-225-D,W,Y, Th-227-W,Y, U-230-D,W,Y, U-232-D,W, Pu-241-W, Cm-240-W, Cm-242-W, Cf-248-Y, Es-254-W, Fm-257-W, and Md-258-W are not present	–	7E-1	3E-10	–	–	–
If, in addition, it is known that Si-32-Y, Ti-44-Y, Fe-60-D, Sr-90-Y, Zr-93-D, Cd-113m-D, Cd-113-D, In-115-D,W, La-138-D, Lu-176-W, Hf-178m-D,W, Hf-182-D,W, Bi-210m-D, Ra-224-W, Ra-228-W, Ac-226-D,W,Y, Pa-230-W,Y, U-233-D,W, U-234-D,W, U-235-D,W, U-236-D,W, U-238-D,W, Pu-241-Y, Bk-249-W, Cf-253-W,Y, and Es-253-W are not present	–	7E+0	3E-9	–	–	–
If it is known that Ac-227-D,W,Y, Th-229-W,Y, Th-232-W,Y, Pa-231-W,Y, Cm-248-W, and Cm-250-W are not present	–	–	–	1E-14	–	–
If, in addition, it is known that Sm-146-W, Gd-148-D,W, Gd-152-D, Th-228-W,Y, Th-230-W,Y, U-232-Y, U-233-Y, U-234-Y, U-235-Y, U-236-Y, U-238-Y, U-Nat-Y, Np-236-W, Np-237-W, Pu-236-W,Y, Pu-238-W,Y, Pu-239-W,Y, Pu-240-W,Y, Pu-242-W,Y, Pu-244-W,Y, Am-241-W, Am-242m-W, Am-243-W, Cm-243-W, Cm-244-W, Cm-245-W, Cm-246-W, Cm-247-W, Bk-247-W, Cf-249-W,Y, Cf-250-W,Y, Cf-251-W,Y, Cf-252-W,Y, and Cf-254-W,Y are not present	–	–	–	1E-13	–	–

Footnotes for Appendix G to Section 3 (Cont'd)

Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage (continued)

Radionuclide	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
	Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col. 3 Inhalation DAC (μCi/ml)	Col. 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
If, in addition, it is known that Sm-147-W, Gd-152-W, Pb-210-D, Bi-210m-W, Po-210-D,W, Ra-223-W, Ra-225-W, Ra-226-W, Ac-225-D,W,Y, Th-227-W,Y, U-230-D,W,Y, U-232-D,W, U-Nat-W, Pu-241-W, Cm-240-W, Cm-242-W, Cf-248-W,Y, Es-254-W, Fm-257-W, and Md-258-W are not present	–	–	–	1E-12	–	–
If, in addition it is known that Fe-60, Sr-90, Cd-113m, Cd-113, In-115, I-129, Cs-134, Sm-145, Sm-147, Gd-148, Gd-152, Hg-194 (organic), Bi-210m, Ra-223, Ra-224, Ra-225, Ac-225, Th-228, Th-230, U-233, U-234, U-235, U-236, U-238, U-Nat, Cm-242, Cf-248, Es-254, Fm-257, and Md-258 are not present	–	–	–	–	1E-6	1E-5

Note (Cont'd):

3. If a mixture of radionuclides consists of uranium and its daughters in ore dust (10 μm AMAD particle distribution assumed) prior to chemical separation of the uranium from the ore, the following values may be used for the DAC of the mixture: 6E-11 μCi of gross alpha activity from uranium-238, uranium-234, thorium-230, and radium-226 per milliliter of air; 3E-11 μCi of natural uranium per milliliter of air; or 45 micrograms of natural uranium per cubic meter of air.

4. If the identity and concentration of each radionuclide in a mixture are known, the limiting values should be derived as follows: determine, for each radionuclide in the mixture, the ratio between the concentration present in the mixture and the concentration otherwise established in Appendix G to Section 3 for the specific radionuclide when not in a mixture. The sum of such ratios for all of the radionuclides in the mixture may not exceed "1" (i.e., "unity").

   Example: If radionuclides "A," "B," and "C" are present in concentrations C_A, C_B, and C_C, and if the applicable DACs are DAC_A, DAC_B, and DAC_C, respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{DAC_A} + \frac{C_B}{DAC_B} + \frac{C_C}{DAC_C} < 1$$

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Hydrogen-3	1,000	Vanadium-47	1,000
Beryllium-7	1,000	Vanadium-48	100
Beryllium-10	1	Vanadium-49	1,000
Carbon-11	1,000	Chromium-48	1,000
Carbon-14	100	Chromium-49	1,000
Fluorine-18	1,000	Chromium-51	1,000
Sodium-22	10	Manganese-51	1,000
Sodium-24	100	Manganese-52m	1,000
Magnesium-28	100	Manganese-52	100
Aluminum-26	10	Manganese-53	1,000
Silicon-31	1,000	Manganese-54	100
Silicon-32	1	Manganese-56	1,000
Phosphorus-32	10	Iron-52	100
Phosphorus-33	100	Iron-55	100
Sulfur-35	100	Iron-59	10
Chlorine-36	10	Iron-60	1
Chlorine-38	1,000	Cobalt-55	100
Chlorine-39	1,000	Cobalt-56	10
Argon-39	1,000	Cobalt-57	100
Argon-41	1,000	Cobalt-58m	1,000
Potassium-40	100	Cobalt-58	100
Potassium-42	1,000	Cobalt-60m	1,000
Potassium-43	1,000	Cobalt-60	1
Potassium-44	1,000	Cobalt-61	1,000
Potassium-45	1,000	Cobalt-62m	1,000
Calcium-41	100	Nickel-56	100
Calcium-45	100	Nickel-57	100
Calcium-47	100	Nickel-59	100
Scandium-43	1,000	Nickel-63	100
Scandium-44m	100	Nickel-65	1,000
Scandium-44	100	Nickel-66	10
Scandium-46	10	Copper-60	1,000
Scandium-47	100	Copper-61	1,000
Scandium-48	100	Copper-64	1,000
Scandium-49	1,000	Copper-67	1,000
Titanium-44	1	Zinc-62	100
Titanium-45	1,000	Zinc-63	1,000

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Zinc-65	10	Bromine-74	1,000
Zinc-69m	100	Bromine-75	1,000
Zinc-69	1,000	Bromine-76	100
Zinc-71m	1,000	Bromine-77	1,000
Zinc-72	100	Bromine-80m	1,000
Gallium-65	1,000	Bromine-80	1,000
Gallium-66	100	Bromine-82	100
Gallium-67	1,000	Bromine-83	1,000
Gallium-68	1,000	Bromine-84	1,000
Gallium-70	1,000	Krypton-74	1,000
Gallium-72	100	Krypton-76	1,000
Gallium-73	1,000	Krypton-77	1,000
Germanium-66	1,000	Krypton-79	1,000
Germanium-67	1,000	Krypton-81	1,000
Germanium-68	10	Krypton-83m	1,000
Germanium-69	1,000	Krypton-85m	1,000
Germanium-71	1,000	Krypton-85	1,000
Germanium-75	1,000	Krypton-87	1,000
Germanium-77	1,000	Krypton-88	1,000
Germanium-78	1,000	Rubidium-79	1,000
Arsenic-69	1,000	Rubidium-81m	1,000
Arsenic-70	1,000	Rubidium-81	1,000
Arsenic-71	100	Rubidium-82m	1,000
Arsenic-72	100	Rubidium-83	100
Arsenic-73	100	Rubidium-84	100
Arsenic-74	100	Rubidium-86	100
Arsenic-76	100	Rubidium-87	100
Arsenic-77	100	Rubidium-88	1,000
Arsenic-78	1,000	Rubidium-89	1,000
Selenium-70	1,000	Strontium-80	100
Selenium-73m	1,000	Strontium-81	1,000
Selenium-73	100	Strontium-83	100
Selenium-75	100	Strontium-85m	1,000
Selenium-79	100	Strontium-85	100
Selenium-81m	1,000	Strontium-87m	1,000
Selenium-81	1,000	Strontium-89	10
Selenium-83	1,000	Strontium-90	0.1
Bromine-74m	1,000	Strontium-91	100

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Strontium-92	100	Technetium-94	1,000
Yttrium-86m	1,000	Technetium-96m	1,000
Yttrium-86	100	Technetium-96	100
Yttrium-87	100	Technetium-97m	100
Yttrium-88	10	Technetium-97	1,000
Yttrium-90m	1,000	Technetium-98	10
Yttrium-90	10	Technetium-99m	1,000
Yttrium-91m	1,000	Technetium-99	100
Yttrium-91	10	Technetium-101	1,000
Yttrium-92	100	Technetium-104	1,000
Yttrium-93	100	Ruthenium-94	1,000
Yttrium-94	1,000	Ruthenium-97	1,000
Yttrium-95	1,000	Ruthenium-103	100
Zirconium-86	100	Ruthenium-105	1,000
Zirconium-88	10	Ruthenium-106	1
Zirconium-89	100	Rhodium-99m	1,000
Zirconium-93	1	Rhodium-99	100
Zirconium-95	10	Rhodium-100	100
Zirconium-97	100	Rhodium-101m	1,000
Niobium-88	1,000	Rhodium-101	10
Niobium-89m (66 min)	1,000	Rhodium-102m	10
Niobium-89 (122 min)	1,000	Rhodium-102	10
Niobium-90	100	Rhodium-103m	1,000
Niobium-93m	10	Rhodium-105	100
Niobium-94	1	Rhodium-106m	1,000
Niobium-95m	100	Rhodium-107	1,000
Niobium-95	100	Palladium-100	100
Niobium-96	100	Palladium-101	1,000
Niobium-97	1,000	Palladium-103	100
Niobium-98	1,000	Palladium-107	10
Molybdenum-90	100	Palladium-109	100
Molybdenum-93m	100	Silver-102	1,000
Molybdenum-93	10	Silver-103	1,000
Molybdenum-99	100	Silver-104m	1,000
Molybdenum-101	1,000	Silver-104	1,000
Technetium-93m	1,000	Silver-105	100
Technetium-93	1,000	Silver-106m	100
Technetium-94m	1,000	Silver-106	1,000

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Silver-108m	1	Tin-127	1,000
Silver-110m	10	Tin-128	1,000
Silver-111	100	Antimony-115	1,000
Silver-112	100	Antimony-116m	1,000
Silver-115	1,000	Antimony-116	1,000
Cadmium-104	1,000	Antimony-117	1,000
Cadmium-107	1,000	Antimony-118m	1,000
Cadmium-109	1	Antimony-119	1,000
Cadmium-113m	0.1	Antimony-120 (16 min)	1,000
Cadmium-113	100	Antimony-120 (5.76 d)	100
Cadmium-115m	10	Antimony-122	100
Cadmium-115	100	Antimony-124m	1,000
Cadmium-117m	1,000	Antimony-124	10
Cadmium-117	1,000	Antimony-125	100
Indium-109	1,000	Antimony-126m	1,000
Indium-110 (69.1 min)	1,000	Antimony-126	100
Indium-110 (4.9 h)	1,000	Antimony-127	100
Indium-111	100	Antimony-128 (10.4 min)	1,000
Indium-112	1,000	Antimony-128 (9.01 h)	100
Indium-113m	1,000	Antimony-129	100
Indium-114m	10	Antimony-130	1,000
Indium-115m	1,000	Antimony-131	1,000
Indium-115	100	Tellurium-116	1,000
Indium-116m	1,000	Tellurium-121m	10
Indium-117m	1,000	Tellurium-121	100
Indium-117	1,000	Tellurium-123m	10
Indium-119m	1,000	Tellurium-123	100
Tin-110	100	Tellurium-125m	10
Tin-111	1,000	Tellurium-127m	10
Tin-113	100	Tellurium-127	1,000
Tin-117m	100	Tellurium-129m	10
Tin-119m	100	Tellurium-129	1,000
Tin-121m	100	Tellurium-131m	10
Tin-121	1,000	Tellurium-131	100
Tin-123m	1,000	Tellurium-132	10
Tin-123	10	Tellurium-133m	100
Tin-125	10	Tellurium-133	1,000
Tin-126	10	Tellurium-134	1,000

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Iodine-120m	1,000	Cesium-135	100
Iodine-120	100	Cesium-136	10
Iodine-121	1,000	Cesium-137	10
Iodine-123	100	Cesium-138	1,000
Iodine-124	10	Barium-126	1,000
Iodine-125	1	Barium-128	100
Iodine-126	1	Barium-131m	1,000
Iodine-128	1,000	Barium-131	100
Iodine-129	1	Barium-133m	100
Iodine-130	10	Barium-133	100
Iodine-131	1	Barium-135m	100
Iodine-132m	100	Barium-139	1,000
Iodine-132	100	Barium-140	100
Iodine-133	10	Barium-141	1,000
Iodine-134	1,000	Barium-142	1,000
Iodine-135	100	Lanthanum-131	1,000
Xenon-120	1,000	Lanthanum-132	100
Xenon-121	1,000	Lanthanum-135	1,000
Xenon-122	1,000	Lanthanum-137	10
Xenon-123	1,000	Lanthanum-138	100
Xenon-125	1,000	Lanthanum-140	100
Xenon-127	1,000	Lanthanum-141	100
Xenon-129m	1,000	Lanthanum-142	1,000
Xenon-131m	1,000	Lanthanum-143	1,000
Xenon-133m	1,000	Cerium-134	100
Xenon-133	1,000	Cerium-135	100
Xenon-135m	1,000	Cerium-137m	100
Xenon-135	1,000	Cerium-137	1,000
Xenon-138	1,000	Cerium-139	100
Cesium-125	1,000	Cerium-141	100
Cesium-127	1,000	Cerium-143	100
Cesium-129	1,000	Cerium-144	1
Cesium-130	1,000	Praseodymium-136	1,000
Cesium-131	1,000	Praseodymium-137	1,000
Cesium-132	100	Praseodymium-138m	1,000
Cesium-134m	1,000	Praseodymium-139	1,000
Cesium-134	10	Praseodymium-142m	1,000
Cesium-135m	1,000	Praseodymium-142	100

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Praseodymium-143	100	Europium-150 (12.62 h)	100
Praseodymium-144	1,000	Europium-150 (34.2 y)	1
Praseodymium-145	100	Europium-152m	100
Praseodymium-147	1,000	Europium-152	1
Neodymium-136	1,000	Europium-154	1
Neodymium-138	100	Europium-155	10
Neodymium-139m	1,000	Europium-156	100
Neodymium-139	1,000	Europium-157	100
Neodymium-141	1,000	Europium-158	1,000
Neodymium-147	100	Gadolinium-145	1,000
Neodymium-149	1,000	Gadolinium-146	10
Neodymium-151	1,000	Gadolinium-147	100
Promethium-141	1,000	Gadolinium-148	0.001
Promethium-143	100	Gadolinium-149	100
Promethium-144	10	Gadolinium-151	10
Promethium-145	10	Gadolinium-152	100
Promethium-146	1	Gadolinium-153	10
Promethium-147	10	Gadolinium-159	100
Promethium-148m	10	Terbium-147	1,000
Promethium-148	10	Terbium-149	100
Promethium-149	100	Terbium-150	1,000
Promethium-150	1,000	Terbium-151	100
Promethium-151	100	Terbium-153	1,000
Samarium-141m	1,000	Terbium-154	100
Samarium-141	1,000	Terbium-155	1,000
Samarium-142	1,000	Terbium-156m (5.0 h)	1,000
Samarium-145	100	Terbium-156m (24.4 h)	1,000
Samarium-146	1	Terbium-156	100
Samarium-147	100	Terbium-157	10
Samarium-151	10	Terbium-158	1
Samarium-153	100	Terbium-160	10
Samarium-155	1,000	Terbium-161	100
Samarium-156	1,000	Dysprosium-155	1,000
Europium-145	100	Dysprosium-157	1,000
Europium-146	100	Dysprosium-159	100
Europium-147	100	Dysprosium-165	1,000
Europium-148	10	Dysprosium-166	100
Europium-149	100	Holmium-155	1,000

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Holmium-157	1,000	Lutetium-176	100
Holmium-159	1,000	Lutetium-177m	10
Holmium-161	1,000	Lutetium-177	100
Holmium-162m	1,000	Lutetium-178m	1,000
Holmium-162	1,000	Lutetium-178	1,000
Holmium-164m	1,000	Lutetium-179	1,000
Holmium-164	1,000	Hafnium-170	100
Holmium-166m	1	Hafnium-172	1
Holmium-166	100	Hafnium-173	1,000
Holmium-167	1,000	Hafnium-175	100
Erbium-161	1,000	Hafnium-177m	1,000
Erbium-165	1,000	Hafnium-178m	0.1
Erbium-169	100	Hafnium-179m	10
Erbium-171	100	Hafnium-180m	1,000
Erbium-172	100	Hafnium-181	10
Thulium-162	1,000	Hafnium-182m	1,000
Thulium-166	100	Hafnium-182	0.1
Thulium-167	100	Hafnium-183	1,000
Thulium-170	10	Hafnium-184	100
Thulium-171	10	Tantalum-172	1,000
Thulium-172	100	Tantalum-173	1,000
Thulium-173	100	Tantalum-174	1,000
Thulium-175	1,000	Tantalum-175	1,000
Ytterbium-162	1,000	Tantalum-176	100
Ytterbium-166	100	Tantalum-177	1,000
Ytterbium-167	1,000	Tantalum-178	1,000
Ytterbium-169	100	Tantalum-179	100
Ytterbium-175	100	Tantalum-180m	1,000
Ytterbium-177	1,000	Tantalum-180	100
Ytterbium-178	1,000	Tantalum-182m	1,000
Lutetium-169	100	Tantalum-182	10
Lutetium-170	100	Tantalum-183	100
Lutetium-171	100	Tantalum-184	100
Lutetium-172	100	Tantalum-185	1,000
Lutetium-173	10	Tantalum-186	1,000
Lutetium-174m	10	Tungsten-176	1,000
Lutetium-174	10	Tungsten-177	1,000
Lutetium-176m	1,000	Tungsten-178	1,000

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Tungsten-179	1,000	Iridium-194m	10
Tungsten-181	1,000	Iridium-194	100
Tungsten-185	100	Iridium-195m	1,000
Tungsten-187	100	Iridium-195	1,000
Tungsten-188	10	Platinum-186	1,000
Rhenium-177	1,000	Platinum-188	100
Rhenium-178	1,000	Platinum-189	1,000
Rhenium-181	1,000	Platinum-191	100
Rhenium-182 (12.7 h)	1,000	Platinum-193m	100
Rhenium-182 (64.0 h)	100	Platinum-193	1,000
Rhenium-184m	10	Platinum-195m	100
Rhenium-184	100	Platinum-197m	1,000
Rhenium-186m	10	Platinum-197	100
Rhenium-186	100	Platinum-199	1,000
Rhenium-187	1,000	Platinum-200	100
Rhenium-188m	1,000	Gold-193	1,000
Rhenium-188	100	Gold-194	100
Rhenium-189	100	Gold-195	10
Osmium-180	1,000	Gold-198m	100
Osmium-181	1,000	Gold-198	100
Osmium-182	100	Gold-199	100
Osmium-185	100	Gold-200m	100
Osmium-189m	1,000	Gold-200	1,000
Osmium-191m	1,000	Gold-201	1,000
Osmium-191	100	Mercury-193m	100
Osmium-193	100	Mercury-193	1,000
Osmium-194	1	Mercury-194	1
Iridium-182	1,000	Mercury-195m	100
Iridium-184	1,000	Mercury-195	1,000
Iridium-185	1,000	Mercury-197m	100
Iridium-186	100	Mercury-197	1,000
Iridium-187	1,000	Mercury-199m	1,000
Iridium-188	100	Mercury-203	100
Iridium-189	100	Thallium-194m	1,000
Iridium-190m	1,000	Thallium-194	1,000
Iridium-190	100	Thallium-195	1,000
Iridium-192m (1.4 min)	10	Thallium-197	1,000
Iridium-192 (73.8 d)	1	Thallium-198m	1,000

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Thallium-198	1,000	Radon-220	1
Thallium-199	1,000	Radon-222	1
Thallium-200	1,000	Francium-222	100
Thallium-201	1,000	Francium-223	100
Thallium-202	100	Radium-223	0.1
Thallium-204	100	Radium-224	0.1
Lead-195m	1,000	Radium-225	0.1
Lead-198	1,000	Radium-226	0.1
Lead-199	1,000	Radium-227	1,000
Lead-200	100	Radium-228	0.1
Lead-201	1,000	Actinium-224	1
Lead-202m	1,000	Actinium-225	0.01
Lead-202	10	Actinium-226	0.1
Lead-203	1,000	Actinium-227	0.001
Lead-205	100	Actinium-228	1
Lead-209	1,000	Thorium-226	10
Lead-210	0.01	Thorium-227	0.01
Lead-211	100	Thorium-228	0.001
Lead-212	1	Thorium-229	0.001
Lead-214	100	Thorium-230	0.001
Bismuth-200	1,000	Thorium-231	100
Bismuth-201	1,000	Thorium-232	100
Bismuth-202	1,000	Thorium-234	10
Bismuth-203	100	Thorium-natural	100
Bismuth-205	100	Protactinium-227	10
Bismuth-206	100	Protactinium-228	1
Bismuth-207	10	Protactinium-230	0.1
Bismuth-210m	0.1	Protactinium-231	0.001
Bismuth-210	1	Protactinium-232	1
Bismuth-212	10	Protactinium-233	100
Bismuth-213	10	Protactinium-234	100
Bismuth-214	100	Uranium-230	0.01
Polonium-203	1,000	Uranium-231	100
Polonium-205	1,000	Uranium-232	0.001
Polonium-207	1,000	Uranium-233	0.001
Polonium-210	0.1	Uranium-234	0.001
Astatine-207	100	Uranium-235	0.001
Astatine-211	10	Uranium-236	0.001

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Uranium-237	100	Americium-246m	1,000
Uranium-238	100	Americium-246	1,000
Uranium-239	1,000	Curium-238	100
Uranium-240	100	Curium-240	0.1
Uranium-natural	100	Curium-241	1
Neptunium-232	100	Curium-242	0.01
Neptunium-233	1,000	Curium-243	0.001
Neptunium-234	100	Curium-244	0.001
Neptunium-235	100	Curium-245	0.001
Neptunium-236 (1.15E+5 y)	0.001	Curium-246	0.001
Neptunium-236 (22.5 h)	1	Curium-247	0.001
Neptunium-237	0.001	Curium-248	0.001
Neptunium-238	10	Curium-249	1,000
Neptunium-239	100	Berkelium-245	100
Neptunium-240	1,000	Berkelium-246	100
Plutonium-234	10	Berkelium-247	0.001
Plutonium-235	1,000	Berkelium-249	0.1
Plutonium-236	0.001	Berkelium-250	10
Plutonium-237	100	Californium-244	100
Plutonium-238	0.001	Californium-246	1
Plutonium-239	0.001	Californium-248	0.01
Plutonium-240	0.001	Californium-249	0.001
Plutonium-241	0.01	Californium-250	0.001
Plutonium-242	0.001	Californium-251	0.001
Plutonium-243	1,000	Californium-252	0.001
Plutonium-244	0.001	Californium-253	0.1
Plutonium-245	100	Californium-254	0.001
Americium-237	1,000	Einsteinium-250	100
Americium-238	100	Einsteinium-251	100
Americium-239	1,000	Einsteinium-253	0.1
Americium-240	100	Einsteinium-254m	1
Americium-241	0.001	Einsteinium-254	0.01
Americium-242m	0.001	Fermium-252	1
Americium-242	10	Fermium-253	1
Americium-243	0.001	Fermium-254	10
Americium-244m	100	Fermium-255	1
Americium-244	10	Fermium-257	0.01
Americium-245	1,000	Mendelevium-257	10

APPENDIX H TO SECTION 3

QUANTITIES[a/] OF LICENSED MATERIAL REQUIRING LABELING

(In order of atomic number)

Radionuclide	Quantity (μCi)[b/]	Radionuclide	Quantity (μCi)[b/]
Mendelevium-258	0.01		
Any alpha emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	0.001	Any radionuclide other than alpha emitting radionuclides not listed above, or mixtures of beta emitters of unknown composition	0.01

Note:

For purposes of RH-1310.a. and RH-1501.c. where there is involved a combination of radionuclides in known amounts, the limit for the combination shall be derived as follows: determine, for each radionuclide in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific radionuclide when not in combination. The sum of such ratios for all radionuclides in the combination may not exceed "1" -- that is, unity.

Footnotes for Appendix H to Section 3:

[a/] The quantities listed above were derived by taking 1/10th of the most restrictive ALI listed in Table I, Columns 1 and 2, of Appendix G to Section 3, rounding to the nearest factor of 10, and constraining the values listed between 37 Bq and 37 MBq (0.001 and 1,000 μCi). Values of 3.7 MBq (100 μCi) have been assigned for radionuclides having a radioactive half-life in excess of E+9 years, except rhenium, 37 MBq (1,000 μCi), to take into account their low specific activity.

[b/] To convert μCi to kBq, multiply the μCi value by 37.

NOTICE TO EMPLOYEES

Arkansas Department of Health
STANDARDS FOR PROTECTION AGAINST RADIATION

The Arkansas Department of Health (ADH) has adopted regulations with standards to protect you from hazards associated with radioactive materials and radiation emitting machines which are licensed or registered by ADH. In particular, the following information is available for your review:

Section 3: Standards for Protection Against Radiation
Part N: Notice, Instructions, and Reports to Workers; Inspections
Any other documents your employer must provide.

These may be found at the following location:

YOUR EMPLOYER'S RESPONSIBILITY
Your employer is required to:

1. Comply with all applicable regulations and the conditions of the license or registration.

2. Post or otherwise make available to you a copy of the regulations, licenses, and operating procedures which apply to work in which you are engaged, and explain the provisions to you.

YOUR RESPONSIBILITY AS A WORKER
You should:

1. Know the provisions of the ADH regulations, the precautions, the operating procedures, and the emergency procedures which apply to your work.

2. Observe the provisions for your own protection and for the protection of your co-workers.

3. Report unsafe working conditions or violations of the license or registration conditions or regulations to ADH.

REPORTS OF YOUR RADIATION EXPOSURE HISTORY

1. The ADH regulations specify the occupational limits for radiation exposure including concentrations of radioactive material in air and water. These regulations require your employer to give you a written report if you receive exposure in excess of any applicable limit. The limits on your exposure are contained in RH-1200, RH-1206, and RH-1207. While these are the maximum allowable limits, your employer should keep your radiation exposure below those limits as is reasonably achievable.

2. If you work where personnel monitoring is required and request information on your radiation exposures,

   a. your employer must advise you annually of your exposure to radiation, and
   b. upon termination of employment, your employer must give you a written report of your radiation exposures.
   c. A report of any exposure in excess of a limit must be reported to you.

INSPECTIONS: All licensed or registered activities are subject to inspection by the ADH.

INQUIRIES

Direct all inquiries on matters outlined above to: ADH, Radiation Control Section, 4815 West Markham Street, Slot 30, Little Rock, Arkansas, 72205-3867 or to (501)661-2301. For emergencies, call (800) 633-1735.

POSTING REQUIREMENT: In accordance with RH-2802, copies of this notice must be posted in every establishment where employees are engaged in activities licensed or registered by the ADH. Posting must permit employees working in or frequenting any portion of a restricted area to observe a copy on the way to or from their place of employment.

~~APPENDIX K TO SECTION 3~~

~~Deleted.~~

~~APPENDIX L TO SECTION 3~~

~~Deleted.~~

FOOTNOTES TO SECTION 3

1/ An organ or tissue is deemed to be significantly irradiated if, for that organ or tissue, the product of the weighting factors, W_T, and the committed dose equivalent, $H_{T,50}$, per unit intake is greater than ten percent (10%) of the maximum weighted value of $H_{T,50}$ (i.e., $W_T H_{T,50}$) per unit intake for any organ or tissue. $H_{T,50}$ was H_{50}.

2/ This section applies to radiation from byproduct, source, or special nuclear materials that are used in sealed sources in non-self-shielded irradiators. This section does not apply to radioactive sources that are used in teletherapy, in industrial radiography, or in completely self-shielded irradiators in which the source is both stored and operated within the same shielding radiation barrier and, in the designed configuration of the irradiator cannot create high levels of radiation in an area that is accessible to any individual. This section also does not apply to sources from which the radiation is incidental to some other use or to nuclear reactor-generated radiation.

3/ Deleted.

4/ Labeled with a Radioactive White I, Yellow II, or Yellow III label as specified in U. S. Department of Transportation regulations, 49 CFR 172.403 and 172.436-440.

5/ Labeling of packages containing radioactive materials is required by the Department of Transportation (DOT) if the amount and type of radioactive material exceeds the limits for an excepted quantity or article as defined and limited by DOT regulations 49 CFR 173.403 and 173.421-426.

6/ Licensees are not required to partition historical dose between external dose equivalent(s) and internal committed dose equivalent(s). Further, occupational exposure histories obtained and recorded on RC FORM 111 (formerly known as Department Form Z or Department Form RH-1), or equivalent, before January 1, 1994, might not have included effective dose equivalent, but may be used in the absence of specific information on the intake of radionuclides by the individual.

7/ Assessments of dose equivalent and records made using units in effect before the licensee's adoption of this Section need not be changed.

FOOTNOTES TO SECTION 3 *(Continued)*

8/ A previous RH-1403. permitted certain burials of small quantities of licensed materials in soil before January 1, 1983, without specific Department authorization. As of January 1, 1983, these burials had to receive specific approval by the Department, in accordance with the revised RH-1403. Disposal by burial in soil came to be regulated under RH-1401.

9/ With respect to the limit for the embryo/fetus (RH-1207), the identifiers should be those of the declared pregnant woman.

10/ Deleted.

11/ The nominal chemical composition of type 1100 aluminum alloy is 99.00 percent (99%) minimum aluminum, 0.12 percent copper.

12/ Deleted.

13/ Deleted.

14/ An example of a suggested plaque is shown at the end of this Part.

15/ Appropriate warnings may include:

a. "Do not drill below plug back depth";

b. "Do not enlarge casing"; or

c. "Do not re-enter the hole," followed by the words, "before contacting the Arkansas Department of Health."

SECTION 4.
TRANSPORTATION OF RADIOACTIVE MATERIALS

PART A.
GENERAL

RH-3000. **Authority**. Act 8 of Second Extraordinary Session of 1961, as amended.

RH-3001. **Effective Date**. The provisions of these ~~Regulations~~ Rules shall become operative on the effective date of an agreement executed by the State of Arkansas and the Federal Government under the provisions of Section 274 of the Atomic Energy Act of 1954 as amended (73 STAT. 689).

RH-3002. **Purpose and Scope**.

a. This Section establishes requirements for packaging, preparation for shipment, and transportation of licensed material.

b. The packaging and transport of licensed material are also subject to the regulations of other agencies (e.g., the U.S. Department of Transportation, the U.S. Nuclear Regulatory Commission, and the U.S. Postal Service) having jurisdiction over means of transport. The requirements of this Section are in addition to, and not in substitution for, other requirements.

c. The ~~regulations~~ rules in this Section apply to any licensee authorized by specific or general license issued by the Department to receive, possess, use, or transfer licensed material, if the licensee delivers that material to a carrier for transport, transports the material outside the site of usage as specified in the Department license, or transports that material on public highways. No provision of this Section authorizes the possession of licensed material.

d. 1. Exemptions from Section 4 requirements are specified in Part C of this Section. General licenses for which no NRC package approval is required are issued in RH-3304. through RH-3306. The general license in RH-3301. requires that an NRC Certificate of Compliance or other package approval be issued for the package to be used under this general license.

RH-3002.d. (Cont'd)

2. A licensee transporting licensed material, or delivering licensed material to a carrier for transport, shall comply with the operating control requirements of Part F; the quality assurance requirements of Part G; and the general provisions of Part A, including referenced U.S. Department of Transportation regulations.

RH-3003. **Communications and Records**.

a. Except where otherwise specified, all communications concerning these ~~Regulations~~ Rules may be addressed to the Arkansas Department of Health, Radiation Control Section, 4815 West Markham Street, Slot 30, Little Rock, Arkansas, 72205-3867.

b. Each record required by this section must be legible throughout the retention period specified by each Department ~~regulation~~ rule. The record may be the original, a reproduced copy, or a microform provided that the copy or microform is authenticated by authorized personnel and that the microform is capable of producing a clear copy throughout the required retention period. The record may also be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records such as letters, drawings, and specifications must include all pertinent information such as stamps, initials, and signatures. The licensee shall maintain adequate safeguards against tampering with and loss of records.

RH-3004. **Requirement for License**.

Except as authorized in a general license or a specific license issued by the Department, or as exempted in this Section, no licensee may:

a. Deliver licensed material to a carrier for transport; or

b. Transport licensed material.

RH-3005. **Transportation of Radioactive Material**.

a. Each licensee who transports licensed material outside the site of usage, as specified in the Department license, or where transport is on public highways, or who delivers licensed material to a carrier for transport, shall comply with the applicable requirements of the DOT regulations in 49 CFR parts 107, 171 through 180, and 390 through 397, appropriate to the mode of transport.

1. The licensee shall particularly note DOT regulations in the following areas:

A. Packaging--49 CFR part 173: Subparts A, B, and I.

B. Marking and labeling--49 CFR part 172: Subpart D; and §§ 172.400 through 172.407 and §§ 172.436 through 172.441 of Subpart E.

C. Placarding--49 CFR part 172: Subpart F, especially §§ 172.500 through 172.519 and 172.556; and appendices B and C.

D. Accident reporting--49 CFR part 171: §§ 171.15 and 171.16.

E. Shipping papers and emergency information--49 CFR part 172: Subparts C and G.

F. Hazardous material employee training--49 CFR part 172: Subpart H.

G. Security plans--49 CFR part 172: Subpart I.

H. Hazardous material shipper/carrier registration--49 CFR part 107: Subpart G.

2. The licensee shall also note DOT regulations pertaining to the following modes of transportation:

A. Rail--49 CFR part 174: Subparts A through D and K.

B. Air--49 CFR part 175.

C. Vessel--49 CFR part 176: Subparts A through F and M.

RH-3005.a.2. (Cont'd)

D. Public Highway--49 CFR part 177 and parts 390 through 397.

b. If DOT regulations are not applicable to a shipment of licensed material, the licensee shall conform to the standards and requirements of the DOT specified in RH-3005.a. of this section to the same extent as if the shipment or transportation were subject to DOT regulations. A request for modification, waiver, or exemption from those requirements, and any notification referred to in those requirements, must be filed with, or made to, the Arkansas Department of Health, Radiation Control Section, 4815 West Markham Street, Slot 30, Little Rock, Arkansas, 72205-3867.

RH-3006. **Interpretations**.

Except as specifically authorized by the Department in writing, no interpretations of the meaning of the ~~regulations~~ rules in this Section by an officer or employee of the Department other than a written interpretation by the Department Director or designee will be recognized as binding upon the Department.

RH-3007.- RH-3099. Reserved.

PART B.
DEFINITIONS

RH-3100. **Definitions**.

The following terms are as defined for the purpose of this Section. To ensure compatibility with international transportation standards, all limits in this Section are given in terms of dual units: The International System of Units (SI) followed or preceded by U.S. standard or customary units. The U.S. customary units are not exact equivalents, but rounded to a convenient value, providing a functionally equivalent unit. For the purpose of this Section, either unit may be used.

A_1 - Maximum activity of special form of radioactive material permitted in a Type A package. These values are either listed in Table A-1 of Appendix A to this Section or may be derived in accordance with the procedure prescribed in Appendix A.

A_2 - Maximum activity of radioactive material, other than special form, LSA and SCO material, permitted in a Type A package. These values are either listed in Table A-1 of Appendix A to this Section or may be derived in accordance with the procedure prescribed in Appendix A.

Act - Act 8 of Second Extraordinary Session of 1961, as amended.

Carrier - A person engaged in the transportation of passengers or property by land or water as a common, contract, or private carrier, or by civil aircraft.

Certificate Holder – a person who has been issued a Certificate of Compliance or other package approval by the U.S. Nuclear Regulatory Commission.

Certificate of Compliance (CoC) - the certificate issued by the U.S. Nuclear Regulatory Commission which approves the design of a package for the transportation of radioactive material.

CFR - Code of Federal Regulations.

Close reflection by water - immediate contact by water of sufficient thickness for maximum reflection of neutrons.

Consignment - Each shipment of a package or groups of packages or load of radioactive material offered by a shipper for transport.

Containment system - the assembly of components of the packaging intended to retain the radioactive material during transport.

RH-3100. (Cont'd)

Contamination - The presence of a radioactive substance on a surface in quantities in excess of 0.4 Bq/cm^2 (1 x 10^{-5} μCi/cm^2) for beta and gamma emitters and low toxicity alpha emitters, or 0.04 Bq/cm^2 (1 x 10^{-6} μCi/cm^2) for all other alpha emitters.

1. **Fixed contamination** - Contamination that cannot be removed from a surface during normal conditions of transport.

2. **Non-fixed contamination** - Contamination that can be removed from a surface during normal conditions of transport.

Conveyance -

1. For transport by public highway or rail, any transport vehicle or large freight container;

2. For transport by water, any vessel, or any hold, compartment, or defined deck area of a vessel including any transport vehicle on board the vessel; and

3. For transport by any aircraft.

Criticality Safety Index (CSI) - The dimensionless number (rounded up to the next tenth) assigned to and placed on the label of a fissile material package, to designate the degree of control of accumulation of packages, overpacks, or freight containers containing fissile material during transportation. Determination of the criticality safety index is described in RH-3305., RH-3306., and in 10 CFR 71.59. The criticality safety index for an overpack, freight container, consignment, or conveyance containing fissile material packages is the arithmetic sum of the criticality safety indices of all the fissile material packages contained within the overpack, freight container, consignment, or conveyance.

Deuterium - For the purposes of RH-3203. and RH-3305., deuterium and any deuterium compounds, including heavy water, in which the ratio of deuterium atoms to hydrogen atoms exceeds 1:5000.

DOT - The U.S. Department of Transportation.

Exclusive use (also referred to in other regulations as "sole") - The sole use of a conveyance by a single consignor of a conveyance for which all initial, intermediate, and final loading and unloading are carried out in accordance with the direction of the consignor or consignee. The consignor and the carrier must ensure that any loading or unloading is performed by personnel having radiological training and resources appropriate for safe handling of the consignment. The consignor must issue specific instructions, in writing, for maintenance of exclusive use shipment controls, and include them with the shipping paper information provided by the consignor.

Fissile material - The radionuclides uranium-233, uranium-235, plutonium-239, and plutonium-241, or any combination of these radionuclides. Fissile material means the fissile nuclides themselves, not material containing fissile nuclides. Unirradiated natural uranium and depleted uranium, that has been irradiated in thermal reactors only, are not included in this definition. Certain exclusions from fissile material controls are provided in RH-3203.

Graphite - For the purposes of RH-3203 and RH-3305, graphite with a boron equivalent content less than five (5) parts per million and density greater than 1.5 grams per cubic centimeter.

Indian Tribe - An Indian or Alaska native Tribe, band, nation, pueblo, village, or community that the Secretary of the Interior acknowledges to exist as an Indian Tribe pursuant to the Federally Recognized Indian Tribe List Act of 1994, 25 U.S.C. 479a.

Licensed material - Radioactive material received, possessed, used, or transferred under a general or specific license issued by the Department pursuant to ~~the regulations in this Section~~ these Rules.

Low Specific Activity (LSA) - Radioactive material with limited specific activity which is nonfissile or is excepted under RH-3203. and which satisfies the descriptions and limits set forth below. Shielding materials surrounding the LSA material may not be considered in determining the estimated average specific activity of the package contents. The LSA material must be in one of three groups:

1. **LSA-I**:

   A. Uranium and thorium ores, concentrates of uranium and thorium ores, and other ores containing naturally occurring radioactive radionuclides that are intended to be processed for the use of these radionuclides;

B. Natural uranium, depleted uranium, natural thorium, or their compounds or mixtures, provided they are unirradiated and in solid or liquid form;

C. Radioactive material other than fissile material, for which the A_2 value is unlimited; or

D. Other radioactive material in which the activity is distributed throughout and the estimated average specific activity does not exceed 30 times the value for exempt material activity concentration determined in accordance with Appendix A to Section 4.

2. **LSA-II**:

A. Water with tritium concentration up to 0.8 TBq/liter (20.0 Ci/liter); or

B. Other radioactive material in which the activity is distributed throughout and the estimated average specific activity does not exceed 10^{-4} A_2/g for solid and gases, and 10^{-5} A_2/g for liquids.

3. **LSA-III**:

Solids (e.g., consolidated wastes, activated materials), excluding powders, that satisfy the requirements of 10 CFR 71.77, in which:

A. The radioactive material is distributed throughout a solid or a collection of solid objects, or is essentially uniformly distributed in a solid compact binding agent (such as concrete, bitumen, ceramic, etc.);

B. The radioactive material is relatively insoluble, or it is intrinsically contained in a relatively insoluble material, so that even under loss of packaging, the loss of radioactive material per package by leaching when placed in water for seven (7) days will not exceed 0.1 A_2.; and

C. The estimated average specific activity of the solid, excluding any shielding material, does not exceed 2 x $10^{-3}$$A_2$/g.

RH-3100. (Cont'd)

Low toxicity alpha emitters - natural uranium, depleted uranium, natural thorium; uranium-235, uranium-238, thorium-232, thorium-228, or thorium-230 when contained in ores or physical or chemical concentrates or tailings; or alpha emitters with a half-life of less than ten (10) days.

Maximum normal operating pressure - the maximum gauge pressure that would develop in the containment system in a period of one (1) year under the heat condition specified in 10 CFR 71.71(c)(1) in the absence of venting, external cooling by an ancillary system, or operational controls during transport.

Natural thorium - Thorium with the naturally occurring distribution of thorium isotopes (essentially 100 weight percent thorium-232).

Normal form radioactive material - Radioactive material that has not been demonstrated to qualify as "special form radioactive material."

Optimum interspersed hydrogenous moderation - The presence of hydrogenous material between packages to such an extent that the maximum nuclear reactivity results.

Package - Packaging together with its radioactive contents as presented for transport.

1. **Fissile material package or Type AF package, Type BF package, Type B(U)F package, or Type B(M)F package** - A fissile material packaging together with its fissile material contents.

2. **Type A package** - A Type A packaging together with its radioactive contents. A Type A package is defined and must comply with the DOT regulations in 49 CFR Part 173.

3. **Type B package** - A Type B packaging together with its radioactive contents. On approval, a Type B package design is designated by NRC as B(U) unless the package has a maximum normal operating pressure of more than 700 kilopascal (100 lb/in^2) gauge or a pressure relief device which would allow the release of radioactive material to the environment under the tests specified in 10 CFR 71.73 (hypothetical accident conditions), in which case it will receive a designation B(M). B(U) refers to the need for unilateral approval of international shipments; B(M) refers to the need for multilateral approval of international shipments.

   There is no distinction made in how packages with these designations may be used in domestic transportation. To determine their distinction for international transportation, see DOT regulations in 49 CFR Part 173. A

Type B package approved prior to September 6, 1983, was designated only as Type B. Limitations on its use are specified in 10 CFR 71.19.

Packaging - Assembly of components necessary to ensure compliance with the packaging requirements of this Section. It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, and devices for cooling or absorbing mechanical shocks. The vehicle, tie-down system, and auxiliary equipment may be designated as part of the packaging.

Special form radioactive material - Radioactive material that satisfies the following conditions:

1. It is either a single solid piece or is contained in a sealed capsule that can be opened only by destroying the capsule;

2. The piece or capsule has at least one dimension not less than five (5) millimeters (0.2 inch); and

3. It satisfies the requirements of 10 CFR 71.75. A special form encapsulation designed in accordance with the requirements of 10 CFR 71.4 in effect on June 30, 1983 (see 10 CFR Part 71, revised as of January 1, 1983), and constructed before July 1, 1985; a special form encapsulation designed in accordance with the requirements of 10 CFR 71.4 in effect on March 31, 1996 (see 10 CFR Part 71, revised as of January 1, 1996), and constructed before April 1, 1998; and special form material that was successfully tested before September 10, 2015, in accordance with the requirements of 10 CFR 71.75(d) in effect before September 10, 2015, may continue to be used. Any other special form encapsulation must meet the specifications of this definition.

Specific activity of a radionuclide - The radioactivity of the radionuclide per unit mass of that nuclide. The specific activity of a material in which the radionuclide is essentially uniformly distributed is the radioactivity per unit mass of the material.

Spent nuclear fuel or Spent fuel -- Fuel that has been withdrawn from a nuclear reactor following irradiation, has undergone at least one (1) year's decay since being used as a source of energy in a power reactor, and has not been chemically separated into its constituent elements by reprocessing. Spent fuel includes the special nuclear material, byproduct material, source material, and other radioactive materials associated with fuel assemblies.

State - A State of the United States, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands.

Surface Contaminated Object (SCO) - A solid object that is not itself classed as radioactive material, but which has radioactive material distributed on any of its surfaces. SCO must be in one of two (2) groups with surface activity not exceeding the following limits:

1. **SCO-I**: A solid object on which:

   A. The non-fixed contamination on the accessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 10^{-4} microcurie/cm^2 (4 Bq/cm^2) for beta and gamma and low toxicity alpha emitters, or 10^{-5} microcurie/cm^2 (0.4 Bq/cm^2) for all other alpha emitters; and

   B. The fixed contamination on the accessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 1.0 microcurie/cm^2 (4×10^4 Bq/cm^2) for beta and gamma and low toxicity alpha emitters, or 0.1 microcurie/cm^2 (4×10^3 Bq/cm) all other alpha emitters; and

   C. The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 1.0 microcurie/cm^2 (4×10^4 Bq/cm^2) for beta and gamma and low toxicity alpha emitters, or 0.1 microcurie/cm^2 (4×10^3 Bq/cm^2) all other alpha emitters.

2. **SCO-II**: A solid object on which the limits for SCO-1 are exceeded and on which:

   A. The non-fixed contamination on the accessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 10^{-2} microcurie/cm^2 (400 Bq/cm^2) for beta and gamma and low toxicity alpha emitters, or 10^{-3} microcurie/cm^2 (40 Bq/cm^2) for all other alpha emitters;

   B. The fixed contamination on the accessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 20 microcurie/cm^2 (8×10^5 Bq/cm^2) for beta and gamma and low toxicity alpha emitters, or 2 microcurie/cm^2 (8×10^4 Bq/cm^2) for all other alpha emitters; and

C. The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 20 microcurie/cm^2 (8 x 10^5 Bq/cm^2) for beta and gamma and low toxicity alpha emitters, or 2 microcurie/cm^2 (8 x 10^4 Bq/cm^2) for all other alpha emitters.

Transport index - The dimensionless number (rounded up to the next tenth) placed on the label of a package, to designate the degree of control to be exercised by the carrier during transportation. (The transport index is the number determined by multiplying the maximum radiation level in millisievert (mSv) per hour at one (1) meter (3.3 ft) from the external surface of the package by 100 (equivalent to the maximum radiation level in millirem per hour at one (1) meter (3.3 ft)).

Tribal official - The highest ranking individual that represents Tribal leadership, such as the Chief, President, or Tribal Council leadership.

Type A quantity - A quantity of radioactive material, the aggregate radioactivity of which does not exceed A_1 for special form radioactive material or A_2 for normal form radioactive material, where A_1 and A_2 are given in Table A-1 of Appendix A to this Section or may be determined by procedures described in Appendix A to this Section.

Type B quantity - A quantity of radioactive material greater than a Type A quantity.

Unirradiated uranium - Uranium containing not more than 2 x 10^3 Bq of plutonium per gram of uranium-235, not more than 9 x 10^6 Bq of fission products per gram of uranium-235, and not more than 5 x 10^{-3} g of uranium-236 per gram of uranium-235.

Uranium - natural, depleted, enriched.

1. **Natural uranium** - Uranium (which may be chemically separated) with the naturally occurring distribution of uranium isotopes (approximately 0.711 weight percent uranium-235 and the remainder by weight essentially uranium-238).

2. **Depleted uranium** - Uranium containing less uranium-235 than the naturally occurring distribution of uranium isotopes.

3. **Enriched uranium** - Uranium containing more uranium-235 than the naturally occurring distribution of uranium isotopes.

RH-3101.- RH-3199. Reserved.

PART C.
EXEMPTIONS

RH-3200. **Specific Exemptions**.

The Department may, upon application of any interested person or upon its own initiative, grant such exemptions from the requirements of the ~~regulations~~ rules in this Section as it determines are authorized by law and will not result in undue hazard to public health and safety or property, and are otherwise in the public interest.

RH-3201. **Exemption of Physicians**.

Any physician, as defined in RH-200., licensed by the State of Arkansas to dispense drugs in the practice of medicine is exempt from RH-3005. with respect to transport by the physician of licensed material for use in the practice of medicine. However, any physician operating under this exemption must be licensed by the Department under Section 9 of these ~~Regulations~~ Rules, U.S. Nuclear Regulatory Commission's 10 CFR Part 35 regulations or the equivalent Agreement State regulations.

RH-3202. **Exemption for Low-Level Radioactive Materials**.

A licensee is exempt from all the requirements of this Section with respect to shipment or carriage of the following low-level materials:

a. Natural material and ores containing naturally occurring radionuclides that are either in their natural state, or have only been processed for purposes other than for the extraction of the radionuclides, and which are not intended to be processed for use of these radionuclides, provided the activity concentration of the material does not exceed ten (10) times the applicable radionuclide activity concentration values specified in Table A-2 or Table A-3 of Appendix A to Section 4.

b. Materials for which the activity concentration is not greater than the activity concentration values specified in Table A-2 or Table A-3 of Appendix A to Section 4, or for which the consignment activity is not greater than the limit for an exempt consignment found in Table A-2 or Table A-3 of Appendix A to Section 4.

c. Non-radioactive solid objects with radioactive substances present on any surfaces in quantities not in excess of the levels cited in the definition of contamination in RH-3100.

RH-3203. **Exemption from Classification as Fissile Material**.

Fissile material meeting the requirements of at least one of the paragraphs a. through f. of this section are exempt from classification as fissile material and from the fissile material package standards of 10 CFR 71.55 and 71.59, but are subject to all other requirements of this Section, except as noted.

a. Individual package containing two (2) grams or less fissile material.

b. Individual or bulk packaging containing 15 grams or less of fissile material provided the package has at least 200 grams of solid nonfissile material for every gram of fissile material. Lead, beryllium, graphite, and hydrogenous material enriched in deuterium may be present in the package but must not be included in determining the required mass for solid nonfissile material.

c. 1. Low concentrations of solid fissile material commingled with solid nonfissile material, provided that:

A. There is at least 2000 grams of solid nonfissile material for every gram of fissile material, and

B. There is no more than 180 grams of fissile material distributed within 360 kg of contiguous nonfissile material.

2. Lead, beryllium, graphite, and hydrogenous material enriched in deuterium may be present in the package but must not be included in determining the required mass of solid nonfissile material.

d. Uranium enriched in uranium-235 to a maximum of one percent (1%) by weight, and with total plutonium and uranium-233 content of up to one percent (1%) of the mass of uranium-235, provided that the mass of any beryllium, graphite, and hydrogenous material enriched in deuterium constitutes less than five percent (5%) of the uranium mass, and that the fissile material is distributed homogenously and does not form a lattice arrangement within the package.

e. Liquid solutions of uranyl nitrate enriched in uranium-235 to a maximum of two percent (2%) by mass, with a total plutonium and uranium-233 content not exceeding 0.002 percent of the mass of uranium, and with a minimum nitrogen to uranium atomic ratio (N/U) of two (2). The material must be contained in at least a DOT Type A package.

RH-3203. (Cont'd)

f. Packages containing, individually, a total plutonium mass of not more than 1000 grams, of which not more than twenty percent (20%) by mass may consist of plutonium-239, plutonium-241, or any combination of these radionuclides.

RH-3204.- RH-3299. Reserved.

PART D.
GENERAL LICENSES

RH-3300. Reserved.

RH-3301. **General License for NRC-Approved Packages**.

a. A general license is hereby issued to any licensee of the Department to transport, or to deliver to a carrier for transport, licensed material in a package for which a license, Certificate of Compliance (CoC), or other approval has been issued by the U.S. Nuclear Regulatory Commission.

b. This general license applies only to a licensee who has a quality assurance program approved by the Department as satisfying the provisions of Part G of this Section.

c. Each licensee issued a general license under paragraph a. of this section shall:

1. Maintain a copy of the CoC, or other approval of the package, and the drawings and other documents referenced in the approval relating to the use and maintenance of the packaging and to the actions to be taken before shipment;

2. Comply with the terms and conditions of the license, certificate, or other approval, as applicable, and the applicable requirements of Parts A, F, and G of this Section;

3. Submit in writing before the first use of the package to the U.S. Nuclear Regulatory Commission: ATTN: Document Control Desk, Director, Division of ~~Spent~~ Fuel Management, Office of Nuclear Material Safety and Safeguards, using an appropriate method listed in 10 CFR 71.1(a), the licensee's name and license number and the package identification number specified in the package approval.

d. This general license applies only when the package approval authorizes use of the package under this general license.

e. For a Type B or fissile material package, the design of which was approved by the U.S. Nuclear Regulatory Commission before April 1, 1996, the general license is subject to the additional restrictions of 10 CFR 71.19.

RH-3302. Reserved.

RH-3303. Reserved.

RH-3304. **General License for Use of Foreign Approved Package**.

a. A general license is hereby issued to any licensee of the Department to transport, or to deliver to a carrier for transport, licensed material in a package, the design of which has been approved in a foreign national competent authority certificate, that has been revalidated by the U.S. Department of Transportation as meeting the applicable requirements of 49 CFR 171.23.

b. Except as otherwise provided in this section, the general license applies only to a licensee who has a quality assurance program approved by the Department as satisfying the applicable provisions of Part G of this Section.

c. This general license applies only to shipments made to or from locations outside the United States.

d. Each licensee issued a general license under paragraph a. of this section shall:

1. Maintain a copy of the applicable certificate, the revalidation, and the drawings and other documents referenced in the certificate, relating to the use and maintenance of the packaging and to the actions to be taken before shipment; and

2. Comply with the terms and conditions of the certificate and revalidation, and with the applicable requirements of Parts A, F, and G of this Section.

RH-3305. **General License: Fissile Material**.

a. A general license is issued to any licensee of the Department to transport fissile material, or to deliver fissile material to a carrier for transport, if the material is shipped in accordance with this section. The fissile material need not be contained in a package which meets the standards of Part E of this Section and 10 CFR Part 71, Subparts E and F; however, the material must be contained in a Type A package. The Type A package must also meet the DOT requirements of 49 CFR 173.417(a).

b. The general license applies only to a licensee who has a quality assurance program approved by the Department as satisfying the provisions of Part G of this Section.

c. The general license applies only when a package's contents:

1. Contain no more than a Type A quantity of radioactive material; and

2. Contain less than 500 total grams of beryllium, graphite, or hydrogenous material enriched in deuterium.

d. The general license applies only to packages containing fissile material that are labeled with a CSI which:

1. Has been determined in accordance with paragraph (e) of this section;

2. Has a value less than or equal to 10; and

3. For a shipment of multiple packages containing fissile material, the sum of the CSIs must be less than or equal to 50 (for shipment on a nonexclusive use conveyance) and less than or equal to 100 (for shipment on an exclusive use conveyance).

e. 1. The value for the CSI must be greater than or equal to the number calculated by the following equation:

$$CSI = 10 \left[\frac{\text{grams of } {}^{235}U}{X} + \frac{\text{grams of } {}^{233}U}{Y} + \frac{\text{grams of Pu}}{Z} \right]$$

2. The calculated CSI must be rounded up to the first decimal place;

3. The values of X, Y, and Z used in the CSI equation must be taken from Tables 71-1 or 71-2, as appropriate;

RH-3305.e. (Cont'd)

4. If Table 71-2 is used to obtain the value of X, then the values for the terms in the equation for uranium-233 and plutonium must be assumed to be zero; and

5. Table 71-1 values for X, Y, and Z must be used to determine the CSI if:

   A. Uranium-233 is present in the package;

   B. The mass of plutonium exceeds one percent (1%) of the mass of uranium-235;

   C. The uranium is of unknown uranium-235 enrichment or greater than 24 weight percent enrichment; or

   D. Substances having a moderating effectiveness (i.e., an average hydrogen density greater than H_2O) (e.g., certain hydrocarbon oils or plastics) are present in any form, except as polyethylene used for packing or wrapping.

Table 71-1. — Mass Limits for General License Packages Containing Mixed Quantities of Fissile Material or Uranium-235 of Unknown Enrichment per RH-3305.e.

Fissile material	Fissile material mass mixed with moderating substances having an average hydrogen density less than or equal to H_2O (grams)	Fissile material mass mixed with moderating substances having an average hydrogen density greater than H_2O[a] (grams)
^{235}U (X)	60	38
^{233}U (Y)	43	27
^{239}Pu or ^{241}Pu (Z)	37	24

[a] When mixtures of moderating substances are present, the lower mass limits shall be used if more than fifteen percent (15%) of the moderating substance has an average hydrogen density greater than H_2O.

Table 71-2. — Mass Limits for General License Packages Containing Uranium-235 of Known Enrichment per RH-3305.e.

Uranium enrichment in weight percent of ^{235}U not exceeding	Fissile material mass of ^{235}U (X) (grams)
24	60
20	63
15	67
11	72
10	76
9.5	78
9	81
8.5	82
8	85
7.5	88
7	90
6.5	93
6	97
5.5	102
5	108
4.5	114
4	120
3.5	132
3	150
2.5	180
2	246
1.5	408
1.35	480
1	1,020
0.92	1,800

RH-3306. **General license: Plutonium-Beryllium Special Form Material**.

a. A general license is issued to any licensee of the Department to transport fissile material in the form of plutonium-beryllium (Pu-Be) special form sealed sources, or to deliver Pu-Be sealed sources to a carrier for transport, if the material is shipped in accordance with this section. This material need not be contained in a package which meets the standards of Part E of this Section and 10 CFR Part 71, Subparts E and F; however, the material must be contained in a Type A package. The Type A package must also meet the DOT requirements of 49 CFR 173.417(a).

b. The general license applies only to a licensee who has a quality assurance program approved by the Department as satisfying the provisions of Part G of this Section.

c. The general license applies only when a package's contents:

1. Contain no more than a Type A quantity of radioactive material; and

2. Contain less than 1000 g of plutonium, provided that: plutonium-239, plutonium-241, or any combination of these radionuclides, constitutes less than 240 g of the total quantity of plutonium in the package.

d. The general license applies only to packages labeled with a CSI which:

1. Has been determined in accordance with paragraph (e) of this section;

2. Has a value less than or equal to 100; and

3. For a shipment of multiple packages containing Pu-Be sealed sources, the sum of the CSIs must be less than or equal to 50 (for shipment on a nonexclusive use conveyance) and less than or equal to 100 (for shipment on an exclusive use conveyance).

e. 1. The value for the CSI must be greater than or equal to the number calculated by the following equation:

$$CSI = 10 \left[\frac{\text{grams of } {}^{239}\text{Pu} + \text{grams of } {}^{241}\text{Pu}}{24} \right] \text{; and}$$

2. The calculated CSI must be rounded up to the first decimal place.

RH-3307.- RH-3399. Reserved.

PART E.
PACKAGE APPROVAL STANDARDS

RH- 3400. **External Radiation Standards for All Packages**.

a. Except as provided in RH-3400.b., each package of radioactive materials offered for transportation must be designed and prepared for shipment so that under conditions normally incident to transportation the radiation level does not exceed 2 mSv/h (200 mrem/h) at any point on the external surface of the package, and the transport index does not exceed 10.

b. A package that exceeds the radiation level limits specified in RH-3400.a. must be transported by exclusive use shipment only, and the radiation levels for such shipment must not exceed the following during transportation:

1. 2 mSv/h (200 mrem/h) on the external surface of the package, unless the following conditions are met, in which case the limit is 10 mSv/h (1000 mrem/h):

A. The shipment is made in a closed transport vehicle;

B. The package is secured within the vehicle so that its position remains fixed during transportation; and

C. There are no loading or unloading operations between the beginning and end of the transportation;

2. 2 mSv/h (200 mrem/h) at any point on the outer surface of the vehicle, including the top and underside of the vehicle; or in the case of a flat-bed style vehicle, at any point on the vertical planes projected from the outer edges of the vehicle, on the upper surface of the load or enclosure, if used, and on the lower external surface of the vehicle; and

3. 0.1 mSv/h (10 mrem/h) at any point 2 meters (80 in) from the outer lateral surfaces of the vehicle (excluding the top and underside of the vehicle); or in the case of a flat-bed style vehicle, at any point 2 meters (6.6 feet) from the vertical planes projected by the outer edges of the vehicle (excluding the top and underside of the vehicle); and

RH-3400.b. (Cont'd)

4. 0.02 mSv/h (2 mrem/h) in any normally occupied space, except that this provision does not apply to private carriers, if exposed personnel under their control wear radiation dosimetry devices in conformance with RH-1302.

c. For shipments made under the provisions of RH-3400.b., the shipper shall provide specific written instructions to the carrier for maintenance of the exclusive use shipment controls. The instructions must be included with the shipping paper information.

d. The written instructions required for exclusive use shipments must be sufficient so that, when followed, they will cause the carrier to avoid actions that will unnecessarily delay delivery or unnecessarily result in increased radiation levels or radiation exposures to transport workers or members of the general public.

RH-3401.- RH-3499. Reserved.

PART F.
OPERATING CONTROLS AND PROCEDURES

RH-3500. **Applicability of Operating Controls and Procedures**.

A licensee subject to this Section, who, under a general or specific license, transports licensed material or delivers licensed material to a carrier for transport, shall comply with the requirements of this Part F, with the quality assurance requirements of Part G of this Section, and with the general provisions of Part A of this Section.

RH-3501. **Assumptions as to Unknown Properties**.

When the isotopic abundance, mass, concentration, degree of irradiation, degree of moderation, or other pertinent property of fissile material in any package is not known, the licensee shall package the fissile material as if the unknown properties have credible values that will cause the maximum neutron multiplication.

RH-3502. **Preliminary Determinations**.

Before the first use of any packaging for the shipment of licensed material, the licensee shall ascertain that the determinations in paragraphs (a) through (c) of 10 CFR 71.85 have been made.

RH-3503. **Routine Determinations**.

Prior to each shipment of licensed material, the licensee shall ensure that the package with its contents satisfies the applicable requirements of this Section and the license. The licensee shall determine that:

a. The package is proper for the contents to be shipped;

b. The package is in unimpaired physical condition except for superficial defects such as marks or dents;

c. Each closure device of the packaging, including any required gasket, is properly installed, secured, and free of defects;

d. Any system for containing liquid is adequately sealed and has adequate space or other specified provision for expansion of the liquid;

RH-3503. (Cont'd)

e. Any pressure relief device is operable and set in accordance with written procedures;

f. The package has been loaded and closed in accordance with written procedures;

g. For fissile material, any moderator or neutron absorber, if required, is present and in proper condition;

h. Any structural part of the package that could be used to lift or tie down the package during transport is rendered inoperable for that purpose unless it satisfies design requirements of 10 CFR 71.45.

i. The level of non-fixed (removable) radioactive contamination on the external surfaces of each package offered for shipment is as low as reasonably achievable, and within the limits specified in DOT regulations in 49 CFR 173.443;

j. External radiation levels around the package and around the vehicle, if applicable, will not exceed the limits specified in RH-3400 at any time during transportation; and

k. Accessible package surface temperatures will not exceed the limits specified in 10 CFR 71.43(g) at any time during transportation.

RH-3504. **Air Transport of Plutonium**.

a. Notwithstanding the provisions of any general licenses and notwithstanding any exemptions stated directly in this Section or included indirectly by citation of the U.S. Department of Transportation regulations (49 CFR Chapter 1), as may be applicable, the licensee shall assure that plutonium in any form, whether for import, export, or domestic shipment, is not transported by air, or delivered to a carrier for air transport, unless:

1. The plutonium is contained in a medical device designed for individual human application; or

2. The plutonium is contained in a material in which the specific activity is less than or equal to the activity concentration values for plutonium specified in Table A-2 of Appendix A to this Section, and in which the radioactivity is essentially uniformly distributed; or

RH-3504.a. (Cont'd)

3. The plutonium is shipped in a single package containing no more than an A_2 quantity of plutonium in any isotope or form and is shipped in accordance with RH-3005.; or

4. The plutonium is shipped in a package specifically authorized for the shipment of plutonium by air in the Certificate of Compliance for that package issued by the U.S. Nuclear Regulatory Commission.

b. Nothing in RH-3504.a. is to be interpreted as removing or diminishing the requirements of the physical protection of plants where special nuclear materials are used as described in 10 CFR Part 73.24, "Prohibitions."

c. For a shipment of plutonium by air which is subject to RH-3504.a.4., the licensee shall, through special arrangement with the carrier, require compliance with 49 CFR 175.704, U.S. Department of Transportation regulations applicable to the air transport of plutonium.

RH-3505. **Opening Instructions**.

Before delivery of a package to a carrier for transport, the licensee shall ensure that any special instructions needed to safely open the package have been sent to, or otherwise made available to, the consignee for the consignee's use in accordance with RH-1307.f.

RH-3506. **Records**.

a. Each licensee shall maintain, for a period of three (3) years after shipment, a record of each shipment of licensed material not exempt under 10 CFR 71.14, showing where applicable:

1. Identification of the packaging by model number and serial number;

2. Verification that there were no significant defects in the packaging, as shipped;

3. Volume and identification of coolant;

4. Type and quantity of licensed material in each package, and the total quantity of each shipment;

RH-3506.a. (Cont'd)

5. For each item of irradiated fissile material:

   A. Identification by model number and serial number;

   B. Irradiation and decay history to the extent appropriate to demonstrate that its nuclear and thermal characteristics comply with license conditions; and

   C. Any abnormal or unusual condition relevant to radiation safety;

6. Date of the shipment;

7. For fissile packages and for Type B packages, any special controls exercised;

8. Name and address of the transferee;

9. Address to which the shipment was made; and

10. Results of the determinations required by RH-3503. and by the conditions of the package approval.

b. The licensee shall make available to the Department for inspection, upon reasonable notice, all records required by this Section. Records are only valid if stamped, initialed, or signed and dated by authorized personnel, or otherwise authenticated.

c. The licensee shall maintain sufficient written records to furnish evidence of the quality of packaging. The records to be maintained include results of the determinations required by RH-3502.; design, fabrication, and assembly records; results of reviews, inspections, tests, and audits; results of monitoring work performance and materials analyses; and results of maintenance, modification, and repair activities. Inspection, test, and audit records must identify the inspector or data recorder, the type of observation, the results, the acceptability, and the action taken in connection with any deficiencies noted. These records must be retained for three (3) years after the life of the packaging to which they apply.

RH-3507. **Inspection and Tests**.

a. Each licensee shall afford to the Department, at all reasonable times, opportunity to inspect the licensed material, packaging, premises, and facilities wherein such licensed material or packaging is used, provided, stored, or shipped.

b. Upon instruction from the Department, each licensee shall perform or cause to have performed and shall permit the Department to perform, such reasonable tests as the Department deems appropriate or necessary for the administration of these ~~Regulations~~ Rules.

RH-3508. **Reports**.

a. Each licensee shall submit a written report to the Department of:

1. Any instance in which there is a significant reduction in the effectiveness of any packaging during use;

2. Details of any defects with safety significance in any packaging, after first use; or

3. Any instance in which the conditions of approval in the Certificate of Compliance were not observed in making a shipment.

b. Each licensee shall submit, in accordance with RH-3003., the written report required by paragraph a. of this section within sixty (60) days of the event or discovery of the event. The licensee shall also provide a copy of each report submitted to the Department to the applicable certificate holder. Written reports prepared under other ~~regulations~~ rules may be submitted to fulfill this requirement if the reports contain all the necessary information.

The written report must include the following:

1. A brief abstract describing the major occurrences during the event, including all component or system failures that contributed to the event and significant corrective action taken or planned to prevent recurrence.

2. A clear, specific, narrative description of the event that occurred so that knowledgeable readers conversant with the requirements of Section 4 and 10 CFR Part 71, but not familiar with the design of the packaging, can understand the complete event. The narrative description must include the following specific information as appropriate for the particular event.

   A. Status of components or systems that were inoperable at the start of the event and that contributed to the event;

   B. Dates and approximate times of occurrences;

   C. The cause of each component or system failure or personnel error, if known;

   D. The failure mode, mechanism, and effect of each failed component, if known;

   E. A list of systems or secondary functions that were also affected for failures of components with multiple functions;

   F. The method of discovery of each component or system failure or procedural error;

   G. For each human performance-related root cause, a discussion of the cause(s) and circumstances;

   H. The manufacturer and model number (or other identification) of each component that failed during the event; and

   I. For events occurring during use of a packaging, the quantities and chemical and physical form(s) of the package contents.

3. An assessment of the safety consequences and implications of the event. This assessment must include the availability of other systems or components that could have performed the same function as the components and systems that failed during the event.

RH-3508.b. (Cont'd)

4. A description of any corrective actions planned as a result of the event, including the means employed to repair any defects, and actions taken to reduce the probability of similar events occurring in the future.

5. Reference to any previous similar events involving the same packaging that are known to the licensee.

6. The name and telephone number of a person within the licensee's organization who is knowledgeable about the event and can provide additional information.

7. The extent of exposure of individuals to radiation or to radioactive materials without identification of individuals by name.

c. **Report legibility**.

The reports submitted by licensees under this section must be of sufficient quality to permit reproduction and micrographic processing.

RH-3509. **Advance Notification of Shipment of Irradiated Reactor Fuel and Nuclear Waste**.

a. 1. As specified in paragraphs b., c., and d. of this section, each licensee shall provide advance notification to the governor of a State, or the governor's designee, of the shipment of licensed material, within or across the boundary of the State, before the transport, or delivery to a carrier, for transport, of licensed material outside the confines of the licensee's plant or other place of use or storage.

2. As specified in paragraphs b., c., and d. of this section, after June 11, 2013, each licensee shall provide advance notification to the Tribal official of participating Tribes referenced in paragraph c.3.C of this section, or the official's designee, of the shipment of licensed material, within or across the boundary of the Tribe's reservation, before the transport, or delivery to a carrier, for transport, of licensed material outside the confines of the licensee's plant or other place of use or storage.

b. Advance notification is also required under this section for the shipment of licensed material, other than irradiated fuel, meeting the following three conditions:

1. The licensed material is required by this Section to be in Type B packaging for transportation;

2. The licensed material is being transported to or across a State boundary en route to a disposal facility or to a collection point for transport to a disposal facility; and

3. The quantity of licensed material in a single package exceeds the least of the following:

A. 3000 times the A_1 value of the radionuclides as specified in Table A-1 of Appendix A to Section 4 for special form radioactive material;

B. 3000 times the A_2 value of the radionuclides as specified in Table A-1 of Appendix A to Section 4 for normal form radioactive material; or

C. 1000 TBq (27,000 Ci).

c. **Procedures for submitting advance notification**.

1. The notification must be made in writing to:

A. The office of each appropriate governor or governor's designee;

B. The office of each appropriate Tribal official or Tribal official's designee; and

C. The Director, Office of Nuclear Security and Incident Response, U.S. Nuclear Regulatory Commission.

2. A notification delivered by mail must be postmarked at least seven (7) days before the beginning of the seven (7) day period during which departure of the shipment is estimated to occur.

3. A notification delivered by any other means than mail must reach the office of the governor or of the governor's designee or the Tribal official or Tribal official's designee at least four (4) days before the beginning of the seven (7) day period during which departure of the shipment is estimated to occur.

   A. Reserved.

   B. Contact information for each State, including telephone and mailing addresses of governors and governors' designees, and participating Tribes, including telephone and mailing addresses of Tribal officials and Tribal officials' designees, is available on the U.S. Nuclear Regulatory Commission website at https://scp.nrc.gov/special/designee.pdf.

   C. A list of the names and mailing addresses of the governors' designees and Tribal officials' designees of participating Tribes is available on request from the Director, Division of Materials Safety, Security, State, and Tribal Programs, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001.

4. The licensee shall retain a copy of the notification as a record for three (3) years.

d. **Information to be furnished in advance notification of shipment**.

Each advance notification of shipment of irradiated reactor fuel or nuclear waste must contain the following information:

1. The name, address, and telephone number of the shipper, carrier, and receiver of the irradiated reactor fuel or nuclear waste shipment;

2. A description of the irradiated reactor fuel or nuclear waste shipment, as specified in the regulations of the U.S. Department of Transportation in 49 CFR 172.202 and 172.203(d);

3. The point of origin of the shipment and the seven (7) day period during which departure of the shipment is estimated to occur;

RH-3509.d. (Cont'd)

4. The seven (7) day period during which arrival of the shipment at State boundaries or Tribal reservation boundaries is estimated to occur;

5. The destination of the shipment, and the seven (7) day period during which arrival of the shipment is estimated to occur; and

6. A point of contact, with a telephone number, for current shipment information.

e. **Revision notice**.

A licensee who finds that schedule information previously furnished to a governor or governor's designee or a Tribal official or Tribal official's designee, in accordance with this section, will not be met, shall telephone a responsible individual in the office of the governor of the State or of the governor's designee or the Tribal official or the Tribal official's designee and inform that individual of the extent of the delay beyond the schedule originally reported. The licensee shall maintain a record of the name of the individual contacted for three (3) years.

f. **Cancellation notice**.

1. Each licensee who cancels an irradiated reactor fuel or nuclear waste shipment for which advance notification has been sent shall send a cancellation notice to the governor of each State or to the governor's designee previously notified, each Tribal official or to the Tribal official's designee previously notified, and the Director, Office of Nuclear Security and Incident Response, U.S. Nuclear Regulatory Commission.

2. The licensee shall state in the notice that it is a cancellation and identify the advance notification that is being canceled. The licensee shall retain a copy of the notice as a record for three (3) years.

RH-3510.- RH-3599. Reserved.

PART G.
QUALITY ASSURANCE

RH-3600. **Quality Assurance Requirements**.

a. **Purpose**.

This Part, in conjunction with Subpart H of 10 CFR Part 71, describes quality assurance requirements applying to design, purchase, fabrication, handling, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair, and modification of components of packaging that are important to safety. As used in this Part and Subpart H of 10 CFR Part 71, "quality assurance" comprises all those planned and systematic actions necessary to provide adequate confidence that a system or component will perform satisfactorily in service. Quality assurance includes quality control, which comprises those quality assurance actions related to control of the physical characteristics and quality of the material or component to predetermined requirements. Each certificate holder and applicant for a package approval, entities governed by the U.S. Nuclear Regulatory Commission, is responsible for satisfying the quality assurance requirements in Subpart H of 10 CFR Part 71 that apply to design, fabrication, testing, and modification of packaging. Each Department licensee is responsible for satisfying the quality assurance requirements that apply to its use of a packaging for the shipment of licensed material subject to this Part.

b. **Establishment of program**.

Each licensee shall establish, maintain, and execute a quality assurance program satisfying each of the applicable criteria of this Part and satisfying any specific provisions that are applicable to the licensee's activities including procurement of packaging. The licensee shall execute the applicable criteria in a graded approach to an extent that is commensurate with the quality assurance requirement's importance to safety.

c. **Approval of program**.

Before the use of any package for the shipment of licensed material subject to this Part, each licensee shall obtain Department approval of its quality assurance program. Each licensee shall submit to the Department a description of its quality assurance program, including a discussion of which requirements of this Part are applicable and how they will be satisfied.

RH-3600. (Cont'd)

d. **Radiography containers**.

A program for transport container inspection and maintenance limited to radiographic exposure devices, source changers, or packages transporting these devices and meeting the requirements of RH-1801.i.2. or equivalent U.S. Nuclear Regulatory Commission or Agreement State requirement, is deemed to satisfy the requirements of RH-3301.b. and RH-3600.b.

RH-3601. **Quality Assurance Organization**.

a. The licensee shall be responsible for the establishment and execution of the quality assurance program. The licensee may delegate to others, such as contractors, agents, or consultants, the work of establishing and executing the quality assurance program, or any part of the quality assurance program, but shall retain responsibility for the program. These activities include performing the functions associated with attaining quality objectives and the quality assurance functions.

b. The quality assurance functions are:

1. Assuring that an appropriate quality assurance program is established and effectively executed; and

2. Verifying, by procedures such as checking, auditing, and inspection, that activities affecting the functions that are important to safety have been correctly performed.

c. The persons and organizations performing quality assurance functions must have sufficient authority and organizational freedom to:

1. Identify quality problems;

2. Initiate, recommend, or provide solutions; and

3. Verify implementation of solutions.

d. The persons and organizations performing quality assurance functions shall report to a management level that assures that the required authority and organizational freedom, including sufficient independence from cost and schedule, when opposed to safety considerations, are provided.

RH-3601. (Cont'd)

e. Because of the many variables involved, such as the number of personnel, the type of activity being performed, and the location or locations where activities are performed, the organizational structure for executing the quality assurance program may take various forms, provided that the persons and organizations assigned the quality assurance functions have the required authority and organizational freedom.

f. Irrespective of the organizational structure, the individual(s) assigned the responsibility for assuring effective execution of any portion of the quality assurance program, at any location where activities subject to this section are being performed, must have direct access to the levels of management necessary to perform this function.

RH-3602. **Quality Assurance Program**.

a. The licensee shall establish, at the earliest practicable time consistent with the schedule for accomplishing the activities, a quality assurance program that complies with this Part. The licensee shall document the quality assurance program by written procedures or instructions and shall carry out the program in accordance with those procedures throughout the period during which the packaging is used. The licensee shall identify the material and components to be covered by the quality assurance program, the major organizations participating in the program, and the designated functions of these organizations.

b. The licensee through its quality assurance program, shall provide control over activities affecting the quality of the identified materials and components to an extent consistent with their importance to safety, and as necessary to assure conformance to the approved design of each individual package used for the shipment of radioactive material. The licensee shall assure that activities affecting quality are accomplished under suitably controlled conditions. Controlled conditions include the use of appropriate equipment; suitable environmental conditions for accomplishing the activity, such as adequate cleanliness; and assurance that all prerequisites for the given activity have been satisfied. The licensee, certificate holder, and applicant for a Certificate of Compliance (CoC) shall take into account, as applicable, the need for special controls, processes, test equipment, tools, and skills to attain the required quality, and the need for verification of quality by inspection and test.

RH-3602. (Cont'd)

c. The licensee, certificate holder, and applicant for a CoC shall base the requirements and procedures of their respective quality assurance programs on the following considerations, as applicable, concerning the complexity and proposed use of the package and its components:

1. The impact of malfunction or failure of the item to safety;

2. The design and fabrication complexity or uniqueness of the item;

3. The need for special controls and surveillance over processes and equipment;

4. The degree to which functional compliance can be demonstrated by inspection or test; and

5. The quality history and degree of standardization of the item.

d. The licensee shall provide for indoctrination and training of personnel performing activities affecting quality, as necessary to assure that suitable proficiency is achieved and maintained. The licensee shall review the status and adequacy of the quality assurance program at established intervals. Management of other organizations participating in the quality assurance program shall review regularly the status and adequacy of that part of the quality assurance program they are executing.

e. **Changes to quality assurance program.**

1. Each quality assurance program approval holder shall submit to the Department a description of a proposed change to its Department-approved quality assurance program that will reduce commitments in the program description as approved by the Department. The quality assurance program approval holder shall not implement the change before receiving Department approval.

A. The description of a proposed change to the Department-approved quality assurance program must identify the change, the reason for the change, and the basis for concluding that the revised program incorporating the change continues to satisfy the applicable requirements of this Part.

B. Reserved.

2. Each quality assurance program approval holder may change a previously approved quality assurance program without prior Department approval, if the change does not reduce the commitments in the quality assurance program previously approved by the Department. Changes to the quality assurance program that do not reduce the commitments shall be submitted to the Department every 24 months. In addition to quality assurance program changes involving administrative improvements and clarifications, spelling corrections, and non-substantive changes to punctuation or editorial items, the following changes are not considered reductions in commitment:

   A. The use of a quality assurance standard approved by the Department that is more recent than the quality assurance standard in the licensee's current quality assurance program at the time of the change;

   B. The use of generic organizational position titles that clearly denote the position function, supplemented as necessary by descriptive text, rather than specific titles, provided that there is no substantive change to either the functions of the position or reporting responsibilities;

   C. The use of generic organizational charts to indicate functional relationships, authorities, and responsibilities, or alternatively, the use of descriptive text, provided that there is no substantive change to the functional relationships, authorities, or responsibilities;

   D. The elimination of quality assurance program information that duplicates language in quality assurance regulatory guides and quality assurance standards to which the quality assurance program approval holder has committed to on record; and

   E. Organizational revisions that ensure that persons and organizations performing quality assurance functions continue to have the requisite authority and organizational freedom, including sufficient independence from cost and schedule when opposed to safety considerations.

3. Each quality assurance program approval holder shall maintain records of quality assurance program changes.

RH-3603. **Handling, Storage, and Shipping Control**.

The licensee shall establish measures to control, in accordance with instructions, the handling, storage, shipping, cleaning, and preservation of materials and equipment to be used in packaging to prevent damage or deterioration. When necessary for particular products, special protective environments, such as inert gas atmosphere, and specific moisture content and temperature levels must be specified and provided.

RH-3604. **Inspection, Test, and Operating Status**.

a. The licensee shall establish measures to indicate, by the use of markings such as stamps, tags, labels, routing cards, or other suitable means, the status of inspections and tests performed upon individual items of the packaging. These measures must provide for the identification of items that have satisfactorily passed required inspections and tests, where necessary to preclude inadvertent bypassing of the inspections and tests.

b. The licensee shall establish measures to identify the operating status of components of the packaging, such as tagging valves and switches, to prevent inadvertent operation.

RH-3605. **Nonconforming Materials, Parts, or Components**.

The licensee shall establish measures to control materials, parts, or components that do not conform to the licensee's requirements to prevent their inadvertent use or installation. These measures must include, as appropriate, procedures for identification, documentation, segregation, disposition, and notification to affected organizations. Nonconforming items must be reviewed and accepted, rejected, repaired, or reworked in accordance with documented procedures.

RH-3606. **Corrective Action**.

The licensee shall establish measures to assure that conditions adverse to quality, such as deficiencies, deviations, defective material and equipment, and nonconformances, are promptly identified and corrected. In the case of a significant condition adverse to quality, the measures must assure that the cause of the condition is determined and corrective action taken to preclude repetition. The identification of the significant condition adverse to quality, the cause of the condition, and the corrective action taken must be documented and reported to appropriate levels of management.

RH-3607. **Quality Assurance Records**.

The licensee shall maintain sufficient written records to describe the activities affecting quality. These records must include changes to the quality assurance program as required by RH-3602.e.; the instructions, procedures, and drawings required by 10 CFR 71.111 to prescribe quality assurance activities; and closely related specifications such as required qualifications of personnel, procedures, and equipment. The records must include the instructions or procedures that establish a records retention program that is consistent with applicable ~~regulations~~ rules and designates factors such as duration, location, and assigned responsibility. The licensee shall retain these records for three (3) years beyond the date when the licensee last engages in the activity for which the quality assurance program was developed. If any portion of the quality assurance program, written procedures, or instructions is superseded, the licensee shall retain the superseded material for three (3) years after it is superseded.

RH-3608. **Audits**.

The licensee shall carry out a comprehensive system of planned and periodic audits to verify compliance with all aspects of the quality assurance program and to determine the effectiveness of the program. The audits must be performed in accordance with written procedures or checklists by appropriately trained personnel not having direct responsibilities in the areas being audited. Audited results must be documented and reviewed by management having responsibility in the area audited. Follow-up action, including re-audit of deficient areas, must be taken where indicated.

RH-3609.- RH-3699. Reserved.

PART H.
ENFORCEMENT

RH-3700. **Violations.**

a. An injunction or other court order may be obtained prohibiting any violation of any provision of the Act or any ~~regulation~~ rule or order issued thereunder. Any person who willfully violates any provision of the Act or any ~~regulation~~ rule or order issued thereunder may be guilty of a felony, misdemeanor, or crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law. Arkansas Code Annotated §20-21-204 describes criminal and civil penalties which may be assessed.

b. **Impounding**.

Sources of radiation shall be subject to impounding pursuant to Section 5 of these ~~Regulations~~ Rules.

RH-3701.- RH-3999. Reserved.

APPENDIX A TO SECTION 4

DETERMINATION OF A_1 AND A_2

I. Values of A_1 and A_2 for individual radionuclides, which are the bases for many activity limits elsewhere in these ~~regulations~~ Rules, are given in Table A-1. The curie (Ci) values specified are obtained by converting from the Terabecquerel (TBq) value. The Terabecquerel values are the regulatory standard. The curie values are for information only and are not intended to be the regulatory standard. Where values of A_1 and A_2 are unlimited, it is for radiation control purposes only. For nuclear criticality safety, some materials are subject to controls placed on fissile material.

II. a. For individual radionuclides whose identities are known, but which are not listed in Table A-1, the A_1 and A_2 values contained in Table A-3 may be used. Otherwise, the licensee shall obtain prior Department approval of the A_1 and A_2 values for radionuclides not listed in Table A-1, before shipping the material.

b. For individual radionuclides whose identities are known, but which are not listed in Table A-2, the exempt material activity concentration and exempt consignment activity values contained in Table A-3 may be used. Otherwise, the licensee shall obtain prior Department approval of the exempt material activity concentration and exempt consignment activity values for radionuclides not listed in Table A-2, before shipping the material.

c. The licensee shall submit requests for prior approval, described under paragraphs II.a. and II.b. of this Appendix, to the Department, in accordance with RH-3003.

III. In the calculations of A_1 and A_2 for a radionuclide not in Table A-1, a single radioactive decay chain, in which radionuclides are present in their naturally occurring proportions, and in which no daughter radionuclide has a half-life either longer than 10 days, or longer than that of the parent radionuclide, shall be considered as a single radionuclide, and the activity to be taken into account, and the A_1 or A_2 value to be applied, shall be those corresponding to the parent radionuclide of that chain. In the case of radioactive decay chains in which any daughter radionuclide has a half-life either longer than 10 days, or greater than that of the parent radionuclide, the parent and those daughter radionuclides shall be considered as mixtures of different radionuclides.

IV. For mixtures of radionuclides whose identities and respective activities are known, the following conditions apply:

a. For special form radioactive material, the maximum quantity transported in a Type A package is as follows:

$$\sum_i \frac{B(i)}{A_1(i)} \leq 1$$

where B(i) is the activity of radionuclide i in special form, and $A_1(i)$ is the A_1 value for radionuclide i.

b. For normal form radioactive material, the maximum quantity transported in a Type A package is as follows:

$$\sum_i \frac{B(i)}{A_2(i)} \leq 1$$

where B(i) is the activity of radionuclide i in normal form, and $A_2(i)$ is the A_2 value for radionuclide i.

c. If the package contains both special and normal form radioactive material, the activity that may be transported in a Type A package is as follows:

$$\sum_i \frac{B(i)}{A_1(i)} + \sum_j \frac{C(j)}{A_2(j)} \leq 1$$

where B(i) is the activity of radionuclide i as special form radioactive material, $A_1(i)$ is the A_1 value for radionuclide i, C(j) is the activity of radionuclide j as normal form radioactive material, and $A_2(j)$ is the A_2 value for radionuclide j.

d. Alternatively, the A_1 value for mixtures of special form material may be determined as follows:

$$A_1 \text{ for mixture} = \frac{1}{\sum_i \frac{f(i)}{A_1(i)}}$$

where f(i) is the fraction of activity for radionuclide i in the mixture**,** and $A_1(i)$ is the appropriate A_1 value for radionuclide i.

e. Alternatively, the A_2 value for mixtures of normal form material may be determined as follows:

$$A_2 \text{ for mixture} = \frac{1}{\sum_i \frac{f(i)}{A_2(i)}}$$

where f(i) is the fraction of activity for radionuclide i in the mixture**,** and $A_2(i)$ is the appropriate A_2 value for radionuclide i.

f. The exempt activity concentration for mixtures of nuclides may be determined as follows:

$$\text{Exempt activity concentration for mixture} = \frac{1}{\sum_i \frac{f(i)}{[A](i)}}$$

where f(i) is the fraction of activity concentration of radionuclide i in the mixture, and [A](i) is the activity concentration for exempt material containing radionuclide i.

g. The activity limit for an exempt consignment for mixtures of radionuclides may be determined as follows:

$$\text{Exempt consignment activity limit for mixture} = \frac{1}{\sum_i \frac{f(i)}{A(i)}}$$

where f(i) is the fraction of activity of radionuclide i in the mixture, and A(i) is the activity limit for exempt consignments for radionuclide i.

V. a. When the identity of each radionuclide is known, but the individual activities of some of the radionuclides are not known, the radionuclides may be grouped~~,~~ and the lowest A_1 or A_2 value, as appropriate, for the radionuclides in each group may be used in applying the formulas in paragraph IV. of this Appendix. Groups may be based on the total alpha activity and the total beta/gamma activity when these are known, using the lowest A_1 or A_2 values for the alpha emitters and beta/gamma emitters, respectively.

b. When the identity of each radionuclide is known, but the individual activities of some of the radionuclides are not known, the radionuclides may be grouped and the lowest [A] (activity concentration for exempt material) or A (activity limit for exempt consignment) value, as appropriate, for the radionuclides in each group may be used in applying the formulas in paragraph IV. of this Appendix. Groups may be based on the total alpha activity and the total beta/gamma activity when these are known, using the lowest [A] or A values for the alpha emitters and beta/gamma emitters, respectively.

TABLE A-1—A_1 AND A_2 VALUES FOR RADIONUCLIDES

Symbol of radionuclide	Element and atomic number	A_1 (TBq)	A_1(Ci)[b]	A_2 (TBq)	A_2(Ci)[b]	Specific activity	
						(TBq/g)	(Ci/g)
Ac-225 (a)	Actinium (89)	$8.0X10^{-1}$	$2.2X10^{1}$	$6.0X10^{-3}$	$1.6X10^{-1}$	$2.1X10^{3}$	$5.8X10^{4}$
Ac-227 (a)		$9.0X10^{-1}$	$2.4X10^{1}$	$9.0X10^{-5}$	$2.4X10^{-3}$	2.7	$7.2X10^{1}$
Ac-228		$6.0X10^{-1}$	$1.6X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$8.4X10^{4}$	$2.2X10^{6}$
Ag-105	Silver (47)	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$1.1X10^{3}$	$3.0X10^{4}$
Ag-108m (a)		$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$9.7X10^{-1}$	$2.6X10^{1}$
Ag-110m (a)		$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.8X10^{2}$	$4.7X10^{3}$
Ag-111		2.0	$5.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$5.8X10^{3}$	$1.6X10^{5}$
Al-26	Aluminum (13)	$1.0X10^{-1}$	2.7	$1.0X10^{-1}$	2.7	$7.0X10^{-4}$	$1.9X10^{-2}$
Am-241	Americium (95)	$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$1.3X10^{-1}$	3.4
Am-242m (a)		$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$3.6X10^{-1}$	$1.0X10^{1}$
Am-243 (a)		5.0	$1.4X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$7.4X10^{-3}$	$2.0X10^{-1}$
Ar-37	Argon (18)	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$3.7X10^{3}$	$9.9X10^{4}$
Ar-39		$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{1}$	$5.4X10^{2}$	1.3	$3.4X10^{1}$
Ar-41		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$1.5X10^{6}$	$4.2X10^{7}$
As-72	Arsenic (33)	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$6.2X10^{4}$	$1.7X10^{6}$
As-73		$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$8.2X10^{2}$	$2.2X10^{4}$
As-74		1.0	$2.7X10^{1}$	$9.0X10^{-1}$	$2.4X10^{1}$	$3.7X10^{3}$	$9.9X10^{4}$
As-76		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$5.8X10^{4}$	$1.6X10^{6}$
As-77		$2.0X10^{1}$	$5.4X10^{2}$	$7.0X10^{-1}$	$1.9X10^{1}$	$3.9X10^{4}$	$1.0X10^{6}$
At-211 (a)	Astatine (85)	$2.0X10^{1}$	$5.4X10^{2}$	$5.0X10^{-1}$	$1.4X10^{1}$	$7.6X10^{4}$	$2.1X10^{6}$
Au-193	Gold (79)	7.0	$1.9X10^{2}$	2.0	$5.4X10^{1}$	$3.4X10^{4}$	$9.2X10^{5}$
Au-194		1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$1.5X10^{4}$	$4.1X10^{5}$
Au-195		$1.0X10^{1}$	$2.7X10^{2}$	6.0	$1.6X10^{2}$	$1.4X10^{2}$	$3.7X10^{3}$
Au-198		1.0	$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$9.0X10^{3}$	$2.4X10^{5}$
Au-199		$1.0X10^{1}$	$2.7X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$7.7X10^{3}$	$2.1X10^{5}$
Ba-131 (a)	Barium (56)	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$3.1X10^{3}$	$8.4X10^{4}$

Table A-1 of Appendix A to Section 4 (Cont'd)

Ba-133		3.0	$8.1X10^{1}$	3.0	$8.1X10^{1}$	9.4	$2.6X10^{2}$
Ba-133m		$2.0X10^{1}$	$5.4X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.2X10^{4}$	$6.1X10^{5}$
Ba-140 (a)		$5.0X10^{-1}$	$1.4X10^{1}$	$3.0X10^{-1}$	8.1	$2.7X10^{3}$	$7.3X10^{4}$
Be-7	Beryllium (4)	$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{1}$	$5.4X10^{2}$	$1.3X10^{4}$	$3.5X10^{5}$
Be-10		$4.0X10^{1}$	$1.1X10^{3}$	$6.0X10^{-1}$	$1.6X10^{1}$	$8.3X10^{-4}$	$2.2X10^{-2}$
Bi-205	Bismuth (83)	$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$1.5X10^{3}$	$4.2X10^{4}$
Bi-206		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$3.8X10^{3}$	$1.0X10^{5}$
Bi-207		$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	1.9	$5.2X10^{1}$
Bi-210		1.0	$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$4.6X10^{3}$	$1.2X10^{5}$
Bi-210m (a)		$6.0X10^{-1}$	$1.6X10^{1}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$2.1X10^{-5}$	$5.7X10^{-4}$
Bi-212 (a)		$7.0X10^{-1}$	$1.9X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$5.4X10^{5}$	$1.5X10^{7}$
Bk-247	Berkelium (97)	8.0	$2.2X10^{2}$	$8.0X10^{-4}$	$2.2X10^{-2}$	$3.8X10^{-2}$	1.0
Bk-249 (a)		$4.0X10^{1}$	$1.1X10^{3}$	$3.0X10^{-1}$	8.1	$6.1X10^{1}$	$1.6X10^{3}$
Br-76	Bromine (35)	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$9.4X10^{4}$	$2.5X10^{6}$
Br-77		3.0	$8.1X10^{1}$	3.0	$8.1X10^{1}$	$2.6X10^{4}$	$7.1X10^{5}$
Br-82		$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{4}$	$1.1X10^{6}$
C-11	Carbon (6)	1.0	$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.1X10^{7}$	$8.4X10^{8}$
C-14		$4.0X10^{1}$	$1.1X10^{3}$	3.0	$8.1X10^{1}$	$1.6X10^{-1}$	4.5
Ca-41	Calcium (20)	Unlimited	Unlimited	Unlimited	Unlimited	$3.1X10^{-3}$	$8.5X10^{-2}$
Ca-45		$4.0X10^{1}$	$1.1X10^{3}$	1.0	$2.7X10^{1}$	$6.6X10^{2}$	$1.8X10^{4}$
Ca-47 (a)		3.0	$8.1X10^{1}$	$3.0X10^{-1}$	8.1	$2.3X10^{4}$	$6.1X10^{5}$
Cd-109	Cadmium (48)	$3.0X10^{1}$	$8.1X10^{2}$	2.0	$5.4X10^{1}$	$9.6X10^{1}$	$2.6X10^{3}$
Cd-113m		$4.0X10^{1}$	$1.1X10^{3}$	$5.0X10^{-1}$	$1.4X10^{1}$	8.3	$2.2X10^{2}$
Cd-115 (a)		3.0	$8.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.9X10^{4}$	$5.1X10^{5}$
Cd-115m		$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$9.4X10^{2}$	$2.5X10^{4}$
Ce-139	Cerium (58)	7.0	$1.9X10^{2}$	2.0	$5.4X10^{1}$	$2.5X10^{2}$	$6.8X10^{3}$
Ce-141		$2.0X10^{1}$	$5.4X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.1X10^{3}$	$2.8X10^{4}$
Ce-143		$9.0X10^{-1}$	$2.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.5X10^{4}$	$6.6X10^{5}$
Ce-144 (a)		$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$1.2X10^{2}$	$3.2X10^{3}$
Cf-248	Californium (98)	$4.0X10^{1}$	$1.1X10^{3}$	$6.0X10^{-3}$	$1.6X10^{-1}$	$5.8X10^{1}$	$1.6X10^{3}$
Cf-249		3.0	$8.1X10^{1}$	$8.0X10^{-4}$	$2.2X10^{-2}$	$1.5X10^{-1}$	4.1
Cf-250		$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{-3}$	$5.4X10^{-2}$	4.0	$1.1X10^{2}$

Table A-1 of Appendix A to Section 4 (Cont'd)

Cf-251		7.0	$1.9X10^{2}$	$7.0X10^{-4}$	$1.9X10^{-2}$	$5.9X10^{-2}$	1.6
Cf-252		$1.0X10^{-1}$	2.7	$3.0X10^{-3}$	$8.1X10^{-2}$	$2.0X10^{1}$	$5.4X10^{2}$
Cf-253 (a)		$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{-2}$	1.1	$1.1X10^{3}$	$2.9X10^{4}$
Cf-254		$1.0X10^{-3}$	$2.7X10^{-2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$3.1X10^{2}$	$8.5X10^{3}$
Cl-36	Chlorine (17)	$1.0X10^{1}$	$2.7X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.2X10^{-3}$	$3.3X10^{-2}$
Cl-38		$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$4.9X10^{6}$	$1.3X10^{8}$
Cm-240	Curium (96)	$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$7.5X10^{2}$	$2.0X10^{4}$
Cm-241		2.0	$5.4X10^{1}$	1.0	$2.7X10^{1}$	$6.1X10^{2}$	$1.7X10^{4}$
Cm-242		$4.0X10^{1}$	$1.1X10^{3}$	$1.0X10^{-2}$	$2.7X10^{-1}$	$1.2X10^{2}$	$3.3X10^{3}$
Cm-243		9.0	$2.4X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$1.9X10^{-3}$	$5.2X10^{1}$
Cm-244		$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{-3}$	$5.4X10^{-2}$	3.0	$8.1X10^{1}$
Cm-245		9.0	$2.4X10^{2}$	$9.0X10^{-4}$	$2.4X10^{-2}$	$6.4X10^{-3}$	$1.7X10^{-1}$
Cm-246		9.0	$2.4X10^{2}$	$9.0X10^{-4}$	$2.4X10^{-2}$	$1.1X10^{-2}$	$3.1X10^{-1}$
Cm-247 (a)		3.0	$8.1X10^{1}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$3.4X10^{-6}$	$9.3X10^{-5}$
Cm-248		$2.0X10^{-2}$	$5.4X10^{-1}$	$3.0X10^{-4}$	$8.1X10^{-3}$	$1.6X10^{-4}$	$4.2X10^{-3}$
Co-55	Cobalt (27)	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$1.1X10^{5}$	$3.1X10^{6}$
Co-56		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$1.1X10^{3}$	$3.0X10^{4}$
Co-57		$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	$3.1X10^{2}$	$8.4X10^{3}$
Co-58		1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$1.2X10^{3}$	$3.2X10^{4}$
Co-58m		$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$2.2X10^{5}$	$5.9X10^{6}$
Co-60		$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$4.2X10^{1}$	$1.1X10^{3}$
Cr-51	Chromium (24)	$3.0X10^{1}$	$8.1X10^{2}$	$3.0X10^{1}$	$8.1X10^{2}$	$3.4X10^{3}$	$9.2X10^{4}$
Cs-129	Cesium (55)	4.0	$1.1X10^{2}$	4.0	$1.1X10^{2}$	$2.8X10^{4}$	$7.6X10^{5}$
Cs-131		$3.0X10^{1}$	$8.1X10^{2}$	$3.0X10^{1}$	$8.1X10^{2}$	$3.8X10^{3}$	$1.0X10^{5}$
Cs-132		1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$5.7X10^{3}$	$1.5X10^{5}$
Cs-134		$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$4.8X10^{1}$	$1.3X10^{3}$
Cs-134m		$4.0X10^{1}$	$1.1X10^{3}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.0X10^{5}$	$8.0X10^{6}$
Cs-135		$4.0X10^{1}$	$1.1X10^{3}$	1.0	$2.7X10^{1}$	$4.3X10^{-5}$	$1.2X10^{-3}$
Cs-136		$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$2.7X10^{3}$	$7.3X10^{4}$
Cs-137 (a)		2.0	$5.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	3.2	$8.7X10^{1}$
Cu-64	Copper (29)	6.0	$1.6X10^{2}$	1.0	$2.7X10^{1}$	$1.4X10^{5}$	$3.9X10^{6}$
Cu-67		$1.0X10^{1}$	$2.7X10^{2}$	$7.0X10^{-1}$	$1.9X10^{1}$	$2.8X10^{4}$	$7.6X10^{5}$

Table A-1 of Appendix A to Section 4 (Cont'd)

Dy-159	Dysprosium (66)	$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{1}$	$5.4X10^{2}$	$2.1X10^{2}$	$5.7X10^{3}$
Dy-165		$9.0X10^{-1}$	$2.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.0X10^{5}$	$8.2X10^{6}$
Dy-166 (a)		$9.0X10^{-1}$	$2.4X10^{1}$	$3.0X10^{-1}$	8.1	$8.6X10^{3}$	$2.3X10^{5}$
Er-169	Erbium (68)	$4.0X10^{1}$	$1.1X10^{3}$	1.0	$2.7X10^{1}$	$3.1X10^{3}$	$8.3X10^{4}$
Er-171		$8.0X10^{-1}$	$2.2X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$9.0X10^{4}$	$2.4X10^{6}$
Eu-147	Europium (63)	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$1.4X10^{3}$	$3.7X10^{4}$
Eu-148		$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$6.0X10^{2}$	$1.6X10^{4}$
Eu-149		$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{1}$	$5.4X10^{2}$	$3.5X10^{2}$	$9.4X10^{3}$
Eu-150 (short lived)		2.0	$5.4X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$6.1X10^{4}$	$1.6X10^{6}$
Eu-150 (long lived)		$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$6.1X10^{4}$	$1.6X10^{6}$
Eu-152		1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	6.5	$1.8X10^{2}$
Eu-152m		$8.0X10^{-1}$	$2.2X10^{1}$	$8.0X10^{-1}$	$2.2X10^{1}$	$8.2X10^{4}$	$2.2X10^{6}$
Eu-154		$9.0X10^{-1}$	$2.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	9.8	$2.6X10^{2}$
Eu-155		$2.0X10^{1}$	$5.4X10^{2}$	3.0	$8.1X10^{1}$	$1.8X10^{1}$	$4.9X10^{2}$
Eu-156		$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$2.0X10^{3}$	$5.5X10^{4}$
F-18	Fluorine (9)	1.0	$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.5X10^{6}$	$9.5X10^{7}$
Fe-52 (a)	Iron (26)	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$2.7X10^{5}$	$7.3X10^{6}$
Fe-55		$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$8.8X10^{1}$	$2.4X10^{3}$
Fe-59		$9.0X10^{-1}$	$2.4X10^{1}$	$9.0X10^{-1}$	$2.4X10^{1}$	$1.8X10^{3}$	$5.0X10^{4}$
Fe-60 (a)		$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{-1}$	5.4	$7.4X10^{-4}$	$2.0X10^{-2}$
Ga-67	Gallium (31)	7.0	$1.9X10^{2}$	3.0	$8.1X10^{1}$	$2.2X10^{4}$	$6.0X10^{5}$
Ga-68		$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$1.5X10^{6}$	$4.1X10^{7}$
Ga-72		$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.1X10^{5}$	$3.1X10^{6}$
Gd-146 (a)	Gadolinium (64)	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$6.9X10^{2}$	$1.9X10^{4}$
Gd-148		$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{-3}$	$5.4X10^{-2}$	1.2	$3.2X10^{1}$
Gd-153		$1.0X10^{1}$	$2.7X10^{2}$	9.0	$2.4X10^{2}$	$1.3X10^{2}$	$3.5X10^{3}$
Gd-159		3.0	$8.1X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.9X10^{4}$	$1.1X10^{6}$
Ge-68 (a)	Germanium (32)	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$2.6X10^{2}$	$7.1X10^{3}$
Ge-71		$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$5.8X10^{3}$	$1.6X10^{5}$
Ge-77		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$1.3X10^{5}$	$3.6X10^{6}$
Hf-172 (a)	Hafnium (72)	$6.0X10^{-1}$	$1.6X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$4.1X10^{1}$	$1.1X10^{3}$
Hf-175		3.0	$8.1X10^{1}$	3.0	$8.1X10^{1}$	$3.9X10^{2}$	$1.1X10^{4}$

Table A-1 of Appendix A to Section 4 (Cont'd)

Hf-181		2.0	$5.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$6.3X10^{2}$	$1.7X10^{4}$
Hf-182		Unlimited	Unlimited	Unlimited	Unlimited	$8.1X10^{-6}$	$2.2X10^{-4}$
Hg-194 (a)	Mercury (80)	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$1.3X10^{-1}$	3.5
Hg-195m (a)		3.0	$8.1X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$1.5X10^{4}$	$4.0X10^{5}$
Hg-197		$2.0X10^{1}$	$5.4X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	$9.2X10^{3}$	$2.5X10^{5}$
Hg-197m		$1.0X10^{1}$	$2.7X10^{2}$	$4.0X10^{-1}$	$1.1X10^{1}$	$2.5X10^{4}$	$6.7X10^{5}$
Hg-203		5.0	$1.4X10^{2}$	1.0	$2.7X10^{1}$	$5.1X10^{2}$	$1.4X10^{4}$
Ho-166	Holmium (67)	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$2.6X10^{4}$	$7.0X10^{5}$
Ho-166m		$6.0X10^{-1}$	$1.6X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$6.6X10^{-2}$	1.8
I-123	Iodine (53)	6.0	$1.6X10^{2}$	3.0	$8.1X10^{1}$	$7.1X10^{4}$	$1.9X10^{6}$
I-124		1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$9.3X10^{3}$	$2.5X10^{5}$
I-125		$2.0X10^{1}$	$5.4X10^{2}$	3.0	$8.1X10^{1}$	$6.4X10^{2}$	$1.7X10^{4}$
I-126		2.0	$5.4X10^{1}$	1.0	$2.7X10^{1}$	$2.9X10^{3}$	$8.0X10^{4}$
I-129		Unlimited	Unlimited	Unlimited	Unlimited	$6.5X10^{-6}$	$1.8X10^{-4}$
I-131		3.0	$8.1X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$4.6X10^{3}$	$1.2X10^{5}$
I-132		$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$3.8X10^{5}$	$1.0X10^{7}$
I-133		$7.0X10^{-1}$	$1.9X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$4.2X10^{4}$	$1.1X10^{6}$
I-134		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$9.9X10^{5}$	$2.7X10^{7}$
I-135 (a)		$6.0X10^{-1}$	$1.6X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.3X10^{5}$	$3.5X10^{6}$
In-111	Indium (49)	3.0	$8.1X10^{1}$	3.0	$8.1X10^{1}$	$1.5X10^{4}$	$4.2X10^{5}$
In-113m		4.0	$1.1X10^{2}$	2.0	$5.4X10^{1}$	$6.2X10^{5}$	$1.7X10^{7}$
In-114m (a)		$1.0X10^{1}$	$2.7X10^{2}$	$5.0X10^{-1}$	$1.4X10^{1}$	$8.6X10^{2}$	$2.3X10^{4}$
In-115m		7.0	$1.9X10^{2}$	1.0	$2.7X10^{1}$	$2.2X10^{5}$	$6.1X10^{6}$
Ir-189 (a)	Iridium (77)	$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	$1.9X10^{3}$	$5.2X10^{4}$
Ir-190		$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$2.3X10^{3}$	$6.2X10^{4}$
Ir-192		[c]1.0	[c]$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.4X10^{2}$	$9.2X10^{3}$
Ir-194		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$3.1X10^{4}$	$8.4X10^{5}$
K-40	Potassium (19)	$9.0X10^{-1}$	$2.4X10^{1}$	$9.0X10^{-1}$	$2.4X10^{1}$	$2.4X10^{-7}$	$6.4X10^{-6}$
K-42		$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$2.2X10^{5}$	$6.0X10^{6}$
K-43		$7.0X10^{-1}$	$1.9X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.2X10^{5}$	$3.3X10^{6}$
Kr-79	Krypton (36)	4.0	$1.1x10^{2}$	2.0	$5.4x10^{1}$	$4.2x10^{4}$	$1.1x10^{6}$
Kr-81		$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$7.8X10^{-4}$	$2.1X10^{-2}$

Table A-1 of Appendix A to Section 4 (Cont'd)

Kr-85		$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	$1.5X10^{1}$	$3.9X10^{2}$
Kr-85m		8.0	$2.2X10^{2}$	3.0	$8.1X10^{1}$	$3.0X10^{5}$	$8.2X10^{6}$
Kr-87		$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$1.0X10^{6}$	$2.8X10^{7}$
La-137	Lanthanum (57)	$3.0X10^{1}$	$8.1X10^{2}$	6.0	$1.6X10^{2}$	$1.6X10^{-3}$	$4.4X10^{-2}$
La-140		$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$2.1X10^{4}$	$5.6X10^{5}$
Lu-172	Lutetium (71)	$6.0X10^{-1}$	$1.6X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$4.2X10^{3}$	$1.1X10^{5}$
Lu-173		8.0	$2.2X10^{2}$	8.0	$2.2X10^{2}$	$5.6X10^{1}$	$1.5X10^{3}$
Lu-174		9.0	$2.4X10^{2}$	9.0	$2.4X10^{2}$	$2.3X10^{1}$	$6.2X10^{2}$
Lu-174m		$2.0X10^{1}$	$5.4X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	$2.0X10^{2}$	$5.3X10^{3}$
Lu-177		$3.0X10^{1}$	$8.1X10^{2}$	$7.0X10^{-1}$	$1.9X10^{1}$	$4.1X10^{3}$	$1.1X10^{5}$
Mg-28 (a)	Magnesium (12)	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$2.0X10^{5}$	$5.4X10^{6}$
Mn-52	Manganese (25)	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$1.6X10^{4}$	$4.4X10^{5}$
Mn-53		Unlimited	Unlimited	Unlimited	Unlimited	$6.8X10^{-5}$	$1.8X10^{-3}$
Mn-54		1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$2.9X10^{2}$	$7.7X10^{3}$
Mn-56		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$8.0X10^{5}$	$2.2X10^{7}$
Mo-93	Molybdenum (42)	$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{1}$	$5.4X10^{2}$	$4.1X10^{-2}$	1.1
Mo-99 (a) (h)		1.0	$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.8X10^{4}$	$4.8X10^{5}$
N-13	Nitrogen (7)	$9.0X10^{-1}$	$2.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$5.4X10^{7}$	$1.5X10^{9}$
Na-22	Sodium (11)	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$2.3X10^{2}$	$6.3X10^{3}$
Na-24		$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$3.2X10^{5}$	$8.7X10^{6}$
Nb-93m	Niobium (41)	$4.0X10^{1}$	$1.1X10^{3}$	$3.0X10^{1}$	$8.1X10^{2}$	8.8	$2.4X10^{2}$
Nb-94		$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$6.9X10^{-3}$	$1.9X10^{-1}$
Nb-95		1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$1.5X10^{3}$	$3.9X10^{4}$
Nb-97		$9.0X10^{-1}$	$2.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$9.9X10^{5}$	$2.7X10^{7}$
Nd-147	Neodymium (60)	6.0	$1.6X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.0X10^{3}$	$8.1X10^{4}$
Nd-149		$6.0X10^{-1}$	$1.6X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$4.5X10^{5}$	$1.2X10^{7}$
Ni-59	Nickel (28)	Unlimited	Unlimited	Unlimited	Unlimited	$3.0X10^{-3}$	$8.0X10^{-2}$
Ni-63		$4.0X10^{1}$	$1.1X10^{3}$	$3.0X10^{1}$	$8.1X10^{2}$	2.1	$5.7X10^{1}$
Ni-65		$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$7.1X10^{5}$	$1.9X10^{7}$
Np-235	Neptunium (93)	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$5.2X10^{1}$	$1.4X10^{3}$
Np-236 (short-lived)		$2.0X10^{1}$	$5.4X10^{2}$	2.0	$5.4X10^{1}$	$4.7X10^{-4}$	$1.3X10^{-2}$
Np-236 (long-lived)		$9.0X10^{0}$	$2.4X10^{2}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$4.7X10^{-4}$	$1.3X10^{-2}$

Table A-1 of Appendix A to Section 4 (Cont'd)

Np-237		$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{-3}$	$5.4X10^{-2}$	$2.6X10^{-5}$	$7.1X10^{-4}$
Np-239		7.0	$1.9X10^{2}$	$4.0X10^{-1}$	$1.1X10^{1}$	$8.6X10^{3}$	$2.3X10^{5}$
Os-185	Osmium (76)	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$2.8X10^{2}$	$7.5X10^{3}$
Os-191		$1.0X10^{1}$	$2.7X10^{2}$	2.0	$5.4X10^{1}$	$1.6X10^{3}$	$4.4X10^{4}$
Os-191m		$4.0X10^{1}$	$1.1X10^{3}$	$3.0X10^{1}$	$8.1X10^{2}$	$4.6X10^{4}$	$1.3X10^{6}$
Os-193		2.0	$5.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.0X10^{4}$	$5.3X10^{5}$
Os-194 (a)		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$1.1X10^{1}$	$3.1X10^{2}$
P-32	Phosphorus (15)	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$1.1X10^{4}$	$2.9X10^{5}$
P-33		$4.0X10^{1}$	$1.1X10^{3}$	1.0	$2.7X10^{1}$	$5.8X10^{3}$	$1.6X10^{5}$
Pa-230 (a)	Protactinium (91)	2.0	$5.4X10^{1}$	$7.0X10^{-2}$	1.9	$1.2X10^{3}$	$3.3X10^{4}$
Pa-231		4.0	$1.1X10^{2}$	$4.0X10^{-4}$	$1.1X10^{-2}$	$1.7X10^{-3}$	$4.7X10^{-2}$
Pa-233		5.0	$1.4X10^{2}$	$7.0X10^{-1}$	$1.9X10^{1}$	$7.7X10^{2}$	$2.1X10^{4}$
Pb-201	Lead (82)	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$6.2X10^{4}$	$1.7X10^{6}$
Pb-202		$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{1}$	$5.4X10^{2}$	$1.2X10^{-4}$	$3.4X10^{-3}$
Pb-203		4.0	$1.1X10^{2}$	3.0	$8.1X10^{1}$	$1.1X10^{4}$	$3.0X10^{5}$
Pb-205		Unlimited	Unlimited	Unlimited	Unlimited	$4.5X10^{-6}$	$1.2X10^{-4}$
Pb-210 (a)		1.0	$2.7X10^{1}$	$5.0X10^{-2}$	1.4	2.8	$7.6X10^{1}$
Pb-212 (a)		$7.0X10^{-1}$	$1.9X10^{1}$	$2.0X10^{-1}$	5.4	$5.1X10^{4}$	$1.4X10^{6}$
Pd-103 (a)	Palladium (46)	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$2.8X10^{3}$	$7.5X10^{4}$
Pd-107		Unlimited	Unlimited	Unlimited	Unlimited	$1.9X10^{-5}$	$5.1X10^{-4}$
Pd-109		2.0	$5.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$7.9X10^{4}$	$2.1X10^{6}$
Pm-143	Promethium (61)	3.0	$8.1X10^{1}$	3.0	$8.1X10^{1}$	$1.3X10^{2}$	$3.4X10^{3}$
Pm-144		$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$9.2X10^{1}$	$2.5X10^{3}$
Pm-145		$3.0X10^{1}$	$8.1X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	5.2	$1.4X10^{2}$
Pm-147		$4.0X10^{1}$	$1.1X10^{3}$	2.0	$5.4X10^{1}$	$3.4X10^{1}$	$9.3X10^{2}$
Pm-148m (a)		$8.0X10^{-1}$	$2.2X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$7.9X10^{2}$	$2.1X10^{4}$
Pm-149		2.0	$5.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.5X10^{4}$	$4.0X10^{5}$
Pm-151		2.0	$5.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.7X10^{4}$	$7.3X10^{5}$
Po-210	Polonium (84)	$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$1.7X10^{2}$	$4.5X10^{3}$
Pr-142	Praseodymium (59)	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$4.3X10^{4}$	$1.2X10^{6}$
Pr-143		3.0	$8.1X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.5X10^{3}$	$6.7X10^{4}$
Pt-188 (a)	Platinum (78)	1.0	$2.7X10^{1}$	$8.0X10^{-1}$	$2.2X10^{1}$	$2.5X10^{3}$	$6.8X10^{4}$

Table A-1 of Appendix A to Section 4 (Cont'd)

Pt-191		4.0	$1.1X10^{2}$	3.0	$8.1X10^{1}$	$8.7X10^{3}$	$2.4X10^{5}$
Pt-193		$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	1.4	$3.7X10^{1}$
Pt-193m		$4.0X10^{1}$	$1.1X10^{3}$	$5.0X10^{-1}$	$1.4X10^{1}$	$5.8X10^{3}$	$1.6X10^{5}$
Pt-195m		$1.0X10^{1}$	$2.7X10^{2}$	$5.0X10^{-1}$	$1.4X10^{1}$	$6.2X10^{3}$	$1.7X10^{5}$
Pt-197		$2.0X10^{1}$	$5.4X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.2X10^{4}$	$8.7X10^{5}$
Pt-197m		$1.0X10^{1}$	$2.7X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.7X10^{5}$	$1.0X10^{7}$
Pu-236	Plutonium (94)	$3.0X10^{1}$	$8.1X10^{2}$	$3.0X10^{-3}$	$8.1X10^{-2}$	$2.0X10^{1}$	$5.3X10^{2}$
Pu-237		$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{1}$	$5.4X10^{2}$	$4.5X10^{2}$	$1.2X10^{4}$
Pu-238		$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$6.3X10^{-1}$	$1.7X10^{1}$
Pu-239		$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$2.3X10^{-3}$	$6.2X10^{-2}$
Pu-240		$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$8.4X10^{-3}$	$2.3X10^{-1}$
Pu-241 (a)		$4.0X10^{1}$	$1.1X10^{3}$	$6.0X10^{-2}$	1.6	3.8	$1.0X10^{2}$
Pu-242		$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$1.5X10^{-4}$	$3.9X10^{-3}$
Pu-244 (a)		$4.0X10^{-1}$	$1.1X10^{1}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$6.7X10^{-7}$	$1.8X10^{-5}$
Ra-223 (a)	Radium (88)	$4.0X10^{-1}$	$1.1X10^{1}$	$7.0X10^{-3}$	$1.9X10^{-1}$	$1.9X10^{3}$	$5.1X10^{4}$
Ra-224 (a)		$4.0X10^{-1}$	$1.1X10^{1}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$5.9X10^{3}$	$1.6X10^{5}$
Ra-225 (a)		$2.0X10^{-1}$	5.4	$4.0X10^{-3}$	$1.1X10^{-1}$	$1.5X10^{3}$	$3.9X10^{4}$
Ra-226 (a)		$2.0X10^{-1}$	5.4	$3.0X10^{-3}$	$8.1X10^{-2}$	$3.7X10^{-2}$	1.0
Ra-228 (a)		$6.0X10^{-1}$	$1.6X10^{1}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$1.0X10^{1}$	$2.7X10^{2}$
Rb-81	Rubidium (37)	2.0	$5.4X10^{1}$	$8.0X10^{-1}$	$2.2X10^{1}$	$3.1X10^{5}$	$8.4X10^{6}$
Rb-83 (a)		2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$6.8X10^{2}$	$1.8X10^{4}$
Rb-84		1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$1.8X10^{3}$	$4.7X10^{4}$
Rb-86		$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$3.0X10^{3}$	$8.1X10^{4}$
Rb-87		Unlimited	Unlimited	Unlimited	Unlimited	$3.2X10^{-9}$	$8.6X10^{-8}$
Rb(nat)		Unlimited	Unlimited	Unlimited	Unlimited	$6.7X10^{6}$	$1.8X10^{8}$
Re-184	Rhenium (75)	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$6.9X10^{2}$	$1.9X10^{4}$
Re-184m		3.0	$8.1X10^{1}$	1.0	$2.7X10^{1}$	$1.6X10^{2}$	$4.3X10^{3}$
Re-186		2.0	$5.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$6.9X10^{3}$	$1.9X10^{5}$
Re-187		Unlimited	Unlimited	Unlimited	Unlimited	$1.4X10^{-9}$	$3.8X10^{-8}$
Re-188		$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$3.6X10^{4}$	$9.8X10^{5}$
Re-189 (a)		3.0	$8.1X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.5X10^{4}$	$6.8X10^{5}$
Re(nat)		Unlimited	Unlimited	Unlimited	Unlimited	0.0	$2.4X10^{-8}$

Table A-1 of Appendix A to Section 4 (Cont'd)

Rh-99	Rhodium (45)	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$3.0X10^{3}$	$8.2X10^{4}$
Rh-101		4.0	$1.1X10^{2}$	3.0	$8.1X10^{1}$	$4.1X10^{1}$	$1.1X10^{3}$
Rh-102		$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$4.5X10^{1}$	$1.2X10^{3}$
Rh-102m		2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$2.3X10^{2}$	$6.2X10^{3}$
Rh-103m		$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$1.2X10^{6}$	$3.3X10^{7}$
Rh-105		$1.0X10^{1}$	$2.7X10^{2}$	$8.0X10^{-1}$	$2.2X10^{1}$	$3.1X10^{4}$	$8.4X10^{5}$
Rn-222 (a)	Radon (86)	$3.0X10^{-1}$	8.1	$4.0X10^{-3}$	$1.1X10^{-1}$	$5.7X10^{3}$	$1.5X10^{5}$
Ru-97	Ruthenium (44)	5.0	$1.4X10^{2}$	5.0	$1.4X10^{2}$	$1.7X10^{4}$	$4.6X10^{5}$
Ru-103 (a)		2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$1.2X10^{3}$	$3.2X10^{4}$
Ru-105		1.0	$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.5X10^{5}$	$6.7X10^{6}$
Ru-106 (a)		$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$1.2X10^{2}$	$3.3X10^{3}$
S-35	Sulphur (16)	$4.0X10^{1}$	$1.1X10^{3}$	3.0	$8.1X10^{1}$	$1.6X10^{3}$	$4.3X10^{4}$
Sb-122	Antimony (51)	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.5X10^{4}$	$4.0X10^{5}$
Sb-124		$6.0X10^{-1}$	$1.6X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$6.5X10^{2}$	$1.7X10^{4}$
Sb-125		2.0	$5.4X10^{1}$	1.0	$2.7X10^{1}$	$3.9X10^{1}$	$1.0X10^{3}$
Sb-126		$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$3.1X10^{3}$	$8.4X10^{4}$
Sc-44	Scandium (21)	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$6.7X10^{5}$	$1.8X10^{7}$
Sc-46		$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$1.3X10^{3}$	$3.4X10^{4}$
Sc-47		$1.0X10^{1}$	$2.7X10^{2}$	$7.0X10^{-1}$	$1.9X10^{1}$	$3.1X10^{4}$	$8.3X10^{5}$
Sc-48		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$5.5X10^{4}$	$1.5X10^{6}$
Se-75	Selenium (34)	3.0	$8.1X10^{1}$	3.0	$8.1X10^{1}$	$5.4X10^{2}$	$1.5X10^{4}$
Se-79		$4.0X10^{1}$	$1.1X10^{3}$	2.0	$5.4X10^{1}$	$2.6X10^{-3}$	$7.0X10^{-2}$
Si-31	Silicon (14)	$6.0X10^{-1}$	$1.6X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.4X10^{6}$	$3.9X10^{7}$
Si-32		$4.0X10^{1}$	$1.1X10^{3}$	$5.0X10^{-1}$	$1.4X10^{1}$	3.9	$1.1X10^{2}$
Sm-145	Samarium (62)	$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	$9.8X10^{1}$	$2.6X10^{3}$
Sm-147		Unlimited	Unlimited	Unlimited	Unlimited	$8.5X10^{-10}$	$2.3X10^{-8}$
Sm-151		$4.0X10^{1}$	$1.1X10^{3}$	$1.0X10^{1}$	$2.7X10^{2}$	$9.7X10^{-1}$	$2.6X10^{1}$
Sm-153		9.0	$2.4X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.6X10^{4}$	$4.4X10^{5}$
Sn-113 (a)	Tin (50)	4.0	$1.1X10^{2}$	2.0	$5.4X10^{1}$	$3.7X10^{2}$	$1.0X10^{4}$
Sn-117m		7.0	$1.9X10^{2}$	$4.0X10^{-1}$	$1.1X10^{1}$	$3.0X10^{3}$	$8.2X10^{4}$
Sn-119m		$4.0X10^{1}$	$1.1X10^{3}$	$3.0X10^{1}$	$8.1X10^{2}$	$1.4X10^{2}$	$3.7X10^{3}$
Sn-121m (a)		$4.0X10^{1}$	$1.1X10^{3}$	$9.0X10^{-1}$	$2.4X10^{1}$	2.0	$5.4X10^{1}$

Table A-1 of Appendix A to Section 4 (Cont'd)

Sn-123		$8.0X10^{-1}$	$2.2X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.0X10^{2}$	$8.2X10^{3}$
Sn-125		$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{3}$	$1.1X10^{5}$
Sn-126 (a)		$6.0X10^{-1}$	$1.6X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.0X10^{-3}$	$2.8X10^{-2}$
Sr-82 (a)	Strontium (38)	$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$2.3X10^{3}$	$6.2X10^{4}$
Sr-85		2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$8.8X10^{2}$	$2.4X10^{4}$
Sr-85m		5.0	$1.4X10^{2}$	5.0	$1.4X10^{2}$	$1.2X10^{6}$	$3.3X10^{7}$
Sr-87m		3.0	$8.1X10^{1}$	3.0	$8.1X10^{1}$	$4.8X10^{5}$	$1.3X10^{7}$
Sr-89		$6.0X10^{-1}$	$1.6X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.1X10^{3}$	$2.9X10^{4}$
Sr-90 (a)		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	5.1	$1.4X10^{2}$
Sr-91 (a)		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$1.3X10^{5}$	$3.6X10^{6}$
Sr-92 (a)		1.0	$2.7X10^{1}$	$3.0X10^{-1}$	8.1	$4.7X10^{5}$	$1.3X10^{7}$
T(H-3)	Tritium (1)	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$3.6X10^{2}$	$9.7X10^{3}$
Ta-178 (long-lived)	Tantalum (73)	1.0	$2.7X10^{1}$	$8.0X10^{-1}$	$2.2X10^{1}$	$4.2X10^{6}$	$1.1X10^{8}$
Ta-179		$3.0X10^{1}$	$8.1X10^{2}$	$3.0X10^{1}$	$8.1X10^{2}$	$4.1X10^{1}$	$1.1X10^{3}$
Ta-182		$9.0X10^{-1}$	$2.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$2.3X10^{2}$	$6.2X10^{3}$
Tb-157	Terbium (65)	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$5.6X10^{-1}$	$1.5X10^{1}$
Tb-158		1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$5.6X10^{-1}$	$1.5X10^{1}$
Tb-160		1.0	$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$4.2X10^{2}$	$1.1X10^{4}$
Tc-95m (a)	Technetium (43)	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$8.3X10^{2}$	$2.2X10^{4}$
Tc-96		$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.2X10^{4}$	$3.2X10^{5}$
Tc-96m (a)		$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.4X10^{6}$	$3.8X10^{7}$
Tc-97		Unlimited	Unlimited	Unlimited	Unlimited	$5.2X10^{-5}$	$1.4X10^{-3}$
Tc-97m		$4.0X10^{1}$	$1.1X10^{3}$	1.0	$2.7X10^{1}$	$5.6X10^{2}$	$1.5X10^{4}$
Tc-98		$8.0X10^{-1}$	$2.2X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$3.2X10^{-5}$	$8.7X10^{-4}$
Tc-99		$4.0X10^{1}$	$1.1X10^{3}$	$9.0X10^{-1}$	$2.4X10^{1}$	$6.3X10^{-4}$	$1.7X10^{-2}$
Tc-99m		$1.0X10^{1}$	$2.7X10^{2}$	4.0	$1.1X10^{2}$	$1.9X10^{5}$	$5.3X10^{6}$
Te-121	Tellurium (52)	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$2.4X10^{3}$	$6.4X10^{4}$
Te-121m		5.0	$1.4X10^{2}$	3.0	$8.1X10^{1}$	$2.6X10^{2}$	$7.0X10^{3}$
Te-123m		8.0	$2.2X10^{2}$	1.0	$2.7X10^{1}$	$3.3X10^{2}$	$8.9X10^{3}$
Te-125m		$2.0X10^{1}$	$5.4X10^{2}$	$9.0X10^{-1}$	$2.4X10^{1}$	$6.7X10^{2}$	$1.8X10^{4}$
Te-127		$2.0X10^{1}$	$5.4X10^{2}$	$7.0X10^{-1}$	$1.9X10^{1}$	$9.8X10^{4}$	$2.6X10^{6}$
Te-127m (a)		$2.0X10^{1}$	$5.4X10^{2}$	$5.0X10^{-1}$	$1.4X10^{1}$	$3.5X10^{2}$	$9.4X10^{3}$

Table A-1 of Appendix A to Section 4 (Cont'd)

Te-129		$7.0X10^{-1}$	$1.9X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$7.7X10^{5}$	$2.1X10^{7}$
Te-129m (a)		$8.0X10^{-1}$	$2.2X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.1X10^{3}$	$3.0X10^{4}$
Te-131m (a)		$7.0X10^{-1}$	$1.9X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$3.0X10^{4}$	$8.0X10^{5}$
Te-132 (a)		$5.0X10^{-1}$	$1.4X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.1X10^{4}$	$3.0X10^{5}$
Th-227	Thorium (90)	$1.0X10^{1}$	$2.7X10^{2}$	$5.0X10^{-3}$	$1.4X10^{-1}$	$1.1X10^{3}$	$3.1X10^{4}$
Th-228 (a)		$5.0X10^{-1}$	$1.4X10^{1}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$3.0X10^{1}$	$8.2X10^{2}$
Th-229		5.0	$1.4X10^{2}$	$5.0X10^{-4}$	$1.4X10^{-2}$	$7.9X10^{-3}$	$2.1X10^{-1}$
Th-230		$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$7.6X10^{-4}$	$2.1X10^{-2}$
Th-231		$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$2.0X10^{4}$	$5.3X10^{5}$
Th-232		Unlimited	Unlimited	Unlimited	Unlimited	$4.0X10^{-9}$	$1.1X10^{-7}$
Th-234 (a)		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$8.6X10^{2}$	$2.3X10^{4}$
Th(nat)		Unlimited	Unlimited	Unlimited	Unlimited	$8.1X10^{-9}$	$2.2X10^{-7}$
Ti-44 (a)	Titanium (22)	$5.0X10^{-1}$	$1.4X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	6.4	$1.7X10^{2}$
Tl-200	Thallium (81)	$9.0X10^{-1}$	$2.4X10^{1}$	$9.0X10^{-1}$	$2.4X10^{1}$	$2.2X10^{4}$	$6.0X10^{5}$
Tl-201		$1.0X10^{1}$	$2.7X10^{2}$	4.0	$1.1X10^{2}$	$7.9X10^{3}$	$2.1X10^{5}$
Tl-202		2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$2.0X10^{3}$	$5.3X10^{4}$
Tl-204		$1.0X10^{1}$	$2.7X10^{2}$	$7.0X10^{-1}$	$1.9X10^{1}$	$1.7X10^{1}$	$4.6X10^{2}$
Tm-167	Thulium (69)	7.0	$1.9X10^{2}$	$8.0X10^{-1}$	$2.2X10^{1}$	$3.1X10^{3}$	$8.5X10^{4}$
Tm-170		3.0	$8.1X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.2X10^{2}$	$6.0X10^{3}$
Tm-171		$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$
U-230 (fast lung absorption) (a)(d)	Uranium (92)	$4.0X10^{1}$	$1.1X10^{3}$	$1.0X10^{-1}$	2.7	$1.0X10^{3}$	$2.7X10^{4}$
U-230 (medium lung absorption) (a)(e)		$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{-3}$	$1.1X10^{-1}$	$1.0X10^{3}$	$2.7X10^{4}$
U-230 (slow lung absorption) (a)(f)		$3.0X10^{1}$	$8.1X10^{2}$	$3.0X10^{-3}$	$8.1X10^{-2}$	$1.0X10^{3}$	$2.7X10^{4}$
U-232 (fast lung absorption) (d)		$4.0X10^{1}$	$1.1X10^{3}$	$1.0X10^{-2}$	$2.7X10^{-1}$	$8.3X10^{-1}$	$2.2X10^{1}$
U-232 (medium lung absorption) (e)		$4.0X10^{1}$	$1.1X10^{3}$	$7.0X10^{-3}$	$1.9X10^{-1}$	$8.3X10^{-1}$	$2.2X10^{1}$
U-232 (slow lung absorption) (f)		$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$8.3X10^{-1}$	$2.2X10^{1}$
U-233 (fast lung absorption) (d)		$4.0X10^{1}$	$1.1X10^{3}$	$9.0X10^{-2}$	2.4	$3.6X10^{-4}$	$9.7X10^{-3}$

Table A-1 of Appendix A to Section 4 (Cont'd)

U-233 (medium lung absorption) (e)		$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$3.6X10^{-4}$	$9.7X10^{-3}$
U-233 (slow lung absorption) (f)		$4.0X10^{1}$	$1.1X10^{3}$	$6.0X10^{-3}$	$1.6X10^{-1}$	$3.6X10^{-4}$	$9.7X10^{-3}$
U-234 (fast lung absorption) (d)		$4.0X10^{1}$	$1.1X10^{3}$	$9.0X10^{-2}$	2.4	$2.3X10^{-4}$	$6.2X10^{-3}$
U-234 (medium lung absorption) (e)		$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$2.3X10^{-4}$	$6.2X10^{-3}$
U-234 (slow lung absorption) (f)		$4.0X10^{1}$	$1.1X10^{3}$	$6.0X10^{-3}$	$1.6X10^{-1}$	$2.3X10^{-4}$	$6.2X10^{-3}$
U-235 (all lung absorption types) (a),(d),(e),(f)		Unlimited	Unlimited	Unlimited	Unlimited	$8.0X10^{-8}$	$2.2X10^{-6}$
U-236 (fast lung absorption) (d)		Unlimited	Unlimited	Unlimited	Unlimited	$2.4X10^{-6}$	$6.5X10^{-5}$
U-236 (medium lung absorption) (e)		$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$2.4X10^{-6}$	$6.5X10^{-5}$
U-236 (slow lung absorption) (f)		$4.0X10^{1}$	$1.1X10^{3}$	$6.0X10^{-3}$	$1.6X10^{-1}$	$2.4X10^{-6}$	$6.5X10^{-5}$
U-238 (all lung absorption types) (d),(e),(f)		Unlimited	Unlimited	Unlimited	Unlimited	$1.2X10^{-8}$	$3.4X10^{-7}$
U (nat)		Unlimited	Unlimited	Unlimited	Unlimited	$2.6X10^{-8}$	$7.1X10^{-7}$
U (enriched to 20% or less) (g)		Unlimited	Unlimited	Unlimited	Unlimited	See Table A-4	See Table A-4
U (dep)		Unlimited	Unlimited	Unlimited	Unlimited	See Table A-4	(See Table A-3)
V-48	Vanadium (23)	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$6.3X10^{3}$	$1.7X10^{5}$
V-49		$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$3.0X10^{2}$	$8.1X10^{3}$
W-178 (a)	Tungsten (74)	9.0	$2.4X10^{2}$	5.0	$1.4X10^{2}$	$1.3X10^{3}$	$3.4X10^{4}$
W-181		$3.0X10^{1}$	$8.1X10^{2}$	$3.0X10^{1}$	$8.1X10^{2}$	$2.2X10^{2}$	$6.0X10^{3}$
W-185		$4.0X10^{1}$	$1.1X10^{3}$	$8.0X10^{-1}$	$2.2X10^{1}$	$3.5X10^{2}$	$9.4X10^{3}$
W-187		2.0	$5.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.6X10^{4}$	$7.0X10^{5}$
W-188 (a)		$4.0X10^{-1}$	$1.1X10^{1}$	$3.0X10^{-1}$	8.1	$3.7X10^{2}$	$1.0X10^{4}$
Xe-122 (a)	Xenon (54)	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$4.8X10^{4}$	$1.3X10^{6}$
Xe-123		2.0	$5.4X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$4.4X10^{5}$	$1.2X10^{7}$

Table A-1 of Appendix A to Section 4 (Cont'd)

Xe-127		4.0	$1.1X10^{2}$	2.0	$5.4X10^{1}$	$1.0X10^{3}$	$2.8X10^{4}$
Xe-131m		$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$3.1X10^{3}$	$8.4X10^{4}$
Xe-133		$2.0X10^{1}$	$5.4X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	$6.9X10^{3}$	$1.9X10^{5}$
Xe-135		3.0	$8.1X10^{1}$	2.0	$5.4X10^{1}$	$9.5X10^{4}$	$2.6X10^{6}$
Y-87 (a)	Yttrium (39)	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$1.7X10^{4}$	$4.5X10^{5}$
Y-88		$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$5.2X10^{2}$	$1.4X10^{4}$
Y-90		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$2.0X10^{4}$	$5.4X10^{5}$
Y-91		$6.0X10^{-1}$	$1.6X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$9.1X10^{2}$	$2.5X10^{4}$
Y-91m		2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$1.5X10^{6}$	$4.2X10^{7}$
Y-92		$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$3.6X10^{5}$	$9.6X10^{6}$
Y-93		$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$1.2X10^{5}$	$3.3X10^{6}$
Yb-169	Ytterbium (70)	4.0	$1.1X10^{2}$	1.0	$2.7X10^{1}$	$8.9X10^{2}$	$2.4X10^{4}$
Yb-175		$3.0X10^{1}$	$8.1X10^{2}$	$9.0X10^{-1}$	$2.4X10^{1}$	$6.6X10^{3}$	$1.8X10^{5}$
Zn-65	Zinc (30)	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$3.0X10^{2}$	$8.2X10^{3}$
Zn-69		3.0	$8.1X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.8X10^{6}$	$4.9X10^{7}$
Zn-69m (a)		3.0	$8.1X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.2X10^{5}$	$3.3X10^{6}$
Zr-88	Zirconium (40)	3.0	$8.1X10^{1}$	3.0	$8.1X10^{1}$	$6.6X10^{2}$	$1.8X10^{4}$
Zr-93		Unlimited	Unlimited	Unlimited	Unlimited	$9.3X10^{-5}$	$2.5X10^{-3}$
Zr-95 (a)		2.0	$5.4X10^{1}$	$8.0X10^{-1}$	$2.2X10^{1}$	$7.9X10^{2}$	$2.1X10^{4}$
Zr-97 (a)		$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$7.1X10^{4}$	$1.9X10^{6}$

[a] A_1 and/or A_2 values include contributions from daughter nuclides with half-lives less than 10 days, as listed in the following:

Mg-28	Al-28
Ca-47	Sc-47
Ti-44	Sc-44
Fe-52	Mn-52m
Fe-60	Co-60m
Zn-69m	Zn-69
Ge-68	Ga-68
Rb-83	Kr-83m
Sr-82	Rb-82
Sr-90	Y-90

Table A-1 of Appendix A to Section 4 (Cont'd)

Sr-91	Y-91m
Sr-92	Y-92
Y-87	Sr-87m
Zr-95	Nb-95m
Zr-97	Nb-97m, Nb-97
Mo-99	Tc-99m
Tc-95m	Tc-95
Tc-96m	Tc-96
Ru-103	Rh-103m
Ru-106	Rh-106
Pd-103	Rh-103m
Ag-108m	Ag-108
Ag-110m	Ag-110
Cd-115	In-115m
In-114m	In-114
Sn-113	In-113m
Sn-121m	Sn-121
Sn-126	Sb-126m
Te-127m	Te-127
Te-129m	Te-129
Te-131m	Te-131
Te-132	I-132
I-135	Xe-135m
Xe-122	I-122
Cs-137	Ba-137m
Ba-131	Cs-131
Ba-140	La-140
Ce-144	Pr-144m, Pr-144
Pm-148m	Pm-148
Gd-146	Eu-146
Dy-166	Ho-166
Hf-172	Lu-172
W-178	Ta-178
W-188	Re-188
Re-189	Os-189m
Os-194	Ir-194

Table A-1 of Appendix A to Section 4 (Cont'd)

Ir-189	Os-189m
Pt-188	Ir-188
Hg-194	Au-194
Hg-195m	Hg-195
Pb-210	Bi-210
Pb-212	Bi-212, Tl-208, Po-212
Bi-210m	Tl-206
Bi-212	Tl-208, Po-212
At-211	Po-211
Rn-222	Po-218, Pb-214, At-218, Bi-214, Po-214
Ra-223	Rn-219, Po-215, Pb-211, Bi-211, Po-211, Tl-207
Ra-224	Rn-220, Po-216, Pb-212, Bi-212, Tl-208, Po-212
Ra-225	Ac-225, Fr-221, At-217, Bi-213, Tl-209, Po-213, Pb-209
Ra-226	Rn-222, Po-218, Pb-214, At-218, Bi-214, Po-214
Ra-228	Ac-228
Ac-225	Fr-221, At-217, Bi-213, Tl-209, Po-213, Pb-209
Ac-227	Fr-223
Th-228	Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208, Po-212
Th-234	Pa-234m, Pa-234
Pa-230	Ac-226, Th-226, Fr-222, Ra-222, Rn-218, Po-214
U-230	Th-226, Ra-222, Rn-218, Po-214
U-235	Th-231
Pu-241	U-237
Pu-244	U-240, Np-240m
Am-242m	Am-242, Np-238
Am-243	Np-239
Cm-247	Pu-243
Bk-249	Am-245
Cf-253	Cm-249

[b] The values of A_1 and A_2 in Curies (Ci) are approximate and for information only; the regulatory standard units are Terabecquerels (TBq). See Appendix A to Section 4 – Determination of A_1 and A_2, Section I.

[c] The activity of Ir-192 in special form may be determined from a measurement of the rate of decay or a measurement of the radiation level at a prescribed distance from the source.

[d] These values apply only to compounds of uranium that take the chemical form of UF_6, UO_2F_2 and $UO_2(NO_3)_2$ in both normal and accident conditions of transport.

Table A-1 of Appendix A to Section 4 (Cont'd)

[e] These values apply only to compounds of uranium that take the chemical form of UO_3, UF_4, UCl_4 and hexavalent compounds in both normal and accident conditions of transport.

[f] These values apply to all compounds of uranium other than those specified in notes (d) and (e) of this table.

[g] These values apply to unirradiated uranium only.

[h] A_2 = 0.74 TBq (20 Ci) for Mo-99 for domestic use.

TABLE A-2—EXEMPT MATERIAL ACTIVITY CONCENTRATIONS AND EXEMPT CONSIGNMENT ACTIVITY LIMITS FOR RADIONUCLIDES

Symbol of radionuclide	Element and atomic number	Activity concentration for exempt material (Bq/g)	Activity concentration for exempt material (Ci/g)	Activity limit for exempt consignment (Bq)	Activity limit for exempt consignment (Ci)
Ac-225	Actinium (89)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Ac-227		$1.0X10^{-1}$	$2.7X10^{-12}$	$1.0X10^{3}$	$2.7X10^{-8}$
Ac-228		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ag-105	Silver (47)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ag-108m (b)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ag-110m		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ag-111		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Al-26	Aluminum (13)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Am-241	Americium (95)	1.0	$2.7X10^{-11}$	$1.0X10^{4}$	$2.7X10^{-7}$
Am-242m (b)		1.0	$2.7X10^{-11}$	$1.0X10^{4}$	$2.7X10^{-7}$
Am-243 (b)		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
Ar-37	Argon (18)	$1.0X10^{6}$	$2.7X10^{-5}$	$1.0X10^{8}$	$2.7X10^{-3}$
Ar-39		$1.0X10^{7}$	$2.7X10^{-4}$	$1.0X10^{4}$	$2.7X10^{-7}$
Ar-41		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{9}$	$2.7X10^{-2}$
As-72	Arsenic (33)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
As-73		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
As-74		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
As-76		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
As-77		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
At-211	Astatine (85)	$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Au-193	Gold (79)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Au-194		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Au-195		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Au-198		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Au-199		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$

Table A-2 of Appendix A to Section 4 (Cont'd)

Ba-131	Barium (56)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ba-133		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ba-133m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ba-140 (b)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Be-7	Beryllium (4)	$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Be-10		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{6}$	$2.7X10^{-5}$
Bi-205	Bismuth (83)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Bi-206		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Bi-207		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Bi-210		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Bi-210m		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Bi-212 (b)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Bk-247	Berkelium (97)	1.0	$2.7X10^{-11}$	$1.0X10^{4}$	$2.7X10^{-7}$
Bk-249		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Br-76	Bromine (35)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Br-77		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Br-82		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
C-11	Carbon (6)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
C-14		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Ca-41	Calcium (20)	$1.0X10^{5}$	$2.7X10^{-6}$	$1.0X10^{7}$	$2.7X10^{-4}$
Ca-45		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Ca-47		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Cd-109	Cadmium (48)	$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{6}$	$2.7X10^{-5}$
Cd-113m		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Cd-115		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Cd-115m		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ce-139	Cerium (58)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ce-141		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Ce-143		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ce-144 (b)		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Cf-248	Californium (98)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Cf-249		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$

Table A-2 of Appendix A to Section 4 (Cont'd)

Cf-250		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Cf-251		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
Cf-252		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Cf-253		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Cf-254		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
Cl-36	Chlorine (17)	$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{6}$	$2.7X10^{-5}$
Cl-38		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Cm-240	Curium (96)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Cm-241		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Cm-242		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Cm-243		1.0	$2.7X10^{-11}$	$1.0X10^{4}$	$2.7X10^{-7}$
Cm-244		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Cm-245		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
Cm-246		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
Cm-247		1.0	$2.7X10^{-11}$	$1.0X10^{4}$	$2.7X10^{-7}$
Cm-248		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
Co-55	Cobalt (27)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Co-56		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Co-57		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Co-58		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Co-58m		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Co-60		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Cr-51	Chromium (24)	$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Cs-129	Cesium (55)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Cs-131		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Cs-132		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Cs-134		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Cs-134m		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{5}$	$2.7X10^{-6}$
Cs-135		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Cs-136		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Cs-137 (b)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Cu-64	Copper (29)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$

Table A-2 of Appendix A to Section 4 (Cont'd)

Cu-67		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Dy-159	Dysprosium (66)	$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Dy-165		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Dy-166		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Er-169	Erbium (68)	$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Er-171		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Eu-147	Europium (63)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Eu-148		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Eu-149		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Eu-150 (short lived)		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Eu-150 (long lived)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Eu-152		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Eu-152m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Eu-154		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Eu-155		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Eu-156		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
F-18	Fluorine (9)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Fe-52	Iron (26)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Fe-55		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{6}$	$2.7X10^{-5}$
Fe-59		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Fe-60		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Ga-67	Gallium (31)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ga-68		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Ga-72		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Gd-146	Gadolinium (64)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Gd-148		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Gd-153		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Gd-159		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ge-68	Germanium (32)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Ge-71		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{8}$	$2.7X10^{-3}$
Ge-77		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$

Table A-2 of Appendix A to Section 4 (Cont'd)

Hf-172	Hafnium (72)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Hf-175		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Hf-181		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Hf-182		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Hg-194	Mercury (80)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Hg-195m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Hg-197		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Hg-197m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Hg-203		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Ho-166	Holmium (67)	$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{5}$	$2.7X10^{-6}$
Ho-166m		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
I-123	Iodine (53)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
I-124		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
I-125		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
I-126		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
I-129		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
I-131		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
I-132		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
I-133		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
I-134		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
I-135		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
In-111	Indium (49)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
In-113m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
In-114m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
In-115m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ir-189	Iridium (77)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Ir-190		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ir-192		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Ir-194		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
K-40	Potassium (19)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
K-42		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
K-43		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$

Table A-2 of Appendix A to Section 4 (Cont'd)

Kr-79	Krypton (36)	$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{5}$	$2.7X10^{-6}$
Kr-81		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Kr-85		$1.0X10^{5}$	$2.7X10^{-6}$	$1.0X10^{4}$	$2.7X10^{-7}$
Kr-85m		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{10}$	$2.7X10^{-1}$
Kr-87		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{9}$	$2.7X10^{-2}$
La-137	Lanthanum (57)	$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
La-140		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Lu-172	Lutetium (71)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Lu-173		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Lu-174		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Lu-174m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Lu-177		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Mg-28	Magnesium (12)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Mn-52	Manganese (25)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Mn-53		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{9}$	$2.7X10^{-2}$
Mn-54		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Mn-56		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Mo-93	Molybdenum (42)	$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{8}$	$2.7X10^{-3}$
Mo-99		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
N-13	Nitrogen (7)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{9}$	$2.7X10^{-2}$
Na-22	Sodium (11)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Na-24		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Nb-93m	Niobium (41)	$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Nb-94		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Nb-95		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Nb-97		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Nd-147	Neodymium (60)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Nd-149		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ni-59	Nickel (28)	$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{8}$	$2.7X10^{-3}$
Ni-63		$1.0X10^{5}$	$2.7X10^{-6}$	$1.0X10^{8}$	$2.7X10^{-3}$
Ni-65		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Np-235	Neptunium (93)	$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$

Table A-2 of Appendix A to Section 4 (Cont'd)

Np-236 (short-lived)		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Np-236 (long-lived)		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Np-237 (b)		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
Np-239		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Os-185	Osmium (76)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Os-191		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Os-191m		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Os-193		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Os-194		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
P-32	Phosphorus (15)	$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{5}$	$2.7X10^{-6}$
P-33		$1.0X10^{5}$	$2.7X10^{-6}$	$1.0X10^{8}$	$2.7X10^{-3}$
Pa-230	Protactinium (91)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pa-231		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
Pa-233		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Pb-201	Lead (82)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pb-202		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pb-203		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pb-205		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Pb-210 (b)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Pb-212 (b)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Pd-103	Palladium (46)	$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{8}$	$2.7X10^{-3}$
Pd-107		$1.0X10^{5}$	$2.7X10^{-6}$	$1.0X10^{8}$	$2.7X10^{-3}$
Pd-109		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pm-143	Promethium (61)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pm-144		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pm-145		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Pm-147		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Pm-148m		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pm-149		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pm-151		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$

Table A-2 of Appendix A to Section 4 (Cont'd)

Po-210	Polonium (84)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Pr-142	Praseodymium (59)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Pr-143		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pt-188	Platinum (78)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pt-191		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pt-193		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Pt-193m		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Pt-195m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pt-197		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pt-197m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Pu-236	Plutonium (94)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Pu-237		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Pu-238		1.0	$2.7X10^{-11}$	$1.0X10^{4}$	$2.7X10^{-7}$
Pu-239		1.0	$2.7X10^{-11}$	$1.0X10^{4}$	$2.7X10^{-7}$
Pu-240		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
Pu-241		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Pu-242		1.0	$2.7X10^{-11}$	$1.0X10^{4}$	$2.7X10^{-7}$
Pu-244		1.0	$2.7X10^{-11}$	$1.0X10^{4}$	$2.7X10^{-7}$
Ra-223 (b)	Radium (88)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Ra-224 (b)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Ra-225		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Ra-226 (b)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Ra-228 (b)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Rb-81	Rubidium (37)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Rb-83		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Rb-84		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Rb-86		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Rb-87		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Rb(nat)		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Re-184	Rhenium (75)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Re-184m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Re-186		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$

Table A-2 of Appendix A to Section 4 (Cont'd)

Re-187		$1.0X10^{6}$	$2.7X10^{-5}$	$1.0X10^{9}$	$2.7X10^{-2}$
Re-188		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Re-189		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Re(nat)		$1.0X10^{6}$	$2.7X10^{-5}$	$1.0X10^{9}$	$2.7X10^{-2}$
Rh-99	Rhodium (45)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Rh-101		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Rh-102		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Rh-102m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Rh-103m		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{8}$	$2.7X10^{-3}$
Rh-105		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Rn-222 (b)	Radon (86)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{8}$	$2.7X10^{-3}$
Ru-97	Ruthenium (44)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Ru-103		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ru-105		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ru-106 (b)		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
S-35	Sulphur (16)	$1.0X10^{5}$	$2.7X10^{-6}$	$1.0X10^{8}$	$2.7X10^{-3}$
Sb-122	Antimony (51)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{4}$	$2.7X10^{-7}$
Sb-124		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Sb-125		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Sb-126		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Sc-44	Scandium (21)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Sc-46		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Sc-47		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Sc-48		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Se-75	Selenium (34)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Se-79		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Si-31	Silicon (14)	$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Si-32		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Sm-145	Samarium (62)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Sm-147		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Sm-151		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{8}$	$2.7X10^{-3}$
Sm-153		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$

Table A-2 of Appendix A to Section 4 (Cont'd)

Sn-113	Tin (50)	$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Sn-117m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Sn-119m		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Sn-121m		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Sn-123		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Sn-125		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Sn-126		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Sr-82	Strontium (38)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Sr-85		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Sr-85m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Sr-87m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Sr-89		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Sr-90 (b)		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{4}$	$2.7X10^{-7}$
Sr-91		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Sr-92		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
T(H-3)	Tritium (1)	$1.0X10^{6}$	$2.7X10^{-5}$	$1.0X10^{9}$	$2.7X10^{-2}$
Ta-178 (long-lived)	Tantalum (73)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Ta-179		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Ta-182		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Tb-157	Terbium (65)	$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Tb-158		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Tb-160		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Tc-95m	Technetium (43)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Tc-96		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Tc-96m		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Tc-97		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{8}$	$2.7X10^{-3}$
Tc-97m		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Tc-98		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Tc-99		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
Tc-99m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Te-121	Tellurium (52)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$

Table A-2 of Appendix A to Section 4 (Cont'd)

Te-121m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Te-123m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Te-125m		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Te-127		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Te-127m		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Te-129		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Te-129m		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Te-131m		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Te-132		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Th-227	Thorium (90)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Th-228 (b)		1.0	$2.7X10^{-11}$	$1.0X10^{4}$	$2.7X10^{-7}$
Th-229 (b)		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
Th-230		1.0	$2.7X10^{-11}$	$1.0X10^{4}$	$2.7X10^{-7}$
Th-231		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Th-232		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
Th-234 (b)		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{5}$	$2.7X10^{-6}$
Th (nat) (b)		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
Ti-44	Titanium (22)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
Tl-200	Thallium (81)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Tl-201		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Tl-202		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Tl-204		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{4}$	$2.7X10^{-7}$
Tm-167	Thulium (69)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Tm-170		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Tm-171		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{8}$	$2.7X10^{-3}$
U-230 (fast lung absorption) (b),(d)	Uranium (92)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
U-230 (medium lung absorption) (e)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$

Table A-2 of Appendix A to Section 4 (Cont'd)

U-230 (slow lung absorption) (f)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
U-232 (fast lung absorption) (b),(d)		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
U-232 (medium lung absorption) (e)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
U-232 (slow lung absorption) (f)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
U-233 (fast lung absorption) (d)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
U-233 (medium lung absorption) (e)		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
U-233 (slow lung absorption) (f)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
U-234 (fast lung absorption) (d)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
U-234 (medium lung absorption) (e)		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
U-234 (slow lung absorption) (f)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
U-235 (all lung absorption types) (b),(d),(e),(f)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
U-236 (fast lung absorption) (d)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
U-236 (medium lung absorption) (e)		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$

Table A-2 of Appendix A to Section 4 (Cont'd)

U-236 (slow lung absorption) (f)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
U-238 (all lung absorption types) (b),(d),(e),(f)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{4}$	$2.7X10^{-7}$
U (nat) (b)		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
U (enriched to 20% or less) (g)		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
U (dep)		1.0	$2.7X10^{-11}$	$1.0X10^{3}$	$2.7X10^{-8}$
V-48	Vanadium (23)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$
V-49		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
W-178	Tungsten (74)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
W-181		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
W-185		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{7}$	$2.7X10^{-4}$
W-187		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
W-188		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Xe-122	Xenon (54)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{9}$	$2.7X10^{-2}$
Xe-123		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{9}$	$2.7X10^{-2}$
Xe-127		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{5}$	$2.7X10^{-6}$
Xe-131m		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{4}$	$2.7X10^{-7}$
Xe-133		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{4}$	$2.7X10^{-7}$
Xe-135		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{10}$	$2.7X10^{-1}$
Y-87	Yttrium (39)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Y-88		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Y-90		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{5}$	$2.7X10^{-6}$
Y-91		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{6}$	$2.7X10^{-5}$
Y-91m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Y-92		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Y-93		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{5}$	$2.7X10^{-6}$
Yb-169	Ytterbium (70)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{7}$	$2.7X10^{-4}$
Yb-175		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Zn-65	Zinc (30)	$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$

Table A-2 of Appendix A to Section 4 (Cont'd)

Zn-69		$1.0X10^{4}$	$2.7X10^{-7}$	$1.0X10^{6}$	$2.7X10^{-5}$
Zn-69m		$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Zr-88	Zirconium (40)	$1.0X10^{2}$	$2.7X10^{-9}$	$1.0X10^{6}$	$2.7X10^{-5}$
Zr-93 (b)		$1.0X10^{3}$	$2.7X10^{-8}$	$1.0X10^{7}$	$2.7X10^{-4}$
Zr-95		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{6}$	$2.7X10^{-5}$
Zr-97 (b)		$1.0X10^{1}$	$2.7X10^{-10}$	$1.0X10^{5}$	$2.7X10^{-6}$

[a] [Reserved]

[b] Parent nuclides and their progeny included in secular equilibrium are listed as follows:

Sr-90	Y-90
Zr-93	Nb-93m
Zr-97	Nb-97
Ru-106	Rh-106
Ag-108m	Ag-108
Cs-137	Ba-137m
Ce-144	Pr-144
Ba-140	La-140
Bi-212	Tl-208 (0.36), Po-212 (0.64)
Pb-210	Bi-210, Po-210
Pb-212	Bi-212, Tl-208 (0.36), Po-212 (0.64)
Rn-222	Po-218, Pb-214, Bi-214, Po-214
Ra-223	Rn-219, Po-215, Pb-211, Bi-211, Tl-207
Ra-224	Rn-220, Po-216, Pb-212, Bi-212, Tl-208(0.36), Po-212 (0.64)
Ra-226	Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
Ra-228	Ac-228
Th-228	Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Th-229	Ra-225, Ac-225, Fr-221, At-217, Bi-213, Po-213, Pb-209
Th-nat	Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Th-234	Pa-234m
U-230	Th-226, Ra-222, Rn-218, Po-214
U-232	Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
U-235	Th-231
U-238	Th-234, Pa-234m

Table A-2 of Appendix A to Section 4 (Cont'd)

U-nat	Th-234, Pa-234m, U-234, Th-230, Ra-226, Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
Np-237	Pa-233
Am-242m	Am-242
Am-243	Np-239

[c] [Reserved]

[d] These values apply only to compounds of uranium that take the chemical form of UF_6, UO_2F_2 and $UO_2(NO_3)_2$ in both normal and accident conditions of transport.

[e] These values apply only to compounds of uranium that take the chemical form of UO_3, UF_4, UCl_4 and hexavalent compounds in both normal and accident conditions of transport.

[f] These values apply to all compounds of uranium other than those specified in notes (d) and (e) of this table.

[g] These values apply to unirradiated uranium only.

TABLE A-3—GENERAL VALUES FOR A_1 AND A_2

Contents	A_1		A_2		Activity concentration for exempt material (Bq/g)	Activity concentration for exempt material (Ci/g)	Activity limits for exempt consignments (Bq)	Activity limits for exempt consignments (Ci)
	(TBq)	(Ci)	(TBq)	(Ci)				
Only beta or gamma emitting nuclides are known to be present	1×10^{-1}	2.7×10^{0}	2×10^{-2}	5.4×10^{-1}	1×10^{1}	2.7×10^{-10}	1×10^{4}	2.7×10^{-7}
Alpha emitting nuclides, but no neutron emitters, are known to be present[a]	2×10^{-1}	5.4×10^{0}	9×10^{-5}	2.4×10^{-3}	1×10^{-1}	2.7×10^{-12}	1×10^{3}	2.7×10^{-8}
Neutron emitting nuclides are known to be present or no relevant data are available	1×10^{-3}	2.7×10^{-2}	9×10^{-5}	2.4×10^{-3}	1×10^{-1}	2.7×10^{-12}	1×10^{3}	2.7×10^{-8}

[a] If beta or gamma emitting nuclides are known to be present, the A_1 value of 0.1 TBq (2.7 Ci) should be used.

TABLE A-4—ACTIVITY-MASS RELATIONSHIPS FOR URANIUM

Uranium Enrichment[1] wt % U-235 present	Specific Activity	
	TBq/g	Ci/g
0.45	1.8×10^{-8}	5.0×10^{-7}
0.72	2.6×10^{-8}	7.1×10^{-7}
1	2.8×10^{-8}	7.6×10^{-7}
1.5	3.7×10^{-8}	1.0×10^{-6}
5	1.0×10^{-7}	2.7×10^{-6}
10	1.8×10^{-7}	4.8×10^{-6}
20	3.7×10^{-7}	1.0×10^{-5}
35	7.4×10^{-7}	2.0×10^{-5}
50	9.3×10^{-7}	2.5×10^{-5}
90	2.2×10^{-6}	5.8×10^{-5}
93	2.6×10^{-6}	7.0×10^{-5}
95	3.4×10^{-6}	9.1×10^{-5}

[1] The figures for uranium include representative values for the activity of the uranium-234 that is concentrated during the enrichment process.

SECTION 5.
RULES OF PRACTICE

PART A.
GENERAL

RH-4000. **Authority**. Act 8 of Second Extraordinary Session of 1961, as amended.

RH-4001. **Effective Date**. January 1, 1963.

RH-4002. **Scope**.

This Section contains the requirements applicable to and governing the proceeding of any administrative hearing pertinent to these ~~Regulations~~ Rules.

RH-4003. **Communications**.

a. Except where otherwise specified, all communications concerning these ~~Regulations~~ Rules may be addressed to the Arkansas Department of Health, Radiation Control Section, 4815 West Markham Street, Slot 30, Little Rock, Arkansas, 72205-3867.

b. The Director of the Arkansas Department of Health or a duly appointed Hearing Officer shall specify the time and place of all hearings.

RH-4004. **Interpretations**.

Except as specifically authorized by the Department in writing, no interpretations of the meaning of the ~~regulations~~ rules in this Section by an officer or employee of the Department other than a written interpretation by the Department Director or designee will be recognized as binding upon the Department.

PART B.
ADMINISTRATION

RH-4005. **Administrative Examination of Applications**.

Applications for the issuance of a license or registration, amendment of a license or registration at the request of the holder, and renewal of a license or registration will be given a docket number or other identifier for administrative examination. The applicant may be required to submit additional information and may be requested to confer informally regarding the application. The Department will give to others such notice of the filing of applications as is required under the applicable provisions of these Rules and such additional notices as it deems appropriate.

RH-4006. **Action on Application, Hearings**.

a. The Department will, upon request of the applicant or intervener and may upon its own initiative, direct the holding of a formal hearing prior to taking action on the application. If no prior formal hearing has been held and no notice of proposed action has been served as provided in paragraph b of this section, the Department will direct the holding of a formal hearing upon receipt of a request therefore from the applicant or intervener within thirty (30) days after the issuance of a license or registration or other approval or a notice of denial.

b. In such cases as it deems appropriate, the Department may cause to be served upon the applicant a notice of proposed action upon his/her application and shall cause copies thereof to be served upon interveners or others entitled to or requesting notification. The notice shall state the terms of the proposed action. If a formal hearing has not been held prior to the issuance of the notice, the Department will direct the holding of a formal hearing upon the request of the applicant or an intervener received within fifteen (15) days following the service of the notice.

RH-4007. **Effect of Timely Renewal Applications**.

In the case of an application for renewal, if the licensee has made application for the renewal of a subsisting license at least thirty (30) days prior to its expiration date, the license shall not be deemed to have expired until such application shall have been determined.

RH-4008. **Notice of Violation**.

a. Prior to the institution of any proceeding for the modification, suspension, or revocation of a license or registration for alleged violation of any provision of the Act, these Rules, conditions of a license, or a registration, the licensee or registrant shall be served with a written notice calling the facts to his/her attention and requesting a written explanation or statement in reply. Within thirty (30) days of the date of the notice or other specified time, the licensee or registrant shall send his/her reply to the Department. If the notice relates to conditions or conduct that may be susceptible to correction or to being brought into full compliance by action of the licensee or registrant, he/she shall state in his/her reply the corrective steps that have been taken and the results achieved, the corrective steps that will be taken, and the date when full compliance will be achieved. Corrective actions must address methods to prevent future noncompliance.

b. Where, in the opinion of the Department, the public health, interest or safety requires; or the failure to be in compliance is willful; the notice provided for in this section may be omitted.

RH-4009. **Orders**.

In any case described in RH-4008., the Department may issue to the licensee or registrant a notice to comply with the applicable provisions of the Act or the rules of the Arkansas State Board of Health or any order issued by the Department. The order shall apprise the licensee or registrant that he/she has the right to request a hearing within thirty (30) days by making a written request therefore to the Director. In the event a request for a hearing is received by the Director within the time specified, a notice of hearing shall be issued by the Department in accordance with RH-4028.

RH-4010. **Emergency Orders**.

Whenever the Department finds that an emergency exists requiring immediate action to protect the public health and safety, the Department may, without notice or hearing, issue a ~~regulation~~ rule or order reciting the existence of such emergency and requiring that such action be taken as is necessary to meet the emergency. Notwithstanding any provision of the Act (Act 8 of Second Extraordinary Session of 1961), such ~~regulation~~ rule or order shall be effective immediately. Any person to whom such ~~regulation~~ rule or order is directed shall comply therewith immediately, but on application to the Department shall be afforded a hearing within ten (10) days. On the basis of such hearing, the emergency ~~regulation~~ rule or order shall be continued, modified or revoked within

thirty (30) days after such hearing. Any final order entered in any proceeding under this paragraph may be appealed

RH-4010. (Cont'd)

within twenty (20) days from the date of issuance thereof, to the Circuit Court of Pulaski County.

RH-4011. **Enforcement of Obedience to Orders**.

In case of the failure on the part of any person, firm or corporation to comply with any lawful order of the Director or with process or in case of the refusal of any witness to testify concerning any matter on which he/she may be lawfully interrogated, the Circuit Court or a Judge thereof having jurisdiction may, on application of the Director, compel obedience by proceeding as in contempt cases.

RH-4012. **Impounding Materials**.

The Department shall have the authority in the event of an emergency to impound or order the impounding of sources of ionizing radiation in the possession of any person who is not equipped to observe or fails to observe the provisions of the Act or any rules ~~or regulations~~ issued thereunder. As promptly as possible and not later than ten (10) days from the impounding, the Department shall serve upon the licensee or registrant an appropriate order for revocation of his/her license or registration together with a notice which shall give the licensee or registrant the right to request a formal hearing concerning the revocation of his/her license or registration and the restoration of the material of which he/she has been deprived.

RH-4013. **Filing of Papers**.

Unless otherwise specified, papers required to be filed with the Department shall be filed with the Arkansas Department of Health, Radiation Control Section, 4815 West Markham Street, Slot 30, Little Rock, Arkansas, 72205-3867. Papers required to be filed with the Department shall be deemed filed upon actual receipt with the Department at the place specified, accompanied by proof of service upon the parties required to be served as provided in RH-4016.~~ of these Regulations.~~ Unless otherwise specified, the filing, when by mail or telegram, shall, upon actual receipt, be deemed complete as of the date of deposit in the mail or with the telegraph company. Papers may be filed in person at the Department's offices at Little Rock, Arkansas.

RH-4014. **Computation of Time**.

The time within which any Act under these ~~Regulations~~ Rules is to be accomplished shall be computed by excluding the first day and including the last, unless the last

RH-4014. (Cont'd)

day is Sunday or is a holiday as defined or fixed by statutes now or hereafter in force in this State, and then it shall also be excluded. If the day succeeding such Sunday or holiday is also a holiday or a Sunday, then such succeeding day shall also be excluded.

RH-4015. **Extension of Time**.

Extensions of time for filing or performing any Act required or allowed to be accomplished, and continuances of any proceeding or hearing, may be granted at the discretion of the Department upon application and good cause shown by any party, or upon the initiative of the Department or stipulation of all parties. Where a Hearing Officer has been designated for hearing, the discretion in granting extensions of time and continuances in matters relating to the hearing shall rest with the Hearing Officer.

RH-4016. **Subpoenas, Service and Papers**.

Subpoenas for the attendance of witnesses from any place in the State of Arkansas or the production of books, papers, accounts or documents at a hearing in a pending proceeding will be issued by the Department upon its own motion or upon application in writing incorporating a showing that such subpoena is reasonably required.

a. **Service**.

1. Service shall be made by delivering in person or by depositing in the United States Mail, properly addressed with postage prepaid, one copy to each party, if entitled thereto. When any party or parties have appeared by attorney, service upon the attorney shall be deemed service upon such party or parties.

2. Proof of service shall be by certificate of attorney affidavit or acknowledgement.

RH-4017. **Representation**.

a. Except as provided in paragraph b. of this section, any person appearing before the Department may do so in person or by a representative. Any person transacting business with the Department in a representative capacity may be required to show his/her authority to act in that capacity.

RH-4017. (Cont'd)

b. In a formal hearing a person may appear in person or be represented by an Attorney-at-Law.

RH-4018. **Intervention**.

a. Any person whose interests may be affected by a proceeding may file a petition to intervene not later than five (5) days before the commencement of the hearing or within such other time as may be specified in the notice, or as permitted by the Hearing Officer, describing his/her interest, how it may be affected by Department action and the position he/she is taking in the matter. Service of copies of the petition shall be made upon all parties to the proceeding. The Department, licensee, registrant, or applicant, upon notice and motion and other parties by leave, may contest the right of the petitioner to intervene. A petition for leave to intervene which is not timely filed will be dismissed unless the petitioner shows good cause for failure to file it on time.

b. As soon as it is practicable after filing of a petition for intervention and a hearing of argument, if any, the Director or Hearing Officer will issue and serve an order either permitting or denying intervention. If the order is a denial of intervention, it shall contain a statement of the grounds. An order permitting intervention may be conditioned upon such terms as the Director or Hearing Officer may direct.

RH-4019. **Effect of Intervention or Denial Thereof**.

A person permitted to intervene becomes a party to the proceeding.

a. Where a notice of hearing has been issued or a hearing has begun, the admission thereafter of an intervener shall not of itself enlarge or alter the issues without amendment as provided in paragraph c of this section.

b. An order denying intervention will be without prejudice to any proposed limited appearance by the petitioner as one who is not party for the purposes provided in RH-4023.~~ of these Regulations.~~

c. At any time prior to the time fixed for hearing but not later than five days prior, the party concerned may amend the petition for intervention by filing an amendment and serving it upon the parties. At any time thereafter, amendments may be permitted at the discretion of the Hearing Officer upon such terms as he/she shall prescribe.

RH-4020. **Consolidation**.

Upon motion and good cause shown or upon its own initiative, the Department or Hearing Officer may consolidate two or more proceedings.

RH-4021. **Hearings - Formal and Informal**.

a. Formal hearings will be held in cases of adjudication of rights.

b. Informal hearings will normally be held for the purposes of obtaining necessary or useful information.

RH-4022. **Authority to Administer Oaths**.

Any oath or affirmation required by or pursuant to the provisions of these ~~Regulations~~ Rules may be administered by any person authorized to administer oaths by the laws of the State of Arkansas.

RH-4023. **Informal Hearings Procedure**.

The procedure to be followed in informal hearings shall be such as will best serve the purpose of the hearing. For example, an informal hearing may consist of the submission of written data, views or arguments with or without oral argument, or may partake of the nature of a conference or may assume some of the aspects of a formal hearing in which the subpoena of witnesses and the production of evidence may be permitted or directed. A formal transcript is not necessarily required.

RH-4024. **Formal Hearings**.

The parties to a formal hearing shall be the Department, the licensee, registrant or applicant as the case may be and any person permitted to intervene pursuant to RH-4018. ~~of these Regulations.~~

RH-4025. **Limited Appearances by Persons Not Parties**.

With the consent of the Hearing Officer, limited appearances may be entered by persons who are not parties to a hearing without request for or grant of permission to intervene. With the consent of the Hearing Officer and on due notice to the parties, such persons may make oral or written statements of their position on the issues involved in the proceeding but may not otherwise participate in the hearing.

RH-4026. **Designation of Hearing Officer**.

The hearings herein provided for may be conducted by the Director or the Director may designate Hearing Officers who shall have the power and authority to conduct hearings in the name of the Department at any reasonable time and place.

RH-4027. **Function of Hearing Officer**.

The function of the Hearing Officer is to schedule and conduct hearings on behalf and in the name of the Department on all matters referred for hearing by the Director. It is the duty of the Hearing Officer to cause to be prepared and furnished to the Director for decision, a complete written transcript of the record of the hearing which contains all evidence introduced at the hearing and all pleas, motions, objections and ruling of the Hearing Officer.

RH-4028. **Notice of Hearing**.

a. Whenever a hearing is granted, the Department will give timely notice of the hearing to all parties and to other persons, if any, entitled to notice. Such notice will state the time, place and nature of the hearing; the legal authority and jurisdiction under which the hearing is to be held; the matters of fact and law asserted or to be considered; and a request for an answer. The time and place for hearing will be fixed with due regard for the convenience and necessity of the parties or their representatives.

b. The notice of hearing may be a separate notice or when appropriate may be embodied in the order issued pursuant to RH-4009.

RH-4029. **Answer**.

a. Within the time allowed by the notice of hearing for filing and serving an answer, and as required, the answer of a licensee, registrant, or applicant shall fully advise the Department and any other parties as to the nature of the defense or other position of the answering party, the issues he/she proposes to controvert and those he/she does not controvert, and whether

or not he/she proposes to appear and present evidence. If facts are alleged, the answer shall admit or deny specifically each allegation of fact; or where knowledge is lacking, the answer may so state and the statement shall operate as a denial. Allegations of fact not denied shall be deemed to be admitted. Matters alleged as affirmative defenses or positions shall be separately stated and identified and, in the absence of a reply, shall be deemed to be controverted. The answer of an intervener shall fully advise

RH-4029. (Cont'd)

the Department and other parties of his/her position and whether or not he/she proposes to appear and present evidence.

b. If a party does not oppose any order or proposed action of the Department embodied in or accompanying the notice of hearing or does not wish to appear and give evidence at the hearing, the answer shall so state. In lieu of appearing, the party may, if he/she chooses, submit a notarized statement of reasons why the proposed order or sanction should not be issued or should be different than proposed, and the Department will attribute such weight as it deems deserving to the written reasons.

RH-4030. **Reply**.

In appropriate cases the Department may file and serve a reply to the answer or, if the answer affects other parties to the proceeding, the Director or the Hearing Officer may permit such parties to file and serve a reply.

RH-4031. **Default**.

Failure of a party to file and serve an answer within the time provided in the notice of hearing or as prescribed herein or to appear at a hearing shall be deemed to authorize the Department, at its discretion, as to such party:

a. To find the facts alleged to be true and to enter such finding or order as may be appropriate, without further notice or hearing; or

b. To proceed to take proof, without further notice, on the Allegations or issues set forth in the Specification of Issues.

RH-4032. **Admissions**.

After answer has been filed, any party may file and serve upon the opposing side a written request for the admission of the genuineness and authenticity of any relevant documents described in or attached to the request or for the admission of

the truth of any relevant matters of fact stated in the request. Each matter for which an admission is requested shall be deemed admitted unless within the time designated in the request, but not less than ten (10) days after service thereof or such further time as the Hearing Officer may allow upon motion and notice, the party to whom the request is directed serves upon motion and notice, the party to whom the request is directed serves upon the requesting party a sworn statement

RH-4032. (Cont'd)

either denying the matters upon which the admission is requested or setting up the reasons why he/she cannot truthfully admit or deny such matters.

RH-4033. **Pre-hearing Conferences**.

a. In order to provide opportunity for the settlement of a proceeding or any of the issues therein or for agreement upon procedural and other matters, there may be held at any time prior to or during a hearing, upon due notice of the time and place given to all parties, such conferences of the parties as, in the discretion of the Hearing Officer, time, the nature of the proceeding, and the public interest may permit.

b. Action taken at a pre-hearing conference may be recorded for appropriate use at the hearing in the form of a written stipulation among the parties reciting the matters upon which there has been an agreement. The stipulation shall be binding upon the parties thereto.

RH-4034. **Public Hearings**.

All formal hearings shall be public except in cases involving restricted data.

RH-4035. **Evidence in Formal Hearings**.

a. Every party to the hearing shall have the right to present such oral or documentary evidence and rebuttal evidence and conduct such cross-examination as may be required for a full and true disclosure of the facts. The parties shall be encouraged to present evidence in written form.

b. The Hearing Officer shall exclude all irrelevant, immaterial, or unduly repetitious evidence.

c. Objections to the admission or exclusion of evidence shall state the grounds of objections. The transcript shall include the objections, the

grounds and the rulings, but not the argument of the grounds, unless ordered by the Hearing Officer.

d. Any offer of proof made in connection with an objection taken to the ruling of the Hearing Officer, excluding or rejecting proffered oral testimony, shall consist of a statement of substance of the evidence which the party contends would be adduced by such testimony. If the excluded

RH-4035. (Cont'd)

material is documentary or written, a copy of such material shall be marked for identification and shall constitute the offer of proof.

e. An official record of a governmental agency or an entry in such record, when admissible, may be evidenced by an official publication thereof or by a copy attested as a true copy by the officer having legal custody of the record, or by his/her deputy and accompanied by a certificate that such officer has the custody.

RH-4036. **Briefs**.

Briefs may be filed within ten (10) days after the close of the hearing provided, however, that the Director may, upon written application, grant an additional period of time not in excess of sixty (60) days within which briefs may be filed.

RH-4037. **Findings and Order**.

The Director shall, after reviewing the entire record of the hearing, make his/her findings and enter his/her order. The findings and order shall be in writing and shall contain a statement of findings and conclusions upon all material issues of fact and law and shall be signed by the Director. The original thereof shall be filed as a part of the record of the case which shall be retained in the custody of the Director unless an appeal is taken therefrom, and one certified copy of the findings and order shall be served on all parties to the proceeding.

RH-4038. **Appeals from Decision of Director**.

Any person who is aggrieved by any ruling, decision, or action of the Director may appeal to the State Board of Health within thirty (30) days after service of said ruling, decision, or action by filing with the President of the State Board of Health a written complaint setting out the ruling, decision, or action complained of, the reason that such person is aggrieved and the relief sought by such person. A copy of such complaint shall also be served by the appealing party upon any

other party in interest. No new evidence shall be introduced, and the appeal shall be tried upon the record prepared by the Director or Hearing Officer. Additional briefs and oral arguments may be granted by the State Board of Health. The State Board of Health may affirm the Findings and Order of the Director or may reverse, modify, or remand the case for further proceedings. Copies of the State Board of Health Order shall be served upon the parties in interest as provided in RH-4037. ~~of this Regulation.~~

RH-4039. **Waiver of Procedures**.

The parties to any hearing may agree to waive any one or more of the procedural steps which would otherwise precede the reaching of a final decision by the Department.

RH-4040. **Public Records - Exceptions**.

Except as provided below, all records shall be deemed public records and shall be open to inspection by the public. The following are not to be considered public records which are available for public inspection:

a. Documents relating to personnel matters and medical and other personal information, which, under general government personnel practices, are not normally made public.

b. Intra-agency and inter-agency communications, including memoranda, reports, correspondence and staff papers prepared by members of the Department personnel or by any other government agency for use within the Department or within the executive branch of the Government.

c. Records and reports of investigations.

d. Documents classified as restricted data under the Atomic Energy Act of 1954, as amended, or classified under Executive Order of the President of the United States as restricted data.

e. Correspondence received in confidence by the Department relating to an alleged or possible violation of any statute, rule, ~~regulation,~~ order, license, registration, or permit.

f. Any other document involving matters of internal Department management.

g. Any other matter required by law to be kept confidential or not available to public inspection.

h. The Department may withhold any document or part thereof from public inspection if disclosure of its contents is not required in the public interest and would adversely affect the interest of a person concerned. Such withholding from public inspection shall not, however, affect the right of persons properly and directly concerned to inspect the document. Persons requesting that documents or information therein be withheld from public disclosure shall make prompt application identifying the material and giving the reasons. Where the applicant is responsible for the preparation

RH-4040. (Cont'd)

of the document, he/she shall, insofar as is possible, segregate in a separate paper the information for which the special treatment is requested. The Department may honor the request upon a finding that public inspection is not required in the public interest and would adversely affect the interest of the person concerned. If the request is denied, the applicant will be notified thereof with a statement of the reasons.

RH-4041.- RH-4999. Reserved.

SECTION 6.
LICENSES AND RADIATION SAFETY REQUIREMENTS FOR PARTICLE ACCELERATORS

PART A.
GENERAL

RH-5000. **Authority**. Act 8 of Second Extraordinary Session of 1961, as amended.

RH-5001. **Effective Date**. January 1, 1972.

RH-5002. **Purpose and Scope**.

a. This Section establishes procedures for the licensing and the use of particle accelerators.

b. In addition to the requirements of this Section, all licensees are subject to applicable requirements in Sections 3 and 4 ~~of these Regulations~~. Licensees engaged in industrial radiographic operations are subject to the applicable requirements in Part I of Section 3. Licensees engaged in well-logging operations are subject to the applicable requirements of Part J of Section 3. Licensees who use an accelerator for medical therapy are subject to the applicable requirements in Section 11 ~~of these Regulations~~.

c. **Production of radioactive material**.

1. A licensee who produces radioactive material incidentally as a result of the operation of an accelerator shall comply with the ~~general~~ license requirements of RH-402.n.

2. A licensee who produces radioactive material intentionally as a result of the operation of an accelerator shall comply with the specific license requirements of Section 2 ~~of these Regulations~~.

RH-5003. **Fees**.

In accordance with ~~Act 596 of 2011, codified at~~ Arkansas Code Annotated §20-21-217, annual fees for licensing shall be paid. Applicants shall be charged for a full calendar year regardless of the month the license is issued. Nonpayment of fees shall result in escalated enforcement action and/or revocation of license.

a. The Accelerator License Fees are as follows:

CATEGORY	FEE
Particle accelerator, non-medical	$200~~.00~~
~~Medical, therapy, non-hospital unit~~	~~$250.00 per unit ($175.00 for each additional unit)~~
Particle accelerator, medical, non-hospital unit	$450~~.00~~ per unit ($300~~.00~~ for each additional unit)
Cyclotron/accelerator for the production of radioactive material	$3,750~~.00~~

b. Other fees are as follows:

CATEGORY	FEE
Arkansas State Board of Health Rules ~~and Regulations~~ for Control of Sources of Ionizing Radiation	$0~~.00~~ for first hard copy $30~~.00~~ for each additional hard copy
Amendment to existing license	$50~~.00~~ per amendment

c. Reciprocity fees are as follows:

CATEGORY	FEE
Particle accelerator, industrial	$200

RH-5004. **Communications**.

Except where otherwise specified, all communications concerning these ~~Regulations~~ Rules may be addressed to the Arkansas Department of Health, Radiation Control Section, 4815 West Markham Street, Slot 30, Little Rock, Arkansas, 72205-3867.

RH-5005. **Interpretations**.

Except as specifically authorized by the Department in writing, no interpretations of the meaning of the ~~regulations~~ rules in this Section by an officer or employee of the Department other than a written interpretation by the Department Director or designee will be recognized as binding upon the Department.

RH-5006.- RH-5099. Reserved.

PART B.
DEFINITIONS

RH-5100. **Definitions**.

Accelerator or Particle Accelerator - Any machine capable of accelerating electrons, protons, deuterons or other charged particles in a vacuum and of discharging the resultant particulate or other radiation into a medium at energies usually in excess of 1 MeV. Therapeutic radiation machines capable of generating energies at or above 500 kV/keV shall be considered particle accelerators.

Accelerator License - Except where otherwise specified, a license issued pursuant to these ~~Regulations~~ Rules.

Act - Act 8 of Second Extraordinary Session of 1961, as amended.

Calibration - The determination of the response or reading of an instrument relative to a series of known radiation values over the range of the instrument, or the strength of a source of radiation relative to a standard.

Control panel - The part of the radiation machine where the switches, knobs, push buttons, and other hardware necessary for manually setting the technique factors are located. For purposes of this Section, console is an equivalent term.

Department - Arkansas Department of Health.

Dosimetry system - A system of devices used for the detection, measurement, and display of qualitative and quantitative radiation exposures.

High Radiation Area - An area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or 30 centimeters from any surface that the radiation penetrates.

Human use - The internal or external administration of radiation or radioactive material to human beings.

Individual - Any human being.

Industrial radiography - The examination of the structure of materials by non-destructive methods utilizing a particle accelerator.

Interlock - A device preventing the start or continued operation of equipment unless certain predetermined conditions prevail.

Licensee - Any person who is licensed by the Department in accordance with these ~~Regulations~~ Rules and the Act.

Operator - A person qualified by training and experience to assume responsibility for the safe operation of a particle accelerator.

Person –

1. Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, agency of this state, political subdivision of this state, any other state or political subdivision or agency thereof; and

2. Any legal successor, representative, agent, or agency of the foregoing, but not including United States Government agencies.

Personnel monitoring equipment - Devices designed to be worn by a single individual for the assessment of dose equivalent. Examples of personnel monitoring equipment are film badges, thermoluminescent dosimeters (TLDs), pocket ionization chambers, optically stimulated luminescence (OSL) dosimeters and personal ("lapel") air sampling devices.

Qualified Expert - An individual specifically approved by the Department as having the knowledge and training to measure ionizing radiation, to evaluate safety techniques, and to advise regarding radiation protection matters. Individuals shall be certified in an appropriate field, commensurate with his/her duties, either by the American Board of Radiology, the American Board of Health Physics, the American Board of Medical Physics, or the Canadian College of Physicists in Medicine, or individuals may have equivalent qualifications. An individual that meets the qualifications in RH-10200.d. for a Qualified Medical Physicist also meets the qualifications of a Qualified Expert.

Radiation - Ionizing radiation, i.e., gamma rays and x-rays, alpha and beta particles, neutrons, high speed electrons, high speed protons, and other particles capable of producing ions. Radiation, as used in these ~~Regulations~~ Rules, does not include non-ionizing radiation, such as radio waves or microwaves, or visible, infrared, or ultraviolet light.

Radiation Safety Officer - An individual who has the knowledge and responsibility to apply appropriate radiation protection ~~regulations~~ rules and has been assigned such responsibility by the licensee.

RH-5100. (Cont'd)

Research and Development -

1. Theoretical analysis, exploration, or experimentation; or

2. The extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, devices, equipment, materials, and processes.

   Research and Development does not include the internal or external administration of radiation or radioactive material to human beings.

Test - The process of verifying compliance with an applicable ~~regulation~~ rule.

Very high radiation area - An area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in one (1) hour at one (1) meter from a radiation source or from any surface that the radiation penetrates.

Note: At very high doses received at high dose rates, units of absorbed dose (e.g., rads and grays) are appropriate, rather than units of dose equivalent (e.g., rems and sieverts).

RH-5101.- RH-5199. Reserved.

PART C.
LICENSES

RH-5200. **License Requirement**.

Except for persons exempt as provided in RH-5214. and RH-5600., ~~N~~no person shall receive, possess, use, transfer, own or acquire a particle accelerator except as authorized in a license issued pursuant to this Section.

RH-5201. **Licensing Procedures**.

a. Application for accelerator licenses shall be filed on forms supplied by:

Radiation Control Section
Arkansas Department of Health
4815 West Markham Street, Slot 30
Little Rock, Arkansas 72205-3867

The application shall set forth all applicable information called for by the form.

b. The Department may at any time after the filing of the original application and before the expiration of the license, require further statements in order to enable the Department to determine whether the application will be granted or denied or whether a license should be modified or revoked.

c. Each application shall be signed by the applicant or licensee or a person duly authorized to act for and on his behalf.

d. In the application, the applicant may incorporate, by reference, information contained in previous applications, statements, or reports filed with the Department, provided that such references are clear and specific.

e. Applications and documents submitted to the Department may be made available for public inspection except that the Department may withhold any document or part thereof from public inspection if disclosure of its contents is not required in the public interest and would adversely affect the interest of a person concerned.

RH-5201. (Cont'd)

f. The Department may verify information contained in applications and secure additional information deemed necessary to make a reasonable determination as to whether to issue a license and whether special conditions should be attached thereto by visiting the facility or location where a particle accelerator would be located and used and by discussing details of proposed use of the particle accelerator with the applicant or his designated representative.

g. Every person possessing a particle accelerator on the effective date of these ~~Regulations~~ Rules shall have a period of ninety (90) days in which to make application for a license.

RH-5202. **General Requirements for the Issuance of a License for Particle Accelerators**.

A license application will be approved if the Department determines that:

a. The applicant is qualified by reason of training and experience to use the accelerator in question for the purpose requested in accordance with this Section and Section 3 in such a manner as to minimize danger to public health and safety or property;

b. The applicant's proposed equipment, facilities, and operating and emergency procedures are adequate to protect health and minimize danger to public health and safety or property;

c. The issuance of the license will not be inimical to the health and safety of the public;

d. The applicant demonstrates that particle accelerator operators have substantial training and experience concerning the requested uses of the accelerator;

e. The applicant has appointed a Radiation Safety Officer; and

f. The applicant satisfies any applicable special requirements in RH-5203.

RH-5203. **Special Requirements for the Issuance of a License for Certain Types of Particle Accelerators**.

a. **Use of particle accelerators in medical therapy**.

In addition to the requirements set forth in RH-5202., a license for use of a particle accelerator in medical therapy will be issued only if:

1. The applicant has appointed a medical committee of at least three members to evaluate all proposals for research, diagnostic, and therapeutic use of a particle accelerator within that facility. Membership of the committee should include physicians expert in internal medicine, hematology, and therapeutic radiology; a person experienced in depth dose calculations and protection against radiation; and a representative of the facility's management;

2. Prospective Authorized User physicians meet training and experience requirements specified in Section 11~~ of these Regulations~~; and

3. The applicant has developed an adequate training program for particle accelerator operators in accordance with the provisions of RH-5411.

b. **Use of particle accelerators in research and development**.

In addition to the requirements of RH-5202., a license for the use of a particle accelerator in research and development will be issued only if:

1. Whenever deemed necessary by the Department, the applicant has established a Radiation Safety Committee to approve, in advance, proposals for uses of particle accelerators in research and development; and

2. The applicant has developed an adequate training program for particle accelerator operators in accordance with the provisions of RH-5411.

RH-5203. (Cont'd)

c. **Use of particle accelerators for the production of radioactive material**.

In addition to the requirements of RH-5202., a license for the use of a particle accelerator to produce radioactive material will be issued only if:

1. The applicant has developed an adequate training program for particle accelerator operators in accordance with the provisions of RH-5411; and

2. The applicant has applied for a radioactive material specific license in accordance with the requirements of Section 2 ~~of these Regulations~~.

d. **Use of particle accelerators in industrial radiography**.

In addition to the requirements of RH-5202., a license for the use of a particle accelerator in industrial radiography will be issued only if:

1. The applicant has developed an adequate training program for radiographers and radiographer's assistants in accordance with the provisions of RH-5411.

RH-5204. **Issuance of Particle Accelerator Licenses**.

Upon a determination that an application meets the requirements of the Act and these ~~Regulations~~ Rules of the Department, the Department will issue a specific license authorizing the proposed activity in such form and containing such conditions and limitations as it deems appropriate or necessary to effectuate the purposes of the Act.

RH-5205. **Specific Terms and Conditions of Licenses**.

a. Each license issued pursuant to this Section shall be subject to all the provisions of the Act, now or hereafter in effect, and to all rules~~, regulations,~~ and orders of the Department.

b. No license issued under this Section and no right to possess or utilize a particle accelerator granted by any license issued pursuant to this Section shall be transferred, assigned or in any manner disposed of, either voluntarily or involuntarily, directly or indirectly, through transfer of control of any license to any person unless the Department shall, after securing full information, find that the transfer is in accordance with the provisions of the Act and shall give its consent in writing.

c. Each person licensed by the Department pursuant to this Section shall confine use and possession of the particle accelerator licensed to the locations and purposes authorized in the license. Any change in facility or location must be approved by the Department.

d. The Department may incorporate in any license at the time of issuance, or thereafter by appropriate rule~~, regulation~~, or order, such additional requirements and conditions with respect to the licensee's use of a particle accelerator as it deems appropriate or necessary in order to:

1. Protect health or to minimize danger to life or property; and

2. Require such reports and the keeping of such records, and to provide for such inspection of activities under the license as may be necessary or appropriate to effectuate the purposes of the Act and these ~~Regulations~~ Rules thereunder.

e. **Bankruptcy notification**.

1. Each licensee shall notify the Department, in writing, immediately following the filing of a voluntary or involuntary petition for bankruptcy under any Chapter of Title II (Bankruptcy) of the United States Code by or against:

A. The licensee;

B. An entity (as that term is defined in 11 U.S.C. 101(15)) controlling the licensee or listing the license or licensee as property of the estate; or

C. An affiliate (as that term is defined in 11 U.S.C. 101 (2)) of the licensee.

RH-5205.e. (Cont'd)

2. This notification must indicate:

A. The bankruptcy court in which the petition for bankruptcy court was filed; and

B. The date of the filing of the petition.

RH-5206. **Expiration and Termination of Licenses.**

a. Except as provided in RH-5206.e.3.A. and RH-5207.b., each particle accelerator license shall expire at the end of the day, in the month and year stated therein.

b. Expiration of the license does not relieve the licensee of the requirements of these ~~Regulations~~ Rules.

c. Each license revoked by the Department expires with the Department's final determination to revoke the license, or on the expiration date stated in the determination, or as otherwise provided by Department Order.

d. When a licensee decides to permanently discontinue activities involving accelerators authorized under the license, the licensee shall immediately notify the Department of such, in writing, and request termination of the license. Actions completed by the licensee and information submitted to the Department shall be as that required in paragraph e of this section.

e. 1. If a licensee does not submit an application for renewal of the license in accordance with RH-5207, the licensee shall, on or before the expiration date specified in the license:

A. Terminate the use of all particle accelerators;

B. Request termination of the license in writing;

C. Submit to the Department a record of the disposition of the accelerators, and if transferred, to whom they were transferred;

D. Properly dispose of incidentally produced radioactive material generated by the operation of an accelerator;

E. Submit to the Department a record of the disposition of incidentally produced radioactive material generated by the operation of an accelerator;

F. Submit to the Department, for its approval, a final status radiation survey plan that addresses all incidentally produced radionuclides specific to the site;

G. Conduct a radiation survey of the premises as delineated in the approved survey plan and submit a report of the results of this survey to confirm the absence of radioactive material or to establish the levels of radioactive contamination, unless the Department approves an alternate method for demonstrating that the premises are suitable for release. The survey report shall specify the instrumentation used and certify that each instrument was properly calibrated and tested. The licensee shall, as applicable, report levels or quantities of:

i. Beta radiation at 1 centimeter from surfaces and gamma radiation at 1 centimeter and 1 meter from surfaces (in units, multiples, or submultiples of rem or seiverts per hour or microroentgens per hour);

ii. Removable and fixed radioactivity on surfaces (in units, multiples, or submultiples of curies or becquerels per 100 square centimeters or in disintegrations per minute per 100 square centimeters);

iii. Radioactivity in contaminated liquids such as water or oil (in units, multiples, or submultiples of curies or becquerels per milliliter or per gram); and

iv. Radioactivity in contaminated solids such as soils or concrete (in units, multiples, or submultiples of curies or becquerels per gram).

2. If no incidentally produced radioactive contamination attributable to activities conducted under the license is detected, the licensee shall submit a certification that no detectable radioactive contamination was found. The Department will notify the licensee, in writing, of the termination of the license, once the certification has been approved.

RH-5206.e. (Cont'd)

3. A. If detectable levels of incidentally produced radioactive contamination attributable to activities conducted under the license are found, the license continues in effect beyond the expiration date, if necessary, until the Department notifies the licensee, in writing, that the license is terminated.

B. In addition to the information submitted under RH-5206.e.1. C., E., F., and G., the licensee shall submit a plan for decontamination and disposal, if required by the Department.

f. Each accelerator licensee who possesses incidentally produced radioactive material and whose license is to be terminated pursuant to paragraph d or e of this section shall:

1. Limit actions involving radioactive material to those related to decontamination and to other activities related to preparation for release for unrestricted use; and

2. Continue to control entry to restricted areas until they are suitable for release for unrestricted use and until the Department notifies the licensee in writing that the license is terminated.

RH-5207. **Renewal of Licenses**.

a. Application for renewal of an accelerator license shall be filed in accordance with RH-5201.

b. In any case in which a licensee, not less than thirty (30) days prior to expiration of this existing license, has filed an application in proper form for renewal or for a new license authorizing the same activities, such existing license shall not expire until the application status has been determined by the Department.

RH-5208. **Amendment of License at Request of Licensee**.

Applications for amendment of a license shall be filed in accordance with RH-5201. and shall specify the respects in which the licensee desires the license to be amended and the grounds for such amendment.

RH-5209. **Department Action on Applications to Renew or Amend**.

In considering an application by a licensee to renew or amend the license, the Department will apply the criteria set forth in RH-5202. and RH-5203., and in Sections 3, 6, and 11 as applicable.

RH-5210. Deleted.

RH-5211. **Modification, Suspension, and Revocation of Licenses**.

a. The terms and conditions of all licenses shall be subject to revision or modification. A license may be suspended or revoked by reason of amendments to the Act, or by reason of rules~~, regulations,~~ or orders issued by the Department.

b. Any license may be revoked, suspended, or modified, in whole or in part, for any of the following:

1. A~~a~~ny material false statement in the application or any statement of fact required under provisions of the Act or of these ~~Regulations~~ Rules~~,~~; ~~or because of~~

2. C~~c~~onditions revealed by such application or statement of fact or any report, record, or inspection or other means ~~which~~ that would warrant the Department to refuse to grant a license on an original application~~,~~; ~~or for~~

3. V~~v~~iolation of, or failure to observe any of, the terms and conditions of the Act, or the license, or of any rule~~, regulation,~~ or order of the Department~~.~~; or

4. Existing conditions that constitute a substantial threat to public health or safety or the environment.

c. Except in cases of willful violation or those in which the public health, interest, or safety requires otherwise, no license shall be modified, suspended, or revoked unless, prior to the institution of proceedings therefor, facts or conduct which may warrant such action shall have been called to the attention of the licensee in writing, and the licensee shall have been accorded opportunity to demonstrate or achieve compliance with all lawful requirements.

d. Deleted. See RH-5206.

RH-5212. **Licensure of Out-of-State Particle Accelerators for Non-Industrial Use**.

a. An out-of-state particle accelerator ~~registrant/~~licensee/registrant seeking to bring a particle accelerator into the State ~~of Arkansas~~ for non-industrial use shall apply for an Arkansas particle accelerator license in accordance with Part C of this Section.

b. Annual fees for licensing shall be paid in accordance with RH-5003.

c. The licensee shall notify the Department in writing at least three (3) working days prior to the accelerator's use in the State. The notice shall include the following:

1. ~~The t~~Type of particle accelerator;

2. ~~The n~~Nature, duration, and scope of use; and

3. ~~The e~~Exact location(s) where the particle accelerator is to be used.

d. If, for a specific case, the three (3) day period would impose an undue hardship, ~~on~~ the licensee may, ~~upon application to~~ at the determination of the Department, obtain permission to proceed sooner ~~may be granted~~.

RH-5213. **Report of Changes**.

The licensee shall notify the Department in writing before making any change that would render the information contained in the license application and/or the license no longer accurate.

RH-5214. **Reciprocal Recognition of Out-of-State Particle Accelerator Licenses for Industrial Use**.

a. Whenever any particle accelerator is brought into the State for any temporary industrial use, the person proposing to bring such a machine into the State shall apply for and receive a notice from the Department granting reciprocal recognition prior to beginning operations. The request for reciprocity shall include the following:

1. Type of particle accelerator;

2. Nature, duration, and scope of use;

3. Exact location(s) where the particle accelerator is to be used;

4. Copy of the person's current license or equivalent document;

5. Qualifications for each radiographer who will be working in Arkansas if the reciprocity request is for industrial radiography as defined in Part I of Section 3; and

6. Applicable fee as specified in RH-5003.

b. Upon a determination that the request for reciprocity meets the requirements of the Department, the Department may issue a notice granting reciprocal recognition authorizing the proposed use.

c. Once reciprocity is granted, the out-of-state licensee shall notify the Department in writing prior to each entry into the State. This notice shall be submitted at least three (3) working days before the particle accelerator is to be used in the State. If, for a specific case, the three (3) day period would impose an undue hardship, the out-of-state licensee may, at the determination of the Department, obtain permission to proceed sooner.

d. The out-of-state licensee shall:

1. Comply with all applicable rules of the Department and with all the terms and conditions of the out-of-state license, except any such terms and conditions that may be inconsistent with applicable rules of the Department;

2. Supply the Department with such other information as the Department may reasonably request; and

3. Only operate in the State for 180 or less calendar days per year.

e. Use in excess of 180 days per calendar year requires a license in accordance with Part C of this Section.

f. If the State from which the particle accelerator is brought does not issue licenses or equivalent documents, a license shall be obtained from the Department in accordance with Part C of this Section.

g. The Department may withdraw, limit, or qualify its acceptance of any license or equivalent document issued by another State upon determining that the action is necessary to prevent undue hazard to occupational or public health and safety.

RH-~~5214~~5215.- RH-5299. Reserved.

PART D.
[RESERVED]

RH-5300.- RH-5301. Deleted. See Part G of this Section.

RH-5302.- RH-5399. Reserved.

PART E.
RADIATION SAFETY REQUIREMENTS FOR THE USE OF PARTICLE ACCELERATORS

RH-5400. **General Provisions.**

This Part establishes radiation safety requirements for the use of particle accelerators. The provisions of this Part are in addition to, and not in substitution for, other applicable provisions of these ~~Regulations~~ Rules.

RH-5401. **Limitations.**

a. No licensee shall permit any individual to act as particle accelerator operator until such individual:

1. Has been instructed in the subjects detailed in RH-5410. and has demonstrated an understanding thereof;

2. Has received copies of and instruction in this Section, the applicable requirements of Section 3 ~~of these Regulations~~, pertinent license conditions, and the licensee's operating and emergency procedures, and has demonstrated understanding thereof; and

3. Has demonstrated competence to use the particle accelerator, related equipment, and survey instruments that will be utilized by the individual.

b. In addition to the initial training requirements in paragraph a. of this section, the training program for accelerator operators shall also include refresher training at intervals not to exceed twelve (12) months and training to be conducted when a significant change occurs in duties, ~~regulations~~ rules, or terms of the license.

c. Operators of particle accelerators for industrial radiography shall have successfully completed the x-ray portion of a radiographer certification exam. A radiographer's assistant may operate an accelerator for industrial radiography only when under the direct supervision of a radiographer.

d. Training records pursuant to paragraphs a. through c. of this section shall be maintained for five (5) years beyond the last date the individual was authorized to operate an accelerator at that facility.

RH-5401. (Cont'd)

e. The Radiation Safety Officer shall have the authority to restrict or terminate operations at an accelerator facility if such action is deemed necessary to minimize danger to health and safety, property, or the environment.

f. The accelerator facility shall operate within the terms and conditions of the license issued for the operation of the accelerator.

RH-5402. **Shielding and Safety Design Requirements.**

a. A Qualified Expert shall be consulted in the shielding design of a particle accelerator installation.

b. Each accelerator installation shall be provided with such primary and/or secondary barriers as are necessary to ensure compliance with RH-1200. and RH-1208. All protective barriers shall be fixed except for entrance doors or movable beam interceptors.

c. For portable or mobile accelerators, such as neutron generators that are used at temporary job sites where permanent shielding is not available, radiation protection shall be provided by temporary shielding or by providing an adequate exclusion area around the accelerator while it is in use.

RH-5403. **Accelerator Controls and Interlock Systems.**

a. Instrumentation, readouts, and controls on the accelerator control console shall be clearly identified and easily discernible.

b. All entrances into a target room or other high or very high radiation area shall have interlocks that meet the requirements of RH-1303. regarding the control of access to high and very high radiation areas. If the radiation beam is interrupted by any door opening, it shall not be possible to restore the machine to operation without closing the door and reinitiating irradiation or treatment by manual action at the control panel.

c. When an interlock system has been tripped, it shall only be possible to resume operation of the accelerator by manually resetting controls at the interlock position and lastly at the main control console.

d. Each safety interlock shall be on an electrical circuit that allows the interlock to operate independently of all other safety interlocks.

RH-5403. (Cont'd)

e. All safety interlocks shall be designed so that any defect or component failure in the safety interlock system prevents or terminates operation of the accelerator.

f. A scram button or other emergency power cut-off switch shall be located and easily identifiable in all high and very high radiation areas. The cut-off switch shall include a manual reset so that the accelerator cannot be restarted from the accelerator control console without resetting the cut-off switch.

g. The control panel shall be located outside the treatment or irradiation room.

RH-5404. **Warning Devices.**

a. In medical facilities, each high and very high radiation area and entrances to such locations shall be equipped with a continuously-operating warning light system that operates when, and only when, radiation is being produced.

b. In non-medical facilities, each high and very high radiation area and entrances to such locations shall be equipped with an easily observable flashing or rotating warning light system that operates when, and only when, radiation is being produced.

c. In non-medical facilities, each high and very high radiation area shall have an audible warning device that is activated for 15 seconds prior to creation of the high or very high radiation area. The audible warning shall be clearly discernible in the high or very high radiation area and in any adjacent high radiation areas and radiation areas.

d. High and very high radiation areas shall be conspicuously posted in accordance with RH-1303.

e. The safety interlock system shall have a visible or audible alarm that will indicate when any interlock has been activated.

RH-5405. **Operating Procedures.**

a. Particle accelerators, when not in operation, shall be secured to prevent unauthorized use.

RH-5405. (Cont'd)

b. Only a button/switch on the accelerator control console shall be routinely used to turn the accelerator beam on and off. The safety interlock system shall not be used to turn off the accelerator beam except in an emergency or for testing the interlock.

c. All safety and warning devices, including interlocks, shall be checked for proper operability at intervals not to exceed three (3) months and shall be repaired as necessary. Results of these checks and records of repairs shall be maintained for five (5) years at the accelerator facility for inspection by the Department.

d. Electrical circuit diagrams of the accelerator and the associated safety, warning, and interlock systems shall be kept current and maintained for inspection by the Department. These diagrams shall also be available to the operator at each accelerator facility.

e. If, for any reason, it is necessary to intentionally bypass a safety interlock or interlocks, such action shall be:

1. Authorized in writing by the Radiation Safety Committee or the Radiation Safety Officer;

2. Recorded in a permanent log and posted as a notice at the accelerator control console and at any affected interlock; and

3. Terminated as soon as possible.

f. In the event of a malfunction of a safety or warning device, the accelerator shall not be operated unless appropriate interim precautions are instituted to provide equivalent protection.

g. A copy of the current operating and emergency procedures shall be maintained at the accelerator control console.

h. For accelerators used to irradiate materials by means of a transfer or conveyance system, a means shall be provided that either terminates the irradiation or prevents entry if an individual attempts to access the irradiation room.

RH-5405. (Cont'd)

i. Windows, mirrors, closed-circuit television, or an equivalent viewing system shall be provided to permit continuous observation of material being irradiated and any transfer or conveyance of material within an irradiation room. The viewing system shall be so located that the operator can observe the material being irradiated from the control panel. The accelerator shall not be used for irradiation unless at least one viewing system is operational.

j. Records of maintenance and/or modifications performed on an accelerator shall be maintained, including the names of persons who performed the services. The licensee shall keep these records for inspection by the Department for five (5) years.

k. Preventative maintenance on an accelerator shall be performed in accordance with the licensee's written procedures.

RH-5406. **Personnel Monitoring Requirements.**

a. In accordance with RH-1302., "Conditions Requiring Individual Monitoring of External and Internal Occupational Dose," each licensee shall monitor exposures to radiation at levels sufficient to demonstrate compliance with the occupational dose limits of Section 3, "Standards for Protection Against Radiation."

b. Each licensee shall maintain records of doses received by all individuals for whom personnel monitoring is required under RH-1302. Such records shall be maintained in accordance with the provisions of RH-1500.

RH-5407. **Area Monitoring and Survey Requirements.**

a. Radiation levels in all high and very high radiation areas shall be continuously monitored. The monitoring devices shall be electrically independent of the accelerator control and safety interlock systems. The monitoring devices shall be capable of providing a remote and local readout with visible and/or audible alarms at both the control panel and monitoring stations. The monitoring devices shall be set to activate at a level of at least 100 mrem/hr.

b. All area monitors shall be checked for proper operation before each day of accelerator use and after each servicing or repair. Records of area monitor operability shall be maintained for five (5) years. Each record shall include the date of the check, notation that the monitor indicates when the beam is "ON" and when it is "OFF," and the initials of the individual who performed the check.

c. There shall be available at each accelerator facility, appropriate portable monitoring equipment that is operable and has been calibrated for the applicable radiations being produced at the facility. As a minimum, such equipment shall include a portable radiation measurement survey instrument capable of measuring dose rates over the range of 1 mrem (10 μSv) per hour to 1000 mrem (10 mSv) per hour.

d. 1. Portable monitoring equipment shall be tested for proper operation by way of a reference check performed at the following frequencies:

A. At the time of calibration;

B. Before each use and also after each survey to ensure the equipment was operational during the survey;

C. After each maintenance and/or battery change; and

D. At least quarterly.

2. If any reference check performed using a pre-defined geometry yields a reading that is not within +/- 20% of the reading measured immediately after calibration, the instrument shall be recalibrated.

3. Records of portable monitoring equipment operability shall be maintained for five (5) years.

e. Portable monitoring equipment shall be calibrated before first use, at intervals specified by the Department, and following any repair that will affect the calibration. Survey instruments shall be calibrated in accordance with RH-5412. Records of portable monitoring equipment calibration shall be maintained for five (5) years.

RH-5407. (Cont'd)

f. A radiation protection survey shall be performed when the accelerator is first capable of producing radiation; when changes have been made in shielding, operation, occupancy of adjacent areas, or equipment, including relocation of equipment within an irradiation or treatment room; and at least annually to check for unknown changes and malfunctioning equipment. Radiation protection surveys shall be performed by, or under the direction of, a Qualified Expert.

g. The Qualified Expert shall report the survey results in writing to the licensee. A copy of the initial survey report shall be maintained by the licensee for inspection by the Department until termination of the license. Other radiation protection survey reports shall be maintained for inspection by the Department for five (5) years. The survey report shall include documentation of all instances where the facility, in the opinion of the Qualified Expert, is in violation of applicable ~~regulations~~ rules. Any deficiencies detected during the survey shall be corrected prior to using the accelerator.

h. The survey report shall include, but not be limited to, the following:

1. The date of the measurements;

2. The reason the survey is required;

3. A description of the accelerator including the manufacturer's name, model number and serial number, beam type, and beam energy;

4. A diagram of the facility that details building structures; areas surrounding an irradiation or treatment room, if applicable, that were surveyed; and the position of the accelerator, control panel, and associated equipment;

5. A description of the instrumentation used to determine radiation measurements, including the date of the most recent calibration and who performed the calibration for each instrument used;

6. The conditions under which radiation measurements were taken;

RH-5407.h. (Cont'd)

7. Survey data including:

A. The measured dose rate at several points in each area expressed in millirems (microsieverts) per hour;

B. The projected maximum "in-any-one-hour" dose equivalent in each unrestricted area adjacent to the accelerator;

C. The projected maximum annual total effective dose equivalent (TEDE) in each restricted and unrestricted area adjacent to the accelerator; and

D. A description of workload, use, and occupancy factors employed in determining the projected annual TEDE; and

8. The signature of the individual responsible for conducting the survey.

i. If the survey required by RH-5407.f. indicates that an individual in an unrestricted area may be exposed to levels of radiation greater than those permitted by RH-1208.a. and RH-1208.b., the licensee shall ensure the following:

1. The unit is equipped with beam direction interlocks or additional radiation shielding is added to ensure compliance with RH-1208.a. and RH-1208.b.;

2. The survey required by RH-5407.f. is performed again; and

3. The survey report generated is in accordance with RH-5407.h. and includes the results of the initial survey, a description of the modification made in order to comply with this paragraph, and the results of the second survey; or

4. A license amendment is requested and received under RH-1208.d.that authorizes radiation levels in unrestricted areas greater than those permitted by RH-1208.a. and RH-1208.b.

j. Copies of the records required in RH-5407.g. and RH-5407.i. shall be submitted to the Department within thirty (30) days following completion of the action that initiated the record requirement. Annual radiation protection surveys shall not be submitted unless it is discovered that radiation levels in unrestricted and/or restricted areas exceed the dose limits specified in Section 3~~ of these Regulations~~.

RH-5407. (Cont'd)

k. Surveys for airborne radiation hazards shall be performed in accordance with written procedures approved by the Department to ensure that any particulate radioactivity present will not result in doses in excess of the limits specified in Section 3~~ of these Regulations~~. Records of surveys for airborne radioactivity shall be maintained for five (5) years.

l. Surveys for ambient radiation levels and removable contamination shall be performed in accordance with written procedures approved by the Department in order to quantify residual activity in target and other pertinent areas. Records of surveys for ambient radiation levels and removable contamination shall be maintained for five (5) years.

m. Surveys for residual activity shall be conducted on all accelerators capable of generating energies above 10 MV (10 MeV) prior to machining, removing, or working on accelerator components which may have become activated due to photo-neutron production. Records of surveys pursuant to this paragraph shall be maintained for five (5) years.

n. Area surveys for residual activity shall be conducted regarding accelerators capable of generating energies above 10 MV (10 MeV) in order to request Department approval for release of the area for unrestricted use. Records of surveys pursuant to this paragraph shall be maintained for five (5) years.

o. Surveys performed in accordance with this section shall be in accordance with written procedures established by a Qualified Expert or the Radiation Safety Officer of the accelerator facility.

p. Radiation measurements shall be performed with a calibrated dosimetry system. The dosimetry system calibration shall be traceable to a national standard. The calibration shall have been performed within the previous twenty-four (24) months and after any servicing that may have affected system calibration. Records of dosimetry system calibrations shall be maintained for five (5) years.

RH-5408. **Ventilation Systems and Waste Disposal.**

a. A licensee shall control occupational dose due to airborne radioactivity so as to meet applicable requirements in "Permissible Doses, Levels, and Concentrations," Part C of Section 3.

RH-5408. (Cont'd)

b. A licensee shall not vent, release, or otherwise discharge airborne radioactive material to an unrestricted area, unless the requirements of RH-1208., "Dose Limits for Individual Members of the Public," are met. Every reasonable effort shall be made to maintain releases of radioactive material to unrestricted areas as far below these limits as practicable. Compliance with this paragraph shall be demonstrated in accordance with RH-1209.

c. For radioactive material specific licensees, waste disposal shall be in accordance with Part E of Section 3~~ of these Regulations~~ and as stated in the specific license. General licensees subject to RH-402.n. shall dispose of incidentally produced radioactive material only by way of Department approved procedures.

RH-5409. **Operating and Emergency Procedures.**

a. The licensee's operating and emergency procedures shall include instructions in at least the following:

1. The use of particle accelerators such that no person is likely to be exposed to radiation doses in excess of the limits established in Section 3, "Standards for Protection Against Radiation";

2. Methods and occasions for conducting radiation surveys;

3. Personnel monitoring and the use of personnel monitoring equipment;

4. Minimizing exposures to persons in the event of an accident;

5. Reporting an actual or suspected exposure;

6. Notifying proper persons in the event of an accident;

7. Safety procedures to be employed whenever an interlock has been either tripped or intentionally bypassed;

8. Testing interlocks, entrance controls, and alarm systems;

9. Preventative maintenance;

10. Methods used to secure the accelerator from unauthorized use;

RH-5409.a. (Cont'd)

11. Methods of testing and training operators in accordance with RH-5401.a.;

12. Posting requirements; and

13. Maintenance of records.

RH-5410. **Minimum Radiation Safety Training Subjects for Instruction of Operators.**

Operators shall have received instruction in and shall have demonstrated an understanding of at least the following subjects in order to meet the requirements of RH-5401.a.1.:

a. **Fundamentals of Radiation Safety.**

1. Characteristics of particulate and electromagnetic radiation.

2. Units of radiation dose and quantity of radioactivity.

3. Biological hazards of exposure to radiation.

4. Measurement of radiation.

5. Methods of controlling radiation dose.

6. Radiation safety procedures, interlock systems and warning systems.

b. **Radiation Detection Instrumentation**.

1. Use of radiation survey instruments.

2. Survey technique.

3. Use of personnel monitoring equipment.

c. **Equipment.**

1. Remote handling equipment.

2. Handling of activated materials.

3. Use of shielding.

RH-5410.c. (Cont'd)

4. Identification of radiation hazards associated with the use of the equipment.

RH-5411. Deleted. See RH-5401.

RH-5412. **Calibration of Survey Instruments.**

a. The licensee shall ensure that the survey instruments used to show compliance with this Section have been calibrated before first use, at intervals not to exceed twelve (12) months, and following any repair that will affect the calibration.

b. To satisfy the requirements of RH-5412.a., the licensee shall ensure:

1. Calibration of all scales with readings up to 1000 mrem (10 mSv) per hour with an appropriate radiation source that is traceable to the National Institute of Standards and Technology (NIST);

2. Calibration of at least two (2) points located at approximately 1/3 and 2/3 of full scale on each scale of a linear scale instrument; calibration at midrange for each decade and at two points of at least one decade on each scale of a logarithmic scale instrument; calibration at three points between 2 and 1000 mrem (0.02 and 10 mSv) per hour for digital instruments.

c. To satisfy the requirements of RH-5412.b., the licensee shall:

1. Consider a point as calibrated if the indicated dose rate differs from the calculated dose rate by not more than ten percent (10%); and

2. Consider a point as calibrated if the indicated dose rate differs from the calculated dose rate by not more than twenty percent (20%) if a correction factor or graph is conspicuously attached to the instrument and is used to interpret readings to within ten percent (10%).

d. The licensee shall retain a record of each calibration required in RH-5412.a. for five (5) years. The record shall include:

1. A description of the calibration procedure; and

RH-5412.d. (Cont'd)

2. A description of the source used and the certified dose rates from the source, and the rates indicated by the instrument being calibrated, the correction factors deduced from the calibration data, the signature of the individual who performed the calibration, and the date of calibration.

e. The licensee may obtain the services of individuals licensed by the Department, the U.S. Nuclear Regulatory Commission, or an Agreement State to perform calibrations of survey instruments. Records of calibrations that contain information required by RH-5412.d. shall be maintained by the licensee.

f. The licensee shall conspicuously note on the instrument the date of calibration.

RH-5413.- RH-5499. Reserved.

PART F.
[RESERVED]

RH-5500.- RH-5513. Deleted. See Section 11, "Therapeutic Radiation Machines."

RH-5514.- RH-5599. Reserved.

PART G.
EXEMPTIONS, ADDITIONAL REQUIREMENTS, INSPECTIONS, AND TESTS

RH-5600. **Exemptions.**

a. Particle accelerators in transit or in storage incident to transit are exempt from the requirements of this Section. This exemption does not apply to the providers of particle accelerators for mobile services. Facilities that have placed all particle accelerators in storage, including on-site storage, and have notified the Department in writing, are exempt from the requirements of this Section. This exemption is void if any particle accelerator is energized resulting in the production of radiation.

b. Inoperable particle accelerators are exempt from the requirements of this Section. For the purposes of this Section, an inoperable particle accelerator means a particle accelerator that cannot be energized when connected to a power supply without repair or modification.

c. Financial institutions that take possession of particle accelerators as the result of foreclosure, bankruptcy, or other default of payment are exempt from the requirements in this Section to the extent that they demonstrate that the unit is operable for the sole purpose of selling, leasing, or transferring.

d. Any U.S. Department of Energy (DOE) contractor or subcontractor and any U.S. Nuclear of Regulatory Commission (NRC) contractor or subcontractor of the following categories operating within this state is exempt from these ~~Regulations~~ Rules to the extent that such contractor or subcontractor under his contract receives, possesses, uses, transfers or acquires sources of radiation:

1. Prime contractors performing work for the DOE at U.S. Government-owned or -controlled sites, including the transportation of sources of radiation to or from such sites and the performance of contract services during temporary interruptions of such transportation;

2. Prime contractors of the DOE performing research in or development, manufacture, storage, testing or transportation of, atomic weapons or components thereof;

3. Prime contractors of the DOE using or operating nuclear reactors or other nuclear devices in a U.S. Government-owned vehicle or vessel; and

RH-5600.d. (Cont'd)

4. Any other prime contractor or subcontractor of the DOE or of the NRC when the State and the NRC jointly determine:

A. That the exemption of the prime contractor or subcontractor is authorized by law; and

B. That, under the terms of the contract or subcontract, there is adequate assurance that the work thereunder can be accomplished without undue risk to the public health and safety.

e. The Department may, upon application of any interested person or upon its own initiative, grant such exemptions from the requirements of the ~~regulations~~ rules in this Section as it determines are authorized by law and will not result in undue hazard to public health and safety or property, and are otherwise in the public interest.

RH-5601. **Additional Requirements.**

The Department may, by rule~~, regulation~~ or order, impose upon any licensee such requirements in addition to those established in these ~~Regulations~~ Rules as it deems appropriate or necessary to minimize danger to public health and safety or property.

RH-5602. **Inspections.**

a. Each licensee shall afford to the Department at all reasonable times opportunity to inspect sources of radiation and the premises and facilities wherein such sources of radiation are used or stored.

b. Each licensee shall make available to the Department for inspection, upon reasonable notice, records kept by the licensee pursuant to these ~~Regulations~~ Rules.

RH-5603. **Tests.**

Upon instruction from the Department, each licensee shall perform or cause to have performed and shall permit the Department to perform, such reasonable tests as the Department deems appropriate or necessary, including, but not limited to, tests of:

a. Sources of radiation;

b. Facilities wherein sources of radiation are used or stored;

c. Radiation detection and monitoring instruments; and

d. Other equipment and devices used in connection with utilization or storage of licensed sources of radiation.

RH-5604.- RH-5699. Reserved.

PART H.
ENFORCEMENT

RH-5700. **Violations.**

a. An injunction or other court order may be obtained prohibiting any violation of any provision of the Act or any ~~regulation~~ rule or order issued thereunder. Any person who willfully violates any provision of the Act or any ~~regulation~~ rule or order issued thereunder may be guilty of a felony, misdemeanor, or crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law. Arkansas Code Annotated §20-21-204 describes criminal and civil penalties which may be assessed.

b. **Impounding**.

Sources of radiation shall be subject to impounding pursuant to Section 5 of these ~~Regulations~~ Rules.

RH-5701.- RH-5799. Reserved.

PART I.
RECORDS

RH-5800. **Receipt, Transfer, and Disposal.**

Each licensee shall maintain records of receipt, transfer, and disposal of accelerators specific to each authorized use location. The records shall include the following information and shall be kept until termination of the license:

a. Date of the receipt, transfer, or disposal;

b. Manufacturer's name;

c. Model and serial number from the control panel;

d. Name and address where accelerator was received from, transferred to, or disposed of; and

e. Name of the individual making the record.

RH-5801. **Record Retention Periods.**

a. Each licensee shall retain each record that is required by this Section or by license condition for the period specified by the appropriate ~~regulation~~ rule or license condition. If a retention period is not otherwise specified by ~~regulation~~ rule or license condition, the record must be retained until the Department terminates each license that authorizes the activity that is subject to the recordkeeping requirement.

b. If there is a conflict between the Department's ~~regulations~~ rules in this Section, license condition, or other written Department approval or authorization pertaining to the retention period for the same type of record, the retention period specified in the ~~regulations~~ rules in this Section for such records shall apply unless the Department, pursuant to RH-5600.e., has granted a specific exemption from the record retention requirements specified in the ~~regulations~~ rules in this Section.

RH-5802. **Record Maintenance.**

Each record required by this Section must be legible throughout the specified retention period. The record may be the original or a reproduced copy or microform if such reproduced copy or microform is duly authenticated by authorized personnel and the microform is capable of producing a clear and legible copy after storage for the period specified by Department ~~regulations~~ rules. The record may also be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records, such as letters, drawings, and specifications, must include all pertinent information such as stamps, initials, and signatures. The licensee shall maintain adequate safeguards against tampering with and loss of records.

RH-5803.- RH-5999. Reserved.

SECTION 7.
NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM)

PART A.
GENERAL

RH-6000. **Authority**.

Act 8 of the Second Extraordinary Session of 1961 as amended (ACA 1987 Title 20 Chapter 21).

RH-6001. **Effective Date**.

The provisions and requirements of this Section shall take effect on June 1, 1992 and shall apply to all facilities or sites owned or controlled by a person on that date. Products distributed and disposals made prior to that date are not subject to the provisions of this Section.

RH-6002. **Purpose**.

This Section establishes radiation protection standards for the possession, use, transfer, and disposal of naturally occurring radioactive materials (NORM) not subject to regulation by the U.S. Nuclear Regulatory Commission.

RH-6003. **Scope**.

These ~~Regulations~~ Rules apply to any person who engages in the extraction, mining, beneficiating, processing, use, transfer, or disposal of NORM in such a manner as to alter the chemical properties or physical state of the NORM or its potential exposure pathway to humans.

The ~~Regulations~~ Rules in this Section address the introduction of NORM into products in which neither the NORM nor the radiation emitted from the NORM is considered to be beneficial to the products. The manufacture and distribution of products containing NORM in which the NORM and/or its associated radiation(s) is considered to be a beneficial attribute are licensed under the provisions of Section 2. This Section also addresses waste management and disposal standards.

PART B.
DEFINITIONS

RH-6004. **Definitions**.

Beneficial attribute or beneficial to the product - The radioactivity of the product is necessary to the use of the product.

Beneficiating - The processing of materials for the purpose of altering the chemical or physical properties to improve the quality, purity, or assay grade.

Breathing zone - Used in determining respiratory requirements, the area of the body within one (1) foot of the mouth and nose of a worker.

Confirmatory survey - A survey by the potential general licensee of potentially contaminated land, equipment, or sites in order to establish, with reasonable certainty, the absence or magnitude of NORM contamination.

Designated facility - A specific-licensed facility capable of receiving NORM shipments for the purpose of processing, storage, or disposal of NORM.

Department - Arkansas Department of Health.

Dose commitment - The total radiation dose to a section of the body that will result from retention in the body of radioactive material. For purposes of estimating the dose commitment, it is assumed that from the time of intake the period of exposure to retained material will not exceed 50 years.

General environment - The total terrestrial, atmospheric, and aquatic environments outside sites within which any activity, operation, or process authorized by a general or specific license issued under this Section is performed.

Licensing State - Means any State with regulations equivalent to the Suggested State Regulations for Control of Radiation relating to, and an effective program for, the regulatory control of NORM and which has been granted final designation by the Conference of Radiation Control Program Directors, Inc.

Major processor - A user processing, handling, or manufacturing radioactive material exceeding Type A quantities as unsealed sources or material, or exceeding four (4) times Type B quantities as sealed sources. Type A and B quantities are defined in RH-3100.

Natural radioactivity - Radioactivity of naturally occurring nuclides.

RH-6004. (Cont'd)

Naturally occurring radioactive material (NORM) - Any nuclide which is radioactive in its natural physical state (i.e., not man-made), but does not include byproduct, source, or special nuclear material.

NORM facility identification number - The number assigned by the Department to a specific facility of a NORM general licensee having more than one site possessing radioactive material exceeding the exemption criteria specified in RH-6005.

NORM field supervisor - An individual who answers to the corporate NORM RSO approved by the Department as being qualified to oversee radiation protection of workers after attending at least forty (40) hours of classroom training in NORM-related health physics and six (6) months documented on-the-job training with a Department-approved qualified third party Radiation Safety Officer.

NORM general license number - The number assigned by the Department to the generator or other responsible party possessing radioactive material exceeding the exemption criteria specified in RH-6005.

NORM Radiation Safety Officer (RSO) - An individual approved by the Department as being qualified to oversee radiation protection of workers after attending at least forty (40) hours of classroom training in NORM-related health physics and six (6) months documented on-the-the job training with a Department-approved qualified third party Radiation Safety Officer.

NORM surveyor - An individual who has completed at least sixteen (16) hours of classroom training and three (3) months documented on-the-job training in NORM-related surveying techniques and health physics approved by the State as being qualified to perform NORM confirmatory and release surveys at NORM job sites.

NORM waste management plan - The plan for the management, i.e., handling, interim storage and disposal, of NORM.

NORM worker - An individual who has completed at least eight (8) hours of classroom training in NORM-related health physics concerning the protection of the worker, hazards involved in dealing with NORM, and other subjects outlined in RH-6018.

Notifier - The person or party meeting the definition of a general licensee according to RH-6010. and therefore, subject to the notification requirement stated in RH-6010.a.1.

Product - Something produced, made, manufactured, refined, or beneficiated.

Regulations of the U.S. Department of Transportation - The regulations in 49 CFR Parts 100-189.

Release survey - The survey required to release either equipment or land for unrestricted use. A land release survey must be approved by the Department before land will be released for unrestricted use.

Working Level (WL) - Any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of alpha particles with a total energy of 130 billion electron volts.

PART C.
EXEMPTIONS

RH-6005. **Exemptions**.

a. Persons who receive, possess, use, process, transfer, distribute, and dispose of NORM are exempt from the requirements of these ~~Regulations~~ Rules if:

The materials contain or are contaminated at concentrations less than 5 picocuries per gram of radium-226 and/or radium-228, 0.05% by weight of uranium or thorium, or 150 picocuries per gram of any other NORM radionuclide, provided that these concentrations are not exceeded at any time.

b. Persons who receive products or materials containing NORM distributed in accordance with a specific license issued by the Department pursuant to RH-6022.c or an equivalent license issued by another Licensing State are exempt from these ~~Regulations~~ Rules.

c. The manufacturing, distribution, use, and disposal of the following products/materials are exempt from the requirements of these ~~Regulations~~ Rules:

1. Potassium and potassium compounds which have not been isotopically enriched in the radionuclide K-40; and

2. Brazil nuts.

d. The wholesale and retail distribution (including custom blending), possession, and use of the following products/ materials are exempt from the requirements of these ~~Regulations~~ Rules:

1. Phosphate and potash fertilizer;

2. Phosphogypsum for agricultural uses if it has not been technologically enhanced; and

3. Materials used for building and highway construction if such materials contain NORM which has not been technologically enhanced.

RH-6005. (Cont'd)

e. The possession and use of natural gas and natural gas products and crude oil and crude oil products as fuel are exempt from the requirements of these ~~Regulations~~ Rules. The distribution of natural gas and crude oil and the manufacturing and distribution of natural gas and crude oil products are exempt from the specific license requirements of this Section but are subject to the general license requirements in RH-6010.

RH-6006.- RH-6009. Reserved.

PART D.
LICENSES AND RADIATION SAFETY REQUIREMENTS

RH-6010. **General License**.

a. 1. A general license is hereby issued to mine, extract, receive, possess, own, use, process, and dispose of NORM not exempted in RH-6005. without regard to quantity. This general license does not authorize the manufacturing or distribution of products containing NORM in concentrations greater than those specified in RH-6005.a. nor the disposal of wastes from other entities. Persons subject to the general license shall notify the Department by filing the Notification of a NORM Facility Form with the Department. The Notification of NORM Facility Form is available from the Department.

NOTE: The Department recommends a general licensee under RH-6010.a.1. conduct or arrange to have conducted a confirmatory survey to determine the extent and magnitude of the NORM contamination at the general licensee's facility.

2. Each general licensee performing on-site maintenance of contaminated facilities, sites, or equipment or the excavation of land shall establish and submit to the Department for approval, written procedures as outlined in RH-6019. to ensure worker protection and survey (or screening) of sites and equipment as outlined in RH-6018.

3. On-site maintenance is authorized only if the maximum radiation level does not exceed two (2) millirem per hour at any accessible point of the work area.

b. Facilities and equipment contaminated with NORM in excess of the levels set forth in Appendix A of this Section, or if the maximum radiation exposure level exceeds 50 microroentgen per hour including background at any accessible point shall not be released for unrestricted use. The decontamination of equipment and facilities shall be performed only by persons specifically licensed by the Department or another Licensing State to conduct such work. Each general licensee shall establish for approval written procedures for the evaluation (or screening) of equipment, components, and facilities prior to release for unrestricted use to ensure that the levels in Appendix A of this Section are not exceeded.