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Appendix

Title

- A Applicable Federal Regulations
 (10CFR Parts 19, 20, 21, 34 and 71)
- B Radiation Incidents
- C Material License

NOTE: Information contained in the Appendices may periodically be updated. Updating of this information does not constitute a revision to the program or require a License change.

2.0 INTRODUCTION

- 2.1 This Industrial Radiography Program Manual contains specific instructions that must be adhered to in order to comply with all applicable federal regulations that govern industrial radiography.
- 2.2 Each manual will be controlled by a number, identifiable to a recipient. It is the responsibility of all manual holders for maintenance and upkeep of the manual. Any changes made within a section will constitute a revision for that entire section (see note). Revisions will be issued by means of a transmittal which is required to be signed, dated and returned to the sender.

NOTE: Phone numbers, mail stops or addresses of individuals identified within this program or information contained in the appendices may periodically be updated. Updating of this information does not constitute a revision to that section or a license change. However, this updated information shall be controlled by means of a transmittal.

- 2.3 All personnel who perform industrial radiography are required to become familiar with the contents of this manual in order to maintain a safe Industrial Radiography Program.
- 2.4 An annual review of the Industrial Radiation Safety manual shall be performed by the RSO or his designee. The review shall consist of verification of content of federal regulations, implementation of the program and principals of ALARA. Any discrepancies shall be resolved and revisions to the manual shall be made as needed.

3.0 STATEMENT OF POLICY

It is the policy of Centerior Service Company to establish, maintain and implement an Industrial Radiography Program that complies with the requirements of Title 10 of the Code of Federal Regulations, Parts 19, 20, 21, 34, and 71.

This program describes in detail the specific responsibilities, duties and authority of all personnel performing radiography. The Radiation Safety Officer is hereby given the authority and responsibility for implementation and maintenance of the program. Each person involved with this program is responsible for compliance with its contents.

This program has the unconditional endorsement of Management at Centerior Service Company.

Frank R Stead

Frank R. Stead - General Manager
Generation Services Department
Centerior Service Company

4.0 RESPONSIBILITIES/ORGANIZATION

4.1 Radiation Safety Officer (RSO)

The Radiation Safety Officer is assigned the duties of maintaining active control of the Industrial Radiography Program. This individual should be a qualified Radiographer with training in the use of radiographic equipment utilized by CSC and familiar with all federal regulations that govern their use.

RSO Responsibilities:

- * Serve as CSC liaison officer with the NRC on industrial radiography licensing matters;
- * Maintaining Control of the Radiation Safety Program;
- * Develop and maintain up-to-date operating and emergency instructions;
- * Ensure that records are maintained in accordance with federal regulations;
- * Assuming control and instituting corrective action in emergency situations;
- * Investigating the cause of incidents and determining necessary preventive action;
- * Conducting audits

NOTE: Some of the above listed duties may be delegated to individuals qualified to perform them at the discretion of the RSO.

4.2 Assistant Radiation Safety Officer (Asst. RSO)

The Assistant Radiation Safety Officer is assigned the duties of assisting the RSO in maintaining the Industrial Radiography Program, and assuming the duties of the RSO in his absence should an emergency situation arise. This individual should be a qualified radiographer with training in the use of radiographic equipment utilized by CSC and familiar with all Federal regulations that govern their use.

4.3 Radiographer

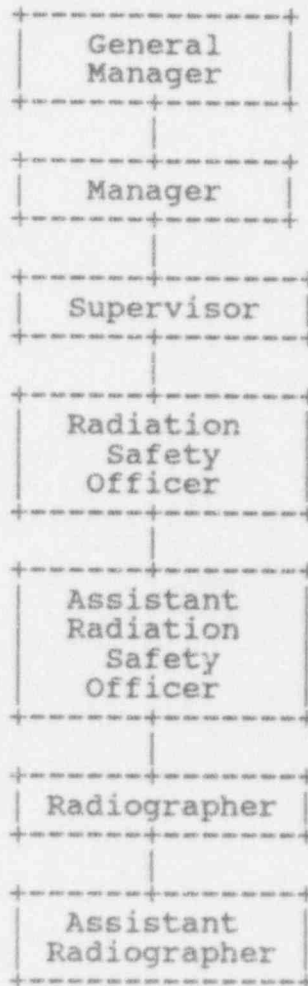
The Radiographer is responsible for the safe use and control of industrial radiography sources and assigned equipment, implementing operating and emergency instructions, performing surveys and completion of records as required by this manual.

4.4 Assistant Radiographer

The Assistant Radiographer is responsible for the safe use and control of industrial radiography sources under the direct supervision of a Radiographer, using personnel monitoring equipment and performing assigned duties as required by this manual.

4.5 ORGANIZATION

Centerior Service Company



5.0 Personnel Training & Certification

5.1 Responsibilities

1. The Radiation Safety Officer (RSO) is responsible for the administration of the program, and the training and examination of the Assistant RSO, Radiographers and Assistant Radiographers.

5.2 Training

1. Personnel being considered as a Radiographer or Assistant Radiographer shall have a minimum of 40 hours of classroom training in the characteristics of radiation and radiation safety (See Table 5-1).

NOTE: This training may be conducted by CSC or any of the following nationally recognized vendors:

Amersham Corp.
Westinghouse Corp.
Conam Inspection

- A. In addition to the above training, those individuals shall also be trained on the Industrial Radiography Program with specific emphasis on emergency instructions and equipment operation.
2. Personnel being considered as a Radiographer shall also be trained to applicable federal regulations.

5.3 Experience

1. Personnel being considered as an Assistant Radiographer shall have a minimum of 3 days (24 hours) of documented on-the-job training.
2. Personnel being considered as a Radiographer shall have a minimum of twelve weeks (520 hours) documented on-the-job training as a Radiographer's Assistant.
 - A. Personnel with sufficient prior experience shall have a minimum of one week of on-the-job training with CSC equipment and operating procedures before assuming the duties of a Radiographer.
3. Personnel being considered for Assistant Radiation Safety Officer should currently be certified as a Radiographer. In addition, they must have a minimum of 2 years experience using radioactive isotopes.
4. Personnel being considered for Radiation Safety Officer should currently be certified as a Radiographer. In addition, they must have a minimum

of 2 years experience using radioactive isotopes.

5.4 Examinations

1. Personnel being considered as a Assistant Radiographer shall complete a minimum 25 question examination on radiation safety (10 questions); emergency instructions and equipment operation (15 questions open book).
2. Personnel being considered as a Radiographer shall complete a minimum 50 question examination on radiation safety (25 questions); emergency instructions, equipment operation, and applicable Federal regulations (20 questions open book).
3. Personnel being considered for Assistant Radiation Safety Officer shall complete a minimum 80 question examination on radiation safety (25 questions); the industrial radiography program, U.S. NRC regulations, the Materials License, and personnel training and certification practices (55 questions open book).
4. The Radiation Safety Officer shall be appointed by the General Manager of his Department and approved by the NRC.
5. The minimum passing score shall be 80%. All missed questions shall be discussed between the examinee and Radiation Safety Officer. The RSO may assign additional training or instruction as necessary to assure complete understanding of the material.
6. In addition to written examinations, Radiographers and Radiographers Assistants shall perform a practical examination, demonstrating his/her ability to perform radiography. Practical examinations are also required for those personnel who are to perform source changes and/or wipe/leak tests. A passing grade of 100% is required on the practical examination.
7. Radiographers and Assistant Radiographers certifications shall remain valid for a period of three years. Recertification shall be by examination.

5.5 Annual Training

All radiographic personnel shall receive annual training in the following as applicable:

- * Revisions to the Industrial Radiography Program
- * Revisions to applicable Federal requirements
- * Review of audit findings
- * Review of radiation incidents

5.6 Records

Personnel training records shall be maintained for at least three years after the individual terminates employment with the Centerior Service Company.

TABLE 5.1 TRAINING GUIDELINES

Characteristics of Radiation

- * Characteristics of Gamma radiation
- * Units of radiation dose
- * Quantity of radioactivity
- * Levels of radiation from licensed materials

Radiation Safety

- * Hazards of exposure to radiation
- * Methods of controlling radiation dose (time, distance, shielding)
- * Use of radiation survey instruments (operation, calibration, limitations)
- * Survey techniques
- * Use of personnel monitoring equipment (film badges, TLD, dosimeters, alarming ratemeters)

Radiographic Equipment Usage

- * Remote handling equipment
- * Radiographic exposure devices
- * Source changers
- * Storage containers
- * Locking and securing sources
- * Inspection and Maintenance

Regulations and Instructions

- * 10 CFR Parts, 19, 20, 21, 34 and 71
- * CSC's Industrial Radiography Program Manual
- * 49 CFR parts 170-189
- * Emergency Instructions
- * Wipe/Leak Tests

Radiography Accidents

- * Case Histories

6.0 PERFORMANCE REVIEWS AND AUDITS

6.1 Performance Reviews

The RSO is responsible for ensuring that performance reviews for each Radiographer and Radiographer's Assistant are performed at intervals not to exceed three months. If a performance review for a Radiographer or Radiographer's Assistant becomes due, and that individual is not currently performing radiography, conduct the performance review the next time that person engages in radiographic operations.

1. Personnel who conduct the reviews shall be familiar with and have had prior radiographic experience. The review shall consist of the following:
 - * Those areas necessary to assure compliance with this manual.
 - * Applicable NRC requirements.
 - * Observation of actual radiographic operations.
2. Each performance review shall be documented on a Performance Review Checklist that describes those areas reviewed.

6.2 Audits

The RSO is responsible for assuring that Audits of the Industrial Radiography Program are performed at intervals not to exceed twelve months.

1. Personnel who perform audits may not have direct involvement with the program. They do not necessarily have to have had prior radiographic experience.
2. The Audit may consist of any or all area's covered within this manual, and shall be documented on a checklist that describes those areas audited.

6.3 Performance Review Corrective Actions

1. If in the judgement of the RSO or Asst. RSO a Radiographer or Radiographer's Assistant fails to demonstrate an adequate understanding of the requirements of this manual they shall be immediately disqualified and prohibited from performing radiographic operations until they have received additional training in those deficient areas.

6.4 Audit Corrective Actions

1. Areas of noncompliance with this manual, as discovered during Audits, shall be brought to the appropriate level of management attention for disposition.
2. Areas of noncompliance must be corrected in a timely manner and corrective actions shall be documented. Copies of all Audits and corrective actions shall be distributed to the RSO and Asst. RSO. as a minimum.
3. Audit findings shall be posted in an area frequented by personnel working under the guidelines of this program. The audit report shall remain posted, as a minimum, for a period of two weeks after corrective actions have been taken, documented and posted along with the Audit report.

6.5 Records

The following records shall be maintained for a minimum of three years:

- * Performance Review Checklists
- * Audit Checklists
- * Corrective Action Documents

7.0 QUALITY ASSURANCE PROGRAM FOR TRANSPORTATION PACKAGING
PER 10CFR71, AS APPLICABLE TO INDUSTRIAL RADIOGRAPHY

7.1 Organization

The final responsibility for the Quality Assurance Program for 10CFR71 requirements rests with the Centerior Service Company. Design and fabrication of radioactive material shipping packages are not conducted under this Quality Assurance Program. The Quality Assurance Program is implemented using the organization specified in Section 4 of Centerior Service Company's Industrial Radiography Program.

The Radiation Safety Officer is responsible for overall administration of the program, training and certification, document control and auditing.

The Radiographers are responsible for handling, storing, shipping, inspection, testing, operating status and record keeping.

7.2 Quality Assurance Program

The management of the Centerior Service Company establishes and implements this Quality Assurance Program. Training for all QA functions, prior to engagement in these functions, is required according to written procedures. QA Program revisions are made according to written procedures with management approval. The QA Program ensures that all defined QC procedures, engineering procedures and specific provisions of the package design approval are satisfied. The QA Program emphasizes control of the characteristics of the package which are critical to safety.

The Radiation Safety Officer shall assure that all radioactive material shipping packages are designed and manufactured under a Quality Assurance Program approved by the Nuclear Regulatory Commission for all packages designed or fabricated after 1 January 1979. This requirement can be satisfied by receiving a certification to this effect from the manufacturer.

7.3 Document Control

All documents related to a specific shipping package will be controlled through the use of written procedures. All document changes are performed according to written procedures approved by management.

The Radiation Safety Officer shall insure that all QA functions are conducted in accordance with the latest applicable changes to these documents.

7.4 Handling, Storage, and Shipping

Procedures concerning the handling, storage and shipping of packages for certain special form radioactive material are provided. Shipments will not be made unless all tests, certifications, acceptances, and final inspections have been completed. Radiography personnel shall perform the critical handling, storage and shipping operations.

Organizations with NRC approved shipping programs (e.g., Perry and Davis Besse) may perform shipments for the Industrial Radiography Program.

7.5 Inspection, Test and Operating Status

Inspection, test and operating status of packages for certain special form radioactive material are indicated and controlled by written procedures. Status is indicated by tags, labels, markings or log entries. Status of nonconforming parts or packages is positively maintained by written procedures.

Radiography personnel shall perform the regulatory required inspections and tests in accordance with written procedures. The Radiation Safety Officer shall ensure that these functions are performed.

7.6 Audits

Established schedules of audits of the Quality Assurance Program shall be performed using written checklists. Results of audits shall be maintained and reported to management. Audit reports shall be evaluated and deficient areas corrected. The audits are dependent on the safety significance of the activity being audited, but each activity shall be audited at least once per year. Audit reports are maintained as part of the quality assurance records. Members of the audit team shall have no responsibility in the activity being audited.

7.7 Quality Assurance Records

Records of package approvals (including references and drawings), certificates of compliances, inspections, tests, operating logs, audit results, personnel training and qualifications and records of shipments will be maintained. Descriptions of equipment and written procedures shall also be maintained.

7.7 (continued)

The records shall be identifiable, retrievable and maintained in fireproof cabinets by the Radiation Safety Officer.

8.0 RECEIPT AND SHIPPING OF RADIOACTIVE MATERIAL

8.1 Receipt of Radioactive Material

Source packages shall be monitored as soon as practicable after receipt, but no later than three hours after receipt during normal working hours, or three hours from the beginning of the next working day if received after normal working hours.

1. Only qualified Radiographers may survey and/or open packages containing radioactive material.

NOTE: If the radioactive material is received at the Perry Nuclear Power Plant (License No. NPF-58), the receipt inspection surveys may be performed by qualified Radiation Protection Section, Health Physics Unit personnel in accordance with approved site procedures. A copy of their inspection report will be attached to the Radioactive Material Receipt Inspection Report (Attachment 5).

2. Upon receipt, survey the exterior surface of the package to assure that radiation levels are not in excess of 200mR/hr, and that radiation levels are not in excess of 10mR/hr at a distance of one meter.
 - A. If the radiation survey reveals radiation levels in excess of allowable limits specified above, the package shall be segregated, roped off, barricaded or otherwise stored to preclude unnecessary exposure above 2mR/hr. The RSO shall be notified immediately in accordance with the Emergency instructions contained in Section 17.
 - B. If the radioactive material is received at Perry or Davis Besse, the Plant Health Physicist shall also be notified if the survey results exceed the limits prescribed in para. 8.1.2.
3. The package shall also be monitored for radioactive contamination, either by Health Physics personnel or by following the guidelines in Section 15.
4. Ensure that the manufacturer has provided proof that a leak test of the source has been accomplished within the previous 6 months. Document the leak test date on the Radioactive Material Receipt Inspection Report.
5. Complete and attach a Leak Test Sticker to the exposure device. Complete the Radioactive Material Receipt Inspection Report and forward it to the RSO.

8.2 Shipping of Radioactive Material - General

1. The radiographer is responsible for assuring that radioactive material is packaged and labeled in accordance with the applicable federal regulations.
2. If the shipping package is to be placed inside a crate or other outer packaging, the outer packaging must be strong enough to withstand the normal conditions of transport and must not reduce the safety of the package. The shipping package must be placed within the outer package with sufficient blocking to prevent shifting during transportation.
3. Each package of radioactive material in excess of 110 pounds must have its gross weight plainly marked on the outside of the package.
4. Each package of radioactive material shall have a separate bill of lading and be identified with its proper shipping name of "Radioactive Material, Special Form, N.O.S.", or "Radioactive Material, articles manufactured from depleted uranium" as identified below.
5. Complete a Radioactive Material Shipping Record for each package of radioactive material as described below. Distribute as follows:
 - * A copy placed in the shipping container.
 - * Two copies attached to the bill of lading or Air Bill
 - * A copy forwarded to the Radiation Safety Officer.
 - * A copy in the radiation safety file for that source.

8.3 Preparation - General All Packages

1. When radiographic exposure devices or source changer's are prepared for shipping, assure that the source is in the properly stored position or that the device or changer is empty. Prepare for shipment as follows:
 - * Exposure Device - ensure that the shipping plug is securely in place and seal wired, and that the device is locked.
 - * Source Changer - ensure that the source hold down cover is properly bolted, locked and seal wired.
2. Each package shall have the exterior surface marked or labeled in accordance with the following:

8.3.2.A. Measure the radiation level at one meter from all exterior surfaces of the outer package to assure that the radiation level is less than 10mR/hr. This is the transport index.

B. Select the proper shipping labels according to the radiation levels at the surface and at one meter and from the surface, as shown in Figure 8-1.

NOTE: The radiation level may not exceed 200mR/hr at any point on the external surface of the package and the transport index may not exceed 10.

C. Enter the name of the radioactive isotope, the activity and the transport index in the blank spaces of two shipping labels using a durable, weather resistant marker.

D. Remove or cover all of the old shipping labels from the shipping container. Apply the properly completed shipping labels to two opposite sides of the outer package. Do not cover permanent labels on source changers or projectors.

E. Any outer packaging, if used, shall be marked with the following statement:

"Inside package complies with prescribed specifications".

F. In addition, the outer packaging shall be marked with the NRC Certificate of Compliance number of the inner package, (e.g., USA/9006/B(U), Type B).

G. Perform a wipe test in accordance with Section 15, to assure that the levels of removable radioactive contamination on the outside surface of the outer package do not exceed 0.0001 microcurie (2200 dpm) per square centimeter.

8.4 Preparation - Specific

Prepare the package for shipment in accordance with the specific package type as outlined below.

1. Exposure Device/Service Changer - Uranium Shielded Container with Radioactive Material

A. The device should be marked with the proper shipping name, e.g., Radioactive Material, Special Form, N.O.S., UN2974.

8.4.1.B. Complete the Radioactive Material Shipping Record (Attachment 7) including:

- * Proper shipping name (e.g., Radioactive Material, Special Form, N.O.S., UN2974)
- * Name of the radionuclide (e.g., Iridium-192)
- * Activity of source (in curies)
- * Category of label (e.g., Radioactive Yellow II)
- * USNRC identification number (as shown on the devices label)
- * Transport Index
- * Type B identification number (if required)
- * Shipper's Certification stating:

"I hereby certify that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked and labeled, and are in proper condition for carriage by air according to national governmental regulations".

Due to the depleted uranium used as shielding, a notice must also be enclosed in or on the package, included with the packing list, or otherwise forwarded with the package. This notice must include the name of the consignor or consignee and the following statement:

"This package conforms to the conditions and limitations specified in 49 CFR 173.424 for radioactive material, excepted package - articles manufactured from depleted uranium, UN2910".

8.4.2. Exposure Device/Source Changer - Empty Uranium Shielded Containers

- A. For shipment of an empty exposure device/source changer, assure that there is no source in the container.
- B. Assure that the levels of removable radioactive contamination on the outside surface of the outer package do not exceed 0.0001 microcurie per 100 square centimeters.
- C. If the radiation level is below 0.5mR/hr at any point on the surface, and there is no measurable

radiation level at 1 meter from the container, radioactive shipping labels shown in Figure 8-1 are not required. The package is to be shipped as Radioactive Material, LSA (low specific activity). Special requirements defined in 49CFR apply, contact the RSO for guidance.

- 8.4.2.D. Mark the outside of the package with the proper shipping name (Radioactive material, articles manufactured from depleted uranium, UN2910). Mark the outside of the package:

"Exempt from specification packaging, shipping paper and certification, marking and labeling and exempt from the requirements of Parts 171-178 per 49 CFR 173.421-1 and 49 CFR 173.424."

- E. Additionally, a notice must be enclosed in or on the package, included with the packing list, or otherwise forwarded with the package. This notice must include the name of the consignor or consignee and the statement:

"This package conforms to the conditions and limitations specified in 49 CFR 173.424 for radioactive material, excepted package - articles manufactured from depleted uranium, UN2910".

- F. If the surface radiation level exceeds 0.5mR/hr, or if there is a measurable radiation level at one meter from the surface, use the criteria of Figure 8-1 to determine the proper shipping labels to be applied to the package.

1. Mark the outside of the package with the proper shipping name and identification number (e.g., Radioactive material, Special Form, N.O.S., UN2974).

2. Properly complete the Radioactive Material Shipping Record including:

- * Proper shipping name and identification number, (e.g., Radioactive Material, Special Form, N.O.S., UN2974)
- * Name of the radionuclide (Uranium-238)
- * Physical and chemical form (Solid Metal)
- * Activity (5 millicuries)
- * Category of label applied (e.g., Radioactive Yellow II)

- * Transport Index
- * USNRC identification number (as shown on the devices label)
- * Sign the Shipper's Certification, stating:
 "I hereby certify that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked and labeled, and are in proper condition for carriage by air according to national governmental regulations".

8.5 Air Shipment




For air shipments the package must be labeled "Cargo Aircraft Only" and the shipping papers must state "This Shipment Is Within The Limitations Prescribed for Cargo Aircraft Only".

8.6 Records

The following records shall be maintained for a minimum of three years.

- * Radioactive Material Receipt Inspection Report.
- * Radioactive Material Shipping Record.

Figure 8-1

	Maximum Radiation Level	
	at Surface	at One Meter
Radioactive White I 	0.5 mrem/hr	None
Radioactive Yellow II 	50 mrem/hr	1.0 mrem/hr
Radioactive Yellow III 	200 mrem/hr	10 mrem/hr

9.0 10 CFR PART 21 REQUIREMENTS

9.1 Responsibility

It is the responsibility of all personnel involved with industrial radiography to identify any safety hazards or conditions adverse to quality which represent:

- * A noncompliance with the Atomic Energy Act of 1954, as amended, or any applicable rule, regulation, order, or license of the NRC relating to substantial safety hazards; or
- * A defect in a basic component supplied to the licensee which could create a substantial safety hazard or a failure in the operation of the component.

9.2 Identification

Any person who has concerns about such matters are encouraged to first identify them to their immediate supervisor and/or the RSO or Asst. RSO. If the concerns are not acted upon or resolved, then the individual should contact the responsible CSC Executive. Names and telephone extensions of the RSO and Asst. RSO are listed in Figure 9-1.

If a satisfactory resolution to the concern has not been provided by the individuals above, then it may be referred directly to the NRC in accordance with NRC Form 3, Notice to Workers (see Figure 9-2), which provides directions for such a contact.

9.3 Notification

When the condition is identified as a reportable condition or a potentially reportable condition pursuant to 10CFR21, then the RSO or designee shall notify the Principal Inspector or his alternate at the applicable U.S. NRC regional office within 24 hours. This notification shall be documented and copies distributed to management and all individuals involved.

9.4 Reporting

A written report shall be prepared, outlining the information listed below and filed with the NRC office(s) in accordance with 10CFR21 no later than 30 days after notification to the NRC regional office. As a minimum this report shall consist of the following;

- * Identification of the activity or basic component

supplied which fails to comply or contains a defect.

- * Identification of the firm supplying the basic component which fails to comply or contains a defect.
- * The nature of the defect or failure to comply and the safety hazard which is created or could be created by such defect or failure to comply.
- * In the case of the basic component which contains a defect or fails to comply, the number and location of all such components.
- * The corrective action which has been, is being, or will be taken; the name of the individual or organization responsible for the action; and the length of time that has been or will be taken to complete the action.
- * Any advice related to the defect or failure to comply about the facility, activity or basic component that has been, is being, or will be given to other purchasers or licensees.

If all the required information is not available, an interim report shall be filed to meet the 30 day reporting requirement. The interim report shall provide a description of the problem, measures being taken, planned corrective action and establish the scheduled date for submittal of the final report.

9.5 Postings

The following documents shall be posted where radiographic exposure devices are stored and where radiographic operations are frequented.

- * NRC Form 3 "Notice to Workers"
- * Section 206 of the Energy Reorganization Act of 1974
- * List of responsible CSC employees (with a reference as to where copies of this procedure and 10CFR21 may be viewed or obtained)

FIGURE 9-1, RESPONSIBLE CSC EMPLOYEES

.....
NOTICE
IN CASE OF AN EMERGENCY OR ACCIDENT INVOLVING
THIS VEHICLE OR RADIOACTIVE MATERIAL STORAGE AREA
.....

NOTIFY:

CENTERIOR SERVICE COMPANY
NONDESTRUCTIVE EXAMINATION
PERRY NUCLEAR POWER PLANT
10 CENTER RD.
PERRY, OHIO 44081

EASTERN OHIO
Call: 216-259-1000
216-622-9800
800-686-2345
Ask for Perry extension 5402

WESTERN OHIO
Call: 419-249-5849
800-447-8883
Ask for extension 5849

Evenings, Weekends or Holidays Call:

James Ewing (RSO) - 216-428-2674
or
William Hilkens (A.RSO) - 313-854-1927
(CALL ANY OF THE ABOVE NUMBERS COLLECT IF NECESSARY)

.....
The following documents are available for review
at the above listed address or the mobile laboratory.

- * 10 CFR Part(s) 19, 20, 21, 34, 71
 - * Section 206 of the Energy Reorganization Act of 1974
 - * CSC - Industrial Radiography Program
 - * USNRC License
-

FIGURE 9-2, NRC FORM 3

UNITED STATES NUCLEAR REGULATORY COMMISSION
Washington, D.C. 20555

NOTICE TO EMPLOYEES

STANDARDS FOR PROTECTION AGAINST RADIATION (PART 20); NOTICES, INSTRUCTIONS AND REPORTS TO WORKERS; INSPECTIONS (PART 19); EMPLOYEE PROTECTION

WHAT IS THE NUCLEAR REGULATORY COMMISSION?
The Nuclear Regulatory Commission is an independent Federal regulatory agency in charge of nuclear power plants and other commercial uses of radioactive materials.

WHAT DOES THE NRC DO?
The NRC's primary responsibility is to ensure the safe use of nuclear energy and the protection of the public and the environment from radiation. The NRC also ensures that nuclear power plants and other facilities are operated in a safe and sound manner. The NRC does not regulate the use of radioactive materials in medicine, industry, or research.

WHAT IS MY RESPONSIBILITY?
For your own protection and the protection of your co-workers, you should know how NRC requirements apply to your work and to your employer. If you observe a violation of NRC requirements, you should report it.

HOW DO I REPORT VIOLATIONS?
If you believe that a violation of NRC rules or regulations has occurred, you should report it to your supervisor or to the nearest NRC Regional Office. If you believe that a violation of NRC rules or regulations has occurred in a high quality standard and you are not being taken care of, you may report this to an NRC Inspector at the nearest NRC Regional Office.

WHAT IF I WORK IN A RADIATION AREA?
If you work with radioactive material or in a radiation controlled area, the amount of radiation exposure that you may receive is limited by NRC Regulations. The limits on your exposure are contained in 10 CFR 20.101, 102 and 20.103. If you are in a radiation area, you should know the maximum allowable limits, your employer should also know your radiation exposure and the limits on these limits is "reasonably achievable."

WHAT RESPONSIBILITY DOES MY EMPLOYER HAVE?
Any company that conducts activities regulated by the NRC must comply with the NRC's requirements. If a company violates NRC requirements, it can be fined or its license suspended, suspended or modified. Your employer must tell you which NRC rules apply to your work and must also NRC Rules of Violations involving radiological working conditions.

HOW DO I CONTACT THE NRC?
Notify an NRC Inspector or call your supervisor. If you are not sure who to contact, call the NRC Inspector nearest to you. The NRC Inspector nearest to you will help you with any questions you have. You must describe the alleged violation in detail. It must be signed by you or your representative.

HOW AM I PROTECTED FROM DISCRIMINATION?
If you believe that you have been discriminated against for bringing safety concerns to the attention of the NRC, you must describe the facts of discrimination and must be filed within 30 days of the occurrence. Send complaints to:
Office of the Assistant
Employment Standards Administration
U.S. Department of Labor
300 Constitution Avenue, NW
Washington, DC 20036

WHAT CAN THE LABOR DEPARTMENT DO?
The Department of Labor will assist the employer that a complaint has been filed and will investigate the claim. If the Department of Labor finds that the employer has unlawfully discriminated against you, it may order you to be reinstated, or it may order the employer to pay any injury suffered as a result of the discrimination.

WHAT WILL THE NRC DO?
The NRC may assist the Department of Labor in its investigation. The NRC may also conduct its own investigation when necessary to determine whether unlawful discrimination has prevented the free flow of information to the Commission. Also, if the NRC or Department of Labor finds that the NRC may have a basis at Violation of the NRC, your employer, NRC may suspend, modify, or revoke your employer's NRC license.

HOW DO I CONTACT THE NRC?
Notify an NRC Inspector or call your supervisor. If you are not sure who to contact, call the NRC Inspector nearest to you. The NRC Inspector nearest to you will help you with any questions you have. You must describe the alleged violation in detail. It must be signed by you or your representative.

HOW AM I PROTECTED FROM DISCRIMINATION?
If you believe that you have been discriminated against for bringing safety concerns to the attention of the NRC, you must describe the facts of discrimination and must be filed within 30 days of the occurrence. Send complaints to:
Office of the Assistant
Employment Standards Administration
U.S. Department of Labor
300 Constitution Avenue, NW
Washington, DC 20036

WHAT CAN THE LABOR DEPARTMENT DO?
The Department of Labor will assist the employer that a complaint has been filed and will investigate the claim. If the Department of Labor finds that the employer has unlawfully discriminated against you, it may order you to be reinstated, or it may order the employer to pay any injury suffered as a result of the discrimination.

WHAT WILL THE NRC DO?
The NRC may assist the Department of Labor in its investigation. The NRC may also conduct its own investigation when necessary to determine whether unlawful discrimination has prevented the free flow of information to the Commission. Also, if the NRC or Department of Labor finds that the NRC may have a basis at Violation of the NRC, your employer, NRC may suspend, modify, or revoke your employer's NRC license.

UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICE LOCATIONS
A representative of the Nuclear Regulatory Commission can be contacted at the following addresses and telephone numbers. The Regional Office will accept collect telephone calls from employees who wish to register complaints or concerns about radiological working conditions or other matters regarding compliance with Commission rules and regulations.



REGION	ADDRESS	TELEPHONE
I	U.S. Nuclear Regulatory Commission Region I 1000 North 17th Street Alexandria, VA 22304-1413	(703) 537-6000
II	U.S. Nuclear Regulatory Commission Region II 1000 North 17th Street Alexandria, VA 22304-1413	(703) 537-6000
III	U.S. Nuclear Regulatory Commission Region III 1000 North 17th Street Alexandria, VA 22304-1413	(703) 537-6000
IV	U.S. Nuclear Regulatory Commission Region IV 1000 North 17th Street Alexandria, VA 22304-1413	(703) 537-6000
V	U.S. Nuclear Regulatory Commission Region V 1000 North 17th Street Alexandria, VA 22304-1413	(703) 537-6000

To report incidents involving health, safety or abuse by an NRC employee or NRC contractor:
Telephone:
OFFICE OF THE INSPECTOR GENERAL
HOTLINE
1-800-333-3487

10.0 PERSONNEL MONITORING

10.1 General

- A. All individuals who perform radiographic operations under this program are required to wear personal monitoring devices and use survey instruments as described in this Section.
- B. Prior to issuance of personal dosimetry, an individual's prior exposure history shall be determined and documented as follows:
 - 1. For determination of current year exposure from other licensees, the individual to be monitored must provide an up to date NRC Form 4, signed by the individual, or a written statement that includes the names of all facilities which provided monitoring for occupational exposure to radiation during the current year and the estimate of the dose received.
 - 2. An attempt shall be made to obtain the records of the individual's lifetime cumulative occupational radiation dose. The individual may provide a written estimate of the cumulative lifetime dose or an up to date NRC Form 4 signed by the individual.
 - 3. The above information should be verified to be complete and accurate. Verification may be documented with an NRC Form 5 for each listed monitoring period or an NRC Form 4 countersigned by a licensee or current employer.

10.2 Dosimeters and Alarming Ratemeters

- A. Dosimeters and alarming ratemeters are stored in a locked cabinet, located in an area of low background radiation.
- B. Dosimeters and an alarming ratemeter will be worn between the waist and neck area, with the dosimeter adjacent to the TLD. All individuals shall wear a pocket dosimeter with a range of at least 0 - 200mR at all times during radiographic operations.
- C. Prior to beginning radiographic activities, dosimeters shall be re-charged and logged on the Weekly Dosimeter Log. The alarming ratemeter serial number and calibration due date must also be logged.

NOTE: A pocket dosimeter shall be considered to be zeroed when the reading is between 0 - 10mR.

- 10.2.D. At the beginning of each shift, alarming ratemeters shall be checked to assure the alarm functions (sounds) properly.
- E. Dosimeters are to be checked at frequent intervals during radiographic activities so that you are aware of any exposure received.
- F. In the event a dosimeter goes off scale due to unknown circumstances, secure the source, cease radiographic activities and have other individuals check their dosimetry. Then contact the RSO for instructions, in accordance with Section 17.
- C The alarming ratemeter is calibrated to alarm when in a radiation area of 500mR/hr. If while performing radiography an alarming ratemeter alarms, assume the source is in the exposed position and move to an area of low radiation.
- NOTE: An alarming ratemeter may alarm briefly if the battery becomes low.
- H. If it is determined that the alarm is due to the source being in the exposed position, immediately read the dosimeters of all persons working in the area, attempt to retract the source to the shielded position, and treat the incident as an emergency as described in Section 17.
- I. After completion of radiographic activities for the day or work period, log the final dosimeter reading and indicated dose on the Weekly Dosimeter Log and return the dosimeter and alarming ratemeter to the storage area.

10.3 Dosimeter and Alarming Ratemeter Calibration

- A. Dosimeters are to be calibrated on an annual basis as follows:
- * Zero the dosimeter on a dosimeter charger.
 - * Place dosimeter in the dosimeter calibrator for the specified time.

EXAMPLE: If utilizing a Dosimeter Corporation of America Dosimeter Calibrator, Model 3060, place dosimeters in the 4 inner holes for 6 hours or in the 8 outer holes for 24 hours. The dosimeters should measure a nominal response of 50mR.

- * Remove the dosimeter after the calculated time per the calibrator source decay curve and log the

results on the Dosimeter Calibration Log (see Attachment 2).

- * The dosimeter should read $\pm 30\%$ of the true radiation exposure (Example: for a known exposure of 50mR the dosimeter must be between 35mR and 65mR). Affix a new calibration sticker to the dosimeter. If the dosimeter is unable to detect $\pm 30\%$, remove the old calibration sticker, take the dosimeter out of service and report the fact to the RSO for disposition of repair or replacement.

10.3.B. Alarming ratemeters are to be calibrated annually or after repair. This will normally be done by the manufacturer.

10.4 TLD's

A. TLD's are stored in a locked cabinet, located in an area of low background radiation

NOTE: Control TLD's are not to be worn by any individual.

- B. TLD's shall be individually assigned on a monthly basis and worn only by those assigned individuals. The RSO or his designee is responsible for assigning and collecting TLD's on a monthly basis.
- C. TLD's are to be worn between the neck and waist area at all times when working with or around radiographic exposures devices. Care should be taken to prevent TLD's from becoming wet or damaged.
- D. Individuals shall notify the RSO in accordance with Section 17, Emergency Instructions, when any of the following events occur:
 - 1) The possibility exists that an excessive radiation exposure may have occurred;
 - 2) An individual's TLD becomes lost or damaged;
 - 3) An individual has reason to believe that his/her TLD may have received dosage that the individual's body did not receive.
- E. Upon completion of radiographic operations for the day or work period, return the TLD to the storage cabinet.

10.5 Survey Instruments

- A. Survey instruments used to perform industrial radiography shall have a range of at least 2mR/hr to 1000mR/hr.
- B. Individuals using survey instruments shall check that the calibration is current and the overall condition and operability of the unit prior to its use (battery level, zeroing scale, etc).
- C. Digital instruments should have a two minute warm-up period with the selector switch set at the lowest setting, prior to zeroing (if required) and use.
- D. Survey meters removed from service which are accessible shall have a out of calibration sticker attached in a conspicuous place to prevent their inadvertent use.
- E. Calibration of survey instruments shall be at intervals not to exceed three months or after servicing, and calibrated in accordance with approved Perry Nuclear Power Plant (License No. NPF-58), Radiation Protection Section, calibration procedures.

10.6 Dose Limits

- A. Occupational dose to adult individuals (excluding planned special exposures), for the purpose of ALARA, shall be limited to 40 percent of the NRC allowable limits, which follow:
 - 1. An annual limit, which is the more limiting of:
 - a. The whole body total effective dose equivalent being equal to 5 Rem.
 - b. The sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 Rem.
 - 2. The annual limits to the lens of the eye, to the skin, and to the extremities, which are:
 - a. An eye dose equivalent of 15 Rem.
 - b. A shallow dose equivalent of 50 Rem to the skin or to any extremity.

NOTE: The extremities are the hands, elbows, arms below the elbows, feet, knees and legs below the knees.

10.6.A.3. An individual's annual dose limit may be extended to 60 percent of the NRC allowable limits provided the following conditions are met:

- a. The individual shall be informed that they have reached the limits set forth in paragraph 10.6.A.
 - b. The RSO will make a determination whether the individual is essential in continuing radiographic operations, or if there are other individuals available, to keep occupational doses ALARA.
 - c. If there are not any other qualified personnel available and the individual's exposure limit must be extended to 60 percent of the NRC allowable limits, a memo shall be generated and signed by the RSO.
 - d. This memo shall be maintained as part of that individual's occupational radiation exposure history.
4. An individual's annual dose limit may be extended to 80 percent of the NRC allowable limits provided the following conditions are met:
- a. The individual shall be informed that they have reached the limits set forth in paragraph 10.6.A.3.
 - b. The RSO and his Supervisor will discuss the situation to make the determination if the individual is essential in continuing radiographic operations.
 - c. If there are not any other qualified personnel and the individual's exposure limit must be extended to 80 percent of the NRC allowable limits, a memo shall be generated and signed by the RSO and his Supervisor.
 - d. This memo shall be maintained as part of that individual's occupational radiation exposure history.
5. An annual report of individual monitoring for each individual monitored under this license shall be recorded on NRC Form 5 or equivalent, in accordance with the instructions for NRC Form 5. Entries to these records shall be made at least annually.

NOTE: All individuals total occupational radiation doses shall be accounted, including any internal uptakes or external doses recorded for the individual by another licensee (Perry, Davis Besse, etc.)

10.6.A.6. A copy of the annual reports for the proceeding year shall be filed on or before April 30 of the current year, to the REIRS Project Manager, Office of Nuclear Regulatory Research, Nuclear Regulatory Commission, Washington, DC 20555.

7. NRC Form 5 or equivalent records shall be maintained until the Industrial Radiography License is terminated by the NRC.

B. Occupational dose limits for minors

Persons under 18 years of age shall not be permitted to receive occupational radiation dose under this licence.

C. Dose limits to members of the public

The dose limits for individual members of the public is 0.1 Rem annually. This limit is not meant to be applied as a long term annual goal.

D. Embryo/Fetus

1. The dose limit for the embryo/fetus of a Declared Pregnant Woman (DPW) is 500 millirem over the entire gestation period (9 months).
2. It is the individual's responsibility to notify the Company of her condition. The woman must declare her pregnancy in writing to her immediate supervisor. Written notification is required if the female chooses to be considered a DPW, and this notification must include an estimated date of conception. A DPW may rescind her notification of pregnancy, in writing, at any time.
3. Following written notification of DPW status, radiation dose to the embryo/fetus will be monitored by the RSO and the employee's supervisor. The employee's job assignments may be adjusted, if required, so as not to cause the employee and her embryo/fetus to exceed the legal limit throughout the gestation period.
4. All possible administrative steps will be taken to keep the radiation dose to the DPW to less than 50mR per month. Note that this is a goal rather than a limit.

- 10.6.D.5. If the dose to the embryo/fetus is found to have exceeded 500 millirem or is within 50 millirem of the 500 millirem limit by the time the pregnancy is declared, any additional dose to the embryo/fetus shall not exceed 50 millirem during the remainder of the pregnancy.
6. Dose to the embryo/fetus will be monitored using the same monitoring devices, procedures and practices used for the pregnant female. The external dose to the embryo/fetus will be taken to be that measured to the mother, even though the fetal dose will actually be slightly less.
7. Records of dose to an embryo/fetus of a DPW shall be kept on file, but may be maintained separately from the dose records of the woman.

E. Planned Special Exposures

1. An adult worker may be authorized to receive dose for Planned Special Exposures (PSE) in addition to and accounted for separately from the doses received under the limits specified in Section 10.6.A, provided that each of the following conditions are satisfied.
2. The PSE is authorized only for an exceptional situation when alternatives that might avoid the exposure are unavailable or unpractical.

NOTE: An emergency situation, such as a source being stuck in the exposed position, is not necessarily a PSE. A PSE is only meant to be used in a situation where exposure to individuals is expected to exceed the annual total effective dose limitations. Once a situation has been declared a PSE, these guidelines must be followed.

3. The RSO (and employer if the employer is other than CSC) specifically authorizes the PSE, in writing, before the exposure occurs.
4. Before a PSE the individuals involved shall be:
 - a. A volunteer.
 - b. Informed of the purpose of the planned operation.
 - c. Informed of the estimated doses and associated potential risks and specific radiation levels or other hazardous conditions that might be involved in performing the task.

- 10.6.E.4.d. Instructed in the measures to be taken to keep the dose ALARA considering other risks that may be present.
5. Prior to permitting an individual to participate in a PSE, doses for each individual involved in the PSE shall be determined as follows:
 - a. The individual's internal and external doses from all previous PSE's.
 - b. All occupational radiation dose received during the lifetime of the individual.
6. The above required information may be acquired by:
 - a. As a record of the occupational dose that the individual received during the current year, a written, signed statement from the individual, or from the individual's most recent employer, that disclosed the nature and amount of any occupational dose the individual may have received.
 - b. As a record of lifetime cumulative radiation dose, an up to date NRC Form 4, or equivalent, signed by the individual, and countersigned by an appropriate individual of CSC, or, if the individual is not employed by CSC, the individual's current employer.
 - c. Reports of the individual's dose equivalent(s) may be obtained by telephone, telegram, electronic media or letter.
 - d. The exposure history shall be recorded on NRC Form 4, or equivalent. The record must show each period in which the individual received occupational radiation exposure and must be signed by the individual who received the exposure. For any period for which the individual does not obtain a report, a notation shall be made on NRC Form 4, or equivalent, indicating the periods of time for which data are not available.
7. If a complete record of the individual's current and previously accumulated occupational dose is unobtainable, it shall be assumed that:
 - a. For the current year the allowable dose limit is reduced by 1.25 Rem for each quarter for which complete records are unavailable.

10.6.E.7.b. That individual is not available to participate in a PSE.

F. PSE Dose Limits

1. The dose limit for any individual involved in any single PSE shall be no more than the annual allowable NRC limits (see paragraphs 10.6.A.1 and 10.6.A.2). The PSE dose and annual occupational dose shall be tracked and accounted for separately.

NOTE: Additional dosimetry may be needed in order to monitor the shallow dose equivalent for extremities.

2. The individual's lifetime allowable PSE total effective dose equivalent is 25 REN.

NOTE: Any doses received during accidents or emergencies must be subtracted from the PSE limits that the individual may receive during the current year and during the individual's lifetime.

G. Records of Planned Special Exposures

1. The records shall be retained until the Radiography License has been terminated by the NRC. The records used in preparing the NRC Form 4, or equivalent, shall be retained for 3 years.
2. The records shall include:
 - A. The exceptional circumstances requiring the use of a PSE.
 - B. The name of the official who authorized the PSE and a copy of the signed authorization.
 - C. What actions were necessary and why the actions were necessary.
 - D. What steps were taken to maintain doses ALARA.
 - E. The estimated individual and collective doses prior to performing the PSE, and the doses actually received during the PSE.
3. The records of doses received during PSE's, accidents and emergency conditions must include, when applicable:
 - A. The deep dose equivalent to the whole body, eye dose equivalent, shallow dose equivalent to the

skin, and shallow dose equivalent to the extremities.

- 10.6.G.3.B. Each individual involved in a PSE shall be informed in writing of the best estimate of the dose resulting from the PSE within 30 days from the date of the PSE.
- C. A written report of a PSE shall be submitted within 30 days to the Administrator, NRC Region III, 799 Roosevelt Road, Glen Ellyn, IL 60137, in accordance with 10 CFR 20.2105.

10.6 Records

- A. Weekly Dosimeter Logs and TLD results shall be maintained until the NRC authorizes disposal.
- B. Dosimeter calibration records are to be maintained for a minimum of three years.
- C. Alarming ratemeter calibration records are to be maintained for a minimum of three years.
- D. Survey instrument calibration records are to be maintained for a minimum of three years in accordance with Perry Nuclear Power Plant, Radiation Protection Section procedures.
- E. NRC Forms 4 or NRC Form 5 shall be maintained until the license is terminated.
- F. Records of planned special exposures shall be maintained until the NRC terminates the License.

11.0 RADIATION SURVEYS AND POSTINGS

11.1 Postings

The following documents may be examined at the nondestructive examination radiographic facility office, at all radiographic source storage locations or at the plants or sites where radiographic operations take place:

- * 10 CFR Parts 19 and 20
- * CSC's Material License
- * Form NRC 3, Notice to Employees
- * Notices of Violation

11.2 Radiation Surveys

1. The use of radiation survey instruments allows the Radiographer and/or Radiographers's Assistant to establish safety perimeters where applicable radiation area signs and barricades can be erected as required.
2. Safety perimeters (yellow and magenta rope, warning signs, etc) shall be established for each exposure set-up. The safety perimeter is established at the point such that the total quantity of radiation in any one hour does not exceed 2mR, or 0.6mR/hr so as not to exceed 100mR in any 7 consecutive days, if applicable.
3. Each safety perimeter shall be physically surveyed during the first exposure to verify the boundary, and adjusted as needed.
4. The high radiation area boundary, which is 100mR per hour, is determined by calculation, and shall not be surveyed. The Radiographer and/or Assistant Radiographer shall maintain continuous surveillance of high radiation areas to prevent unauthorized entry.
5. Signs used at the perimeters of the radiation area and high radiation area will have the tri-bladed radiation symbol in either black or magenta displayed on a yellow background (see examples, Figure 11-1) and shall be placed as follows:
 - A. Radiation Area - An area within which the radiation level exceeds 2mR/hr. The sign "Caution-Radiation Area" shall be placed conspicuously at the perimeters of this area.

11.2.5.B. High radiation area - The sign "Caution-High Radiation Area" or "Danger-High Radiation Area" shall be placed at the perimeter of the area with a calculated radiation level of 100mR/hr.

6. After each radiographic exposure, a physical radiation survey shall be made to determine that the source has returned to a safe position in the camera. Log the results on a Radiographic Operation Report.

NOTE: This survey should be made at the same location relative to the camera after each exposure and must include the entire circumference of the exposure device, the source guide tube and the area at the front of the camera near the port.

7. At the conclusion of each radiographic operation, at the time of securing the source, a physical radiation survey shall be made to determine the source is in the safe position. Additional physical radiation surveys shall be made at the time the exposure device is stored in the storage area. Record the results on a Radiographic Operations Report.

NOTE: Anytime the source is stored in a designated storage area, post the area with the sign "Caution-Radioactive Material" (see example, Figure 11-1)

11.3 Records

1. Notices of Violation - These notices shall be posted within two days of receipt and shall remain posted for a minimum of five days or until the corrective action is completed, whichever is later.
2. Radiographic Operation Report - These reports shall be maintained for a minimum of three years.

FIGURE 11-1 EXAMPLE SIGNS



A.) CAUTION - RADIATION AREA



B.) CAUTION - HIGH RADIATION AREA



C.) CAUTION - RADIOACTIVE MATERIALS

12.0 OPERATING, LOCKING AND SECURING SOURCES

12.1 General

1. Only those personnel qualified by CSC as Radiographers and Assistant Radiographers are authorized to use the radiographic exposure devices and sealed sources stipulated on CSC's material license issued by the NRC.

NOTE: Assistant Radiographers must be under the direct surveillance of a Radiographer.

2. Each radiographic exposure device, storage container or source changer shall be provided with a lock to prevent unauthorized or accidental removal or exposure of a sealed source and shall be kept locked at all times except when conducting radiographic operations under the control and direct surveillance of the Radiographer or Assistant Radiographers.

12.2 Pre-Operation

The Radiographer and/or Assistant Radiographer shall perform the following prior to engaging in radiographic operations:

- * Initiate a Radiographic Operations Report and log the source out on the Source Utilization Log.
- * Ensure that personnel are wearing the required dosimetry, and that the Weekly Dosimetry Logs have been initiated (see Section 10).
- * At least one calibrated and operable survey instrument is present.
- * Survey the camera for excessive radiation levels. If excessive levels are present, notify the RSO.
- * Inspect the camera for damage to the connector, lock, fittings and fasteners.
- * Inspect the control unit assembly for damage to connectors, loose hardware and cable for breaks, kinks and freedom of operation.
- * Inspect source guide tubes for cuts, breaks, dents, broken or loose fittings and damaged threads.
- * If collimators are to be used, inspect them for dirt or other obstructions, damage or galling of threads and ensure that they can be securely attached to the source guide tube.

- * If a source positioner (such as J-Tubes or centering devices) is used, inspect for dirt or other obstructions, damage or kinking of tube, end cap for looseness or damage, and threads for damage or galling.
- * Take a reference survey of the exposure device and record the result on the Radiographic Operations Report. Complete the prior to use checklist.
- * Establish safety perimeters per Section 11.

12.3 Assembly

The Radiographer and/or Assistant Radiographer shall assemble the exposure device in accordance with the following guidelines (*). If necessary refer to the manufacturer's manual for additional guidance.

- * Depending on the particular application steps 12.3.A thru E may be worked in a different order.

Amersham Model 660

- A. Position and secure the source stop of the master source guide tube or source positioner at the radiographic focal position.

NOTE: Wherever practical use a collimator to reduce the levels of unnecessary primary and scatter radiation.

- B. Determine where the exposure device will be positioned and connect the extension source guide tubes together as required, laying them as straight as possible. Where practical bends should have a radius of at least 20 inches.

WARNING: Never operate the system with more than three guide tube sections (21 feet). If using a screw-on type collimator or source positioner, never operate the system with more than two guide tube sections (14 feet).

- C. Remove the storage plug from the exposure device and then connect the source guide tube to the exposure device.
- D. Connect the control unit to the exposure device, refer to Figures 12-1 through 12-5.
- E. Determine where the control unit will be positioned, as far away from the radiographic focal position as possible and preferably behind radiation shielding. Lay out the control housing. Where practical bends should have a radius of at least 36 inches.

- 12.3.F. Before operation, check all connections and bend radii, and the position of the source stop, which represents the radiographic focal position of the source.
- G. Prior to exposing the source, check the established restricted area to assure that no one has entered and that the appropriate radiation warning signs have been posted in accordance with Section 11. Clear all personnel from the area.

12.4 Operation

The Radiographer and/or Assistant Radiographer shall conduct radiography in accordance with the following guidelines:

Amersham Model 660

- A. Unlock the exposure device and then turn the selector ring to the OPERATE position.
- B. The positive locking device indicator must be moved from the GREEN to the RED position.
- C. Rapidly rotate the crank in the EXPOSE direction to move the source to the radiographic focal position.
- D. When the source reaches the source stop, the hand crank will stop turning. Never exert more than 5 foot pounds of torque on the hand crank, as this may cause damage to the control unit or drive cable. Set the brake (if so equipped) to ON to prevent movement of the source during the exposure.
- E. Begin the specimen exposure time from the moment the source reaches the source stop. Physically survey the Radiation Area perimeter and make adjustments as needed to maintain the boundary at 2 mR/hr or less.
- F. During the exposure, maintain continuous surveillance of the safety perimeter spending as little time as possible in the Radiation Area to minimize personal exposure.
- G. To return the source to the exposure device after the desired exposure time has elapsed, turn the brake (if so equipped) to OFF and rapidly turn the crank in the RETRACT direction until the crank will no longer move.
- H. When the source is fully retracted to its safe shielded position, the positive locking device

indicator will move from the RED to the GREEN position.

- 12.4.I. Approach the exposure device with the survey meter and survey the exposure device on all sides. The meter should indicate the same radiation level as observed prior to radiographic operations after each exposure.
- J. Survey the entire source guide tube and collimator (if attached) with the survey meter. If the meter shows a sharp increase, the source could still be exposed or incompletely shielded.
- K. If the source is still exposed, leave the area and attempt to store it properly by cranking the source a short distance toward the source stop or collimator and retracting it, repeating if necessary.
- L. If the source becomes jammed in an exposed position do not try to retrieve the source. Treat the situation as an emergency and refer to Section 17.
- M. When the source is properly stored in the exposure device, rotate the selector ring from the OPERATE position to the LOCK position and secure it with the exposure device lock.

NOTE: If the selector ring cannot be rotated to the LOCK position, the source has not been fully retracted. Turn the hand crank to the full RETRACT position.

- N. Record the results on a Radiographic Operations Report.

NOTE: It is not permissible to chain or secure an exposure device and leave it unattended. A source must always remain under the direct surveillance of a Radiographer, an Assistant Radiographer, or a Health Physics technician to prevent unauthorized removal.



Figure 12-1

Unlock the exposure device with the key provided and turn the selector ring from the LOCK position to the CONNECT position. When the ring is in the CONNECT position, the storage cover will disengage from the exposure device as shown.

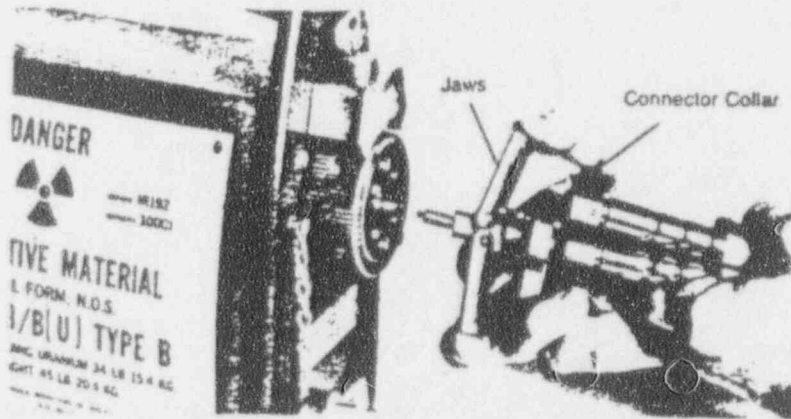


Figure 12-2

Slide the Model 661 connector collar back and open the jaws of the Model 661 connector. This exposes the male portion of the swivel type drive cable connector as shown.

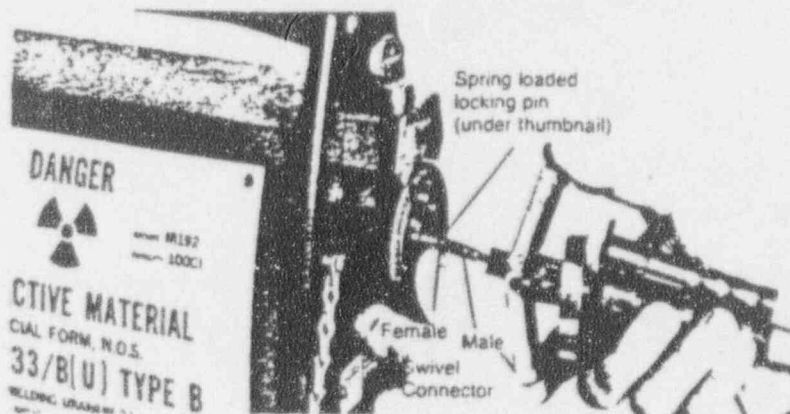
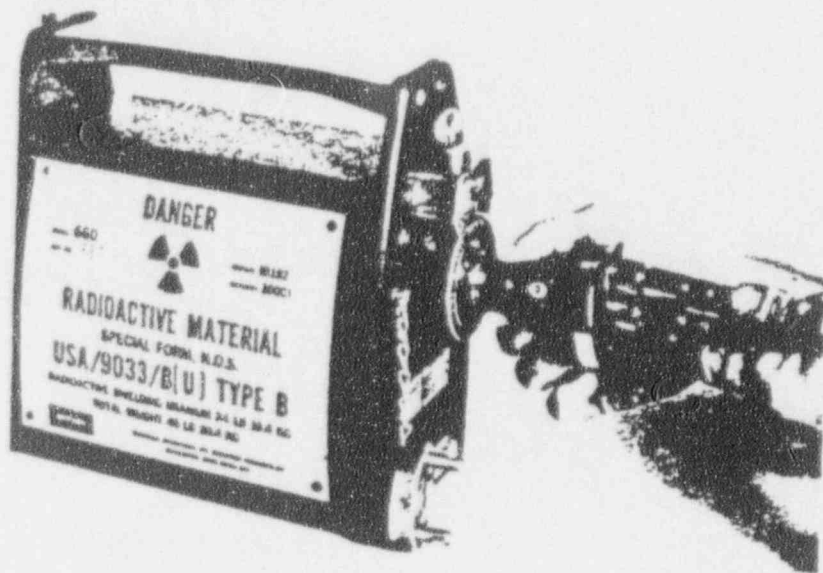


Figure 12-3

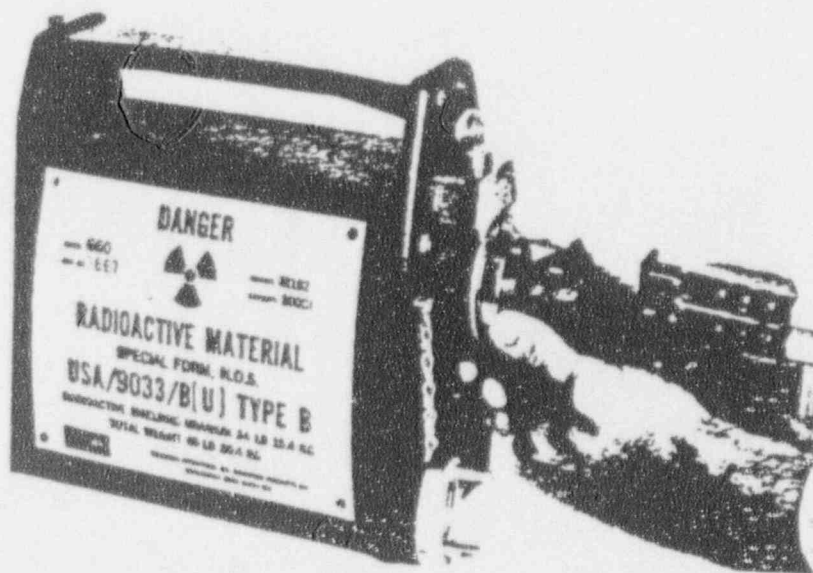
Engage the male and female portions of the swivel connector as shown by depressing the spring-loaded locking pin toward the exposure device with the thumbnail. Release the locking pin and test that the connection has been properly made.

Figure 12-4



Close the jaws of the Model 661 connector over the swivel connector.

Figure 12-5



Slide the Model 661 connector collar over the connector jaws. Hold the collar flush against the control unit connector and rotate the selector ring from the CONNECT position to the LOCK position. Keep the exposure device locked until operation is ready to start.

12.5 Post-Operation

When the radiography has been completed, the Radiographer and/or Assistant Radiographer will perform the following disassembly and post-operation items.

Amersham Model 660

- A. Unlck the exposure device, and rotate the selector ring from LOCK to CONNECT. The control unit connector will partially disengage.
- B. Refer to Figures 12-1 through 12-5 to disengage the control unit from the exposure device.
- C. Replace the storage cover in the control unit connector and rotate the selector ring to the LOCK position. Remove the key and engage the lock to secure the exposure device. Survey the entire circumference of the exposure device with the survey meter to ensure the source is properly secured.
- D. Unscrew the source guide tube sections and remove the master guide tube from the radiographic focal position. Protect the threads and cover the ends of the tubes and control cable connectors to prevent dust and dirt from entering.
- E. Insert the storage plug into the guide tube connector and hand tighten.
- F. Perform a survey of the entire circumference of the exposure device to determine that the source is in its properly shielded position. Document the results on a Radiographic Operations Report (see Attachment 3).
- G. Return the exposure device and equipment to the designated storage area and perform a time of storage survey at 18 inches from the surface of the storage container.
- H. Lock the designated storage area and complete the Radiographic Operations Report and Source Utilization Log. Post the area per Section 11.

12.6 Records

The Radiographic Operations Report shall be maintained for a minimum of three years after completion.

The Source Utilization Log shall be maintained for a minimum of three years after disposal of the source.

13.0 QUARTERLY INVENTORY AND MAINTENANCE

13.1 Quarterly Inventory and Maintenance

The RSO shall ensure that the following maintenance, inspection and inventory requirements are performed Quarterly and documented on a Quarterly Inventory/Periodic Maintenance Report.

- A. Inventory of Sealed Sources - This includes documenting types of byproduct material, quantity, activity, location, and date of inventory.
- B. Radiation Survey - Ensure that the radiation levels do not exceed 200mR/hr at the surface and 10mR/hr at 1 meter (3.3 feet).
- C. Inspect the overall condition of the exposure device noting any areas of concern which could impair the safe operation of the equipment. For exposure devices pay particular attention to the locking mechanism, ensuring that the lock operates smoothly. Clean and lubricate the lock if necessary.

13.2 Periodic Maintenance - Control Assembly

Ensure that the following maintenance is performed at the time of source change operations. Refer to the Manufacturers Operation and Maintenance Manual for further guidance or clarification.

A. Control Unit Drive Cable, Control Housings and Source Guide Tubes

Service the drive cable, control housings and source guide tubes, follow these steps:

1. Turn the hand crank of the control unit in the EXPOSE direction until the crank will no longer turn. Do not use force, as this may damage the drive wheel inside the control box.

NOTE: The emergent cable should be cranked into a bucket or other container to keep it clean.

2. Disconnect the control housing from the RETRACT side of the crank and remove the stop spring from the drive cable. The drive cable will now pass through the crank.
3. Turn the crank until the drive cable is totally disconnected.

- 13.2.A.4. Pull the drive cable out through the control cable connector and coil it with a radius of no less than 4 inches.
 5. Remove the control cable connector and connector plug from the control housings, and disconnect the other control housing from the crank.
 6. Clean the drive cable with a noncorrosive solvent cleaner/degreaser and flush the control housings and source guide tubes.
 7. Using compressed dry air (15 psi max.), thoroughly dry the drive cable, control housings and guide tubes. Any remaining solvent can cause permanent damage.
 8. Check the source guide tubes for binding by holding them vertical and dropping a dummy source (or jumper) through them.
 9. Wipe the guide tubes and control housings with a cloth soaked in solvent and flex them to check for internal damage. Damage is evidenced by a crunching feeling when the housing or tube is bent. While doing this, feel and look for dents, cuts or flattened areas which indicate the need for repair or replacement.
 10. The guide tubes or control housing may be covered with tape where only the outer plastic is cut through.
 11. Using a Model 550 no-go gauge, check the male connector of the drive cable. If the ball of the connector fits through the hole of the gauge or the ball shank fits into the slot in the gauge, the connector is worn and the cable must be replaced.
 12. Lightly grease the cable using TEXACO "Uni-Temp" grease (or equivalent).
 13. Remove the crank arm assembly from the control housing by removing the 5/16" hex head bolt.
- CAUTION:** Safety glasses should be worn to avoid possible injury from or loss of the tension-loaded wear strip. Make sure the cable adaptors stay in the lower control box housing during separation.
14. Separate the two halves of the control housing, keeping the cable adaptors in the lower control housing to ensure the wear strip does not fly out.

Remove the drive wheel, wear strip, two cable adaptors, two brake jaws, brake arm and brake bearing.

- 13.2.A.15. The two ball bearing assemblies in each side of the control housings should be left in place.

Reassembly

16. Clean all the control box parts in solvent and dry them thoroughly by air drying or with compressed dry air (15 psi max). Inspect for damage and excessive wear. Replace any defective parts.
 17. Lightly grease all moving parts at their contact surfaces with TEXACO "Uni-Temp" grease (or equivalent).
 18. Place two cable adaptors in the lower control housing with the angled sides facing inward in order to provide clearances for the drive wheel.
 19. Place the wear strip in the control housing.
- CAUTION:** Wear safety glasses when inserting the wear strip, it will be under tension and could pop out.
20. Place the drive wheel in the lower control box housing.
 21. Position the two brake jaws, brake bearing and brake arm in the lower control box housing. When installing the brake jaws, make sure that they are slightly bent an in opposing "C" shape.
 22. Place the upper control box housing over the lower control box housing while keeping them level, and press them together.
 23. Check the control box for proper reassembly by turning the shaft. It should spin freely. If not, disassemble and reinspect the parts for damage and proper alignment. Reassemble and check the operation again.
 24. Secure the control housing to the control handle with the four large binder head screws and 3/8" nuts, and secure the crank arm to the shaft with the 5/16" bevel washer and 5/16" hex head bolt.
 25. After complete reassembly, check for proper operation by turning the crank, it should spin freely. Run the drive cable through the control box and turn the crank. It should turn easily and

with no snags. Set the brake to ON (if equipped) and attempt to turn the crank. It should not turn with moderate pressure. Do not apply excessive pressure to the crank, as this may cause damage.

- 13.2.A.26. If the control housing fails any of these tests, disassemble, check the parts for damage and proper alignment, then reassemble and check for proper operation again.

B. Control Unit - Drive cable, Control Housing and Source Guide Tubes - Reassembly

1. Feed the drive cable into the control housing as far as it will go. As the drive cable is being fed in, feel the resistance to the drive cable to detect any binding of the cable. This indicates a dent in the control housing which should be repaired or replaced.
2. Turn the hand crank until the drive cable is protruding, and screw the stop spring to the end of the drive cable.
3. Connect the other control housing to the crank and to the connector plug.
4. Turn the crank fully to the RETRACT position and watch for any binding of the drive cable to check the other section of the control housing for dents. Repair or replace the control housing if necessary.
5. Protect the threads and cover the ends of the source guide tubes and control cable connector to eliminate dust accumulation.

13.3 Periodic Maintenance - Exposure Device

A. Exposure Device - Amersham Model 660

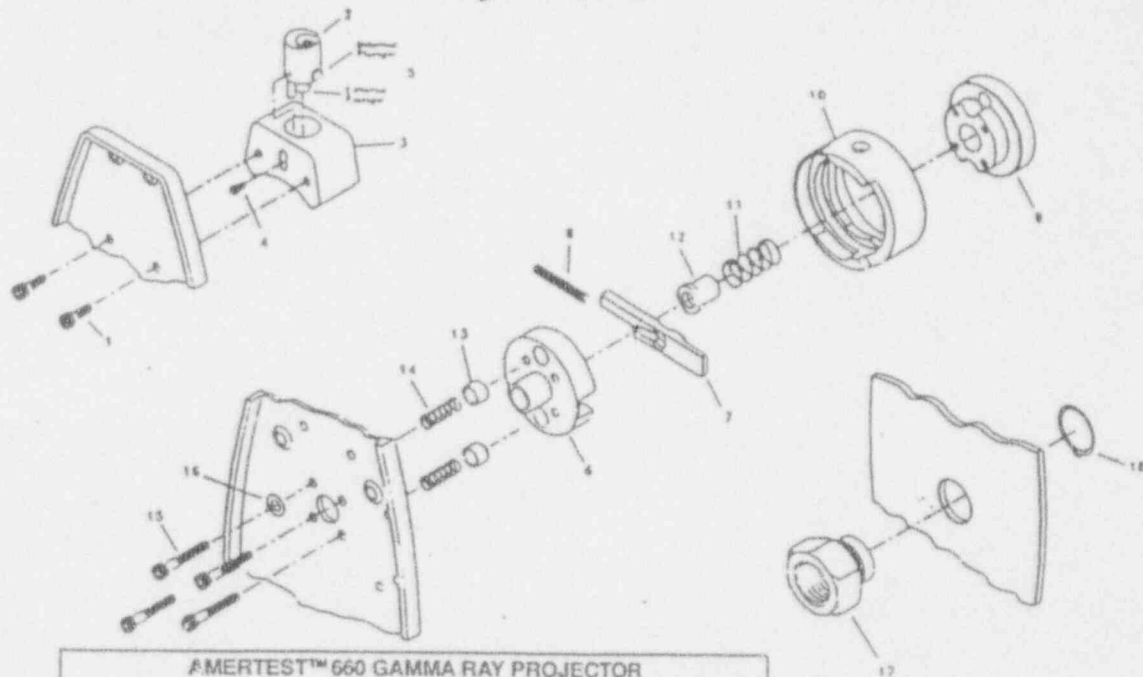
Perform the following maintenance at the time of source change.

1. Check the connector end of the source pigtail with a Model 550 No-Go Gage. The width of the Gage should not fit into the slot of the connector. If it does, the source will have to be returned to the manufacturer.
2. Remove old source in accordance with Section 16.
3. Remove the Danger Tag (secured with rivets) from the bottom of the rear plate.

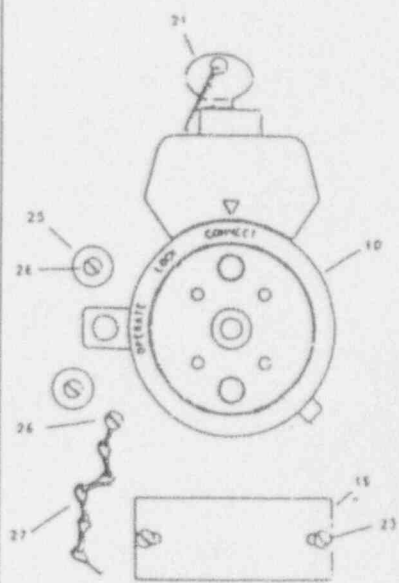
- 13.3.A.4. Remove the rear plate by unscrewing the six phillips head screws securing it to the exposure device body.
5. Unlock the connector lock, and then remove the lock assembly and control unit connector assembly by unscrewing the six allen head screws securing them to the rear plate.
6. Disassemble the control unit connector assembly, referring to Figure 13-1 for component identification. There are several spring loaded parts in the connector assembly, so care should be taken that these parts are not lost.
7. Remove the lock (5) from the lock retainer (3) by unscrewing the screw (4) and turning the key about 90°.
8. Remove the front end plate from the exposure device, and remove the guide tube connector and retaining ring with snap ring pliers, referring to Figure 13-1. The handle may be left on the front plate.
9. Clean all parts in solvent and flush the source tube. Dry the parts and the source tube thoroughly using dry compressed air (15 psi maximum). Clean the S-Tube in the exposure device by running a cloth soaked with solvent through it several times. Dry the S-Tube by running a dry cloth through the tube.
10. Inspect all parts for damage or excessive wear, and replace if necessary. Use Figure 13-1 for component identification numbers.
11. Lightly grease all moving parts at their contact surfaces with TEXACO "Uni-Temp" grease (or equivalent).
12. Reassemble the front end plate, and secure it to the exposure device with the proper screws.
13. Reassemble the lock by placing the return springs and spring guides into the lock (5), depressing the internal plunger, inserting the lock (5) into the lock retainer (3), and securing the lock with the set screw (4).
14. Attach the lock assembly to the rear plate with two allen head screws.

NOTE: The allen head screws were treated with a coating when new. If the coating is worn or if new screws are needed, they should be coated with "Loctite" or equivalent.

Figure 13-1



Ref #	Cat Code	Part # U.S.A.	Qty	Description	660 Repair Kit Code Kit-002 Qty in Kit
1	TMN1		2	10-32x5/8" Socket Head Screw	4
2	TSN66011	66001-11	1	Lock	
3	TSN66012	66001-12	1	Lock Retainer	
4			1	Screw (Supplied with item 2)	
5			1	Internal Plunger	
6	TSN85712	85701-2	1	Selector Body	
7	TSN85714	85701-4	1	Locking Side	
8	TSN0321		1	Compression Spring (LC-022C-7)	2
9	TSN85715	85701-5	1	Selector Ring Retainer	
10	TSN85713	85701-3	1	Selector Ring	
11	TSN0541		1	Compression Spring (LC-045H-5)	1
12	TSN85716	85701-6	1	Sleeve	
13	TSN66006	66001-6	2	Anti-Rotation Lugs	
14	TSN0267		2	Compression Spring (LC-026D-7)	2
15	TMN1		4	Socket Head Screws 10-32x1 1/4" (st. steel).	4
16	TMN1		4	Lock Washers, #10	4
17	TSN53311	53301-11	1	Guide Tube Connector Nut	
18	TMN1		1	Retaining Ring 5160-08	1
19	TSN002	LBL-010	1	Source Identification Plate	
20			8	1/4-20x3/4" Flat Head Phillips Key	
21	TSN003	66001-811	1	Jumper Connector (Not Shown)	
22	TSN66020	66001-20	1	Jumper Connector (Not Shown)	
23			2	BHMS 4-40x3/16"	4
24			8	10-32x5/8" Flat Head Phillips	4
25		RUB-007	2	Protective Bumper BH-2082	
26			3	6-32x5/8" Binder Head Phillips	3
27			1	Braided Cable	1
			1	#30 Drill Bit	1
			12	1/8" S.S. Pop Rivets	12
			1	#4 Scott Drive Screws 5/6"	2
		GRE-TUB		Grease	
		660-CL		Check List	
		MAN-006	1	660 Operations/Maint. Manual	
		SK1761	1	U-Tool	
		TSN66039	1	Cover (Selector) (Not Shown)	
		66010-1		Label (Control Certification)	



- 13.3.A.15. To reassemble the control unit connector assembly, refer to Figure 13-1 for component identification.
16. Hold the rear end plate horizontally, face up and the lock in the 12 o'clock position. The face plate may be held carefully in a vise or other fixture to free both hands for this assembly procedure.
17. Insert the 5/8" diameter of the selector body (6) into the mating hole in the center of the rear plate. The narrow end of the slot opening is to be at the 3 o'clock position.
18. Locate the locking slide (7) and the return spring (8) into the mating slot of the selector body.
19. Place the selector ring (10) with the word CONNECT at the 12 o'clock position, over the selector body. Push the locking slide so the selector ring will clear and rest the selector ring on the top surface of the selector body.
20. Insert springs (14) into holes at the top and bottom of the selector body. place the anti-rotation lugs (13) over the springs. Place the sleeve (12), with the large diameter facing down, on the center of the locking slide. Place the spring (11) over the sleeve.
21. Install the selector ring retainer (9) into the selector ring. Insure that the three non threaded holes line up under the word CONNECT. See Figure 13-1. Depress the selector ring retainer into the selector ring until its top is flush with the top of the selector ring.
22. While holding the assembly firmly against the end plates, turn it over to expose the back side. Install the four allen head screws (15) and the lock washers (16) to secure the connector assembly to the rear plate.
23. Insert the U-tool into the top and bottom holes of the selector assembly. Rotate the selector ring toward the OPERATE position.
24. Push the lock slide until the sleeve snaps into place.

- 13.3.A.25. Secure the rear end plate to the exposure device and handle using the six phillips head screws and replace the protective plate over the bottom two rear plate screws using pop rivets (.125" diameter x .294" long).

B. FINAL INSPECTION

1. Test the assembled exposure device using the jumper or a dummy source. Make sure that everything works satisfactorily.
2. Check the system for proper reassembly. Check all connections and fittings for tightness. Check for proper operation of the control unit and control unit connector assembly.
3. Check the exposure device for the proper labels.
4. Reload the new source in the exposure device in accordance with Section 16.

13.4 Records

The Quarterly Inventory/Periodic Maintenance Report shall be maintained for a minimum three years after completion.

14.0 TRANSPORTATION OF SOURCES

14.1 Transporting Radiographic Sources

This section applies to transporting Radiographic exposure devices and source changers to and from work and storage areas by vehicle (for shipping and receiving see Section 8).

14.2 Loading Vehicle

- A. Initialize a Radioactive Material Shipping Paper.
- B. Ensure that personnel are wearing the required dosimetry and that an operable calibrated survey meter is utilized.
- C. Check the vehicle, make sure it is in good operating condition and as a minimum, a sufficient quantity of safety equipment such as radiation area signs, rope, calibrated survey meters and proper shipping papers are present.
- D. Place the exposure device and/or source changer in the vehicle storage container, secure against movement and lock the container. Ensure that the storage container is labeled "Inside Package Complies with Prescribed Specifications". Survey the drivers and passenger seating area to ensure that radiation levels are below 2mR per hour.
- E. Survey the shipping container surface and select the proper shipping label (refer to Section 8, Fig. 8-1). Measure the radiation level at 3.3 feet and enter the Transportation Index on the shipping labels.
- F. Record the source type (IR-192) and source strength on the shipping labels. Attach the shipping labels two sides of the shipping container.
- G. If the radiation levels of the vehicle storage container are such that it requires a Radioactive Yellow III Label, the vehicle must display "Radioactive" placards on all four sides (See Figure 14-1). The driver of the vehicle must also possess a CDL.
- H. Complete and sign the Radioactive Material Shipping Paper. The shipping paper must be within reach of the driver while he is restrained by his lap belt, and shall be stored in a holder which is mounted on the inside of the drivers door.

14.3 Storing Radiographic Sources in Vehicles

- A. In the event that the vehicle is used for storage, conduct a survey to ensure that radiation levels are less than 2mR per hour at a distance of 18 inches from the surface of the vehicle. Also, the vehicle door shall be posted with a "Caution - Radioactive Material" sign and the list of responsible persons to contact in case of an emergency (Attachment 15).

NOTE: If storing in a vehicle for longer than 2 days, ensure that the radiation levels at 18 inches from the exterior surface is less than 0.6mR/hr, as to not exceed the 100mR in a 7 day period limit.

- B. Perform a time of storage survey and document the results on the Radiographic Operation Report.
- C. Complete the Source Utilization Log.

14.4 Accidents

If involved in a traffic accident while transporting a radioactive source, follow the instructions in Section 17.

14.5 Records

1. Source Utilization Logs shall be maintained for a minimum of three years.
2. Radiographic Operations Reports shall be maintained for a minimum of three years.
3. Radioactive Material Shipping Papers shall be maintained for a minimum of three years.

FIGURE 14-1



15.0 LEAK TESTS

15.1 General

Only qualified Radiographers who have been instructed in leak testing and have demonstrated satisfactory performance to the Radiation Safety Officer may conduct leak tests.

All applicable radiation safety precautions shall be maintained throughout the performance of the test.

15.2 Performance of Test

A. Source Leak Test

Radiographic sources contained in an exposure device shall be leak tested at intervals not to exceed 6 months to ensure that the level of removable contamination is not in excess of 0.005 microcuries (11,100 dpm).

Remove the exposure device shipping plug, and wipe the inside of the S-Tube and the end of the shipping plug with a smear sample. Reinstall the shipping plug and place the sample in a plastic envelope. Check the sample with a survey meter in an area of low background radiation, ensuring the sample is 2mR/hr or less before taking the sample for evaluation.

B. Packaging Wipe Test

When required, the outside surface of the outer package to be shipped must be wipe tested to assure that the levels of removable radioactive contamination do not exceed 0.0001 microcuries per 100 square centimeters (2200 disintegrations per minute [dpm]).

NOTE: Health Physics personnel should be requested to perform wipe tests of the radiographic equipment.

Wipe the outer surface with a smear and place it in a plastic envelope. Check the sample with a survey meter in an area of low background radiation, ensuring the sample is 2mR/hr or less before taking the sample for evaluation.

C. Sample Survey

If the sample indicates a radiation level greater than 2mR/hr, do not send the sample for evaluation and notify the RSO immediately.

Document the required information on the applicable data sheet (see Attachments 7 and 8).

15.3 Sample Evaluation

Samples and applicable data sheets shall be taken to the Health Physics Unit at Perry Nuclear Power Plant.

Samples shall be evaluated (counted) by qualified personnel utilizing calibrated equipment in accordance with PNPP (License No. NPF-58), Radiation Protection Section procedure HPI-L2 and documented on the appropriate analysis report.

15.4 Test Results

If the leak test results are greater than 0.005 microcuries (11,100 dpm), the RSO shall be immediately notified. Immediately withdraw the equipment from service and notify the NRC regional office. A written report shall be filed within 5 days in accordance with applicable Federal regulations.

If the wipe test results are greater than 0.0001 microcuries (2200 dpm), the RSO shall immediately be notified and the package shall be decontaminated and retested prior to shipping or next use.

15.5 Records

The Leak Test Data Sheet shall be maintained for at least six months after the next required leak test or until the source is disposed of.

The Radioactive Material Shipping Record shall be maintained for a minimum of three years.

16.0 SOURCE CHANGES

16.1 Qualification

Only qualified Radiographers who have been instructed in the operation of source changers and have demonstrated satisfactory performance to the Radiation Safety Officer may conduct source change operations.

16.2 Leak Test

No sealed source will be put into a camera without evidence of having a leak test performed within the previous six months. New sources may show evidence of a leak test on the supplied source decay curve. Older sources may show evidence on a Leak Test Data Sheet.

16.3 Operation

Initiate a Radiographic Operations Report and a Source Transfer/Disposal Record. Ensure a calibrated and operable survey meter is used while performing the following steps:

1. Amersham Model 660
Exchanging Source - From Exposure Device to Source Changer
 - A. Locate the source changer and radiographic exposure device in a restricted area as established in Section 11. Arrange them so that one length of guide tube will fit between them without any sharp bends or kinks in the tube. The bend radius of the source guide tube during source changing operations should be greater than 20 inches (when practical).

NOTE: THE SOURCE CHANGER MUST REMAIN UPRIGHT AT ALL TIMES. DO NOT LAY THE SOURCE CHANGER ON ITS SIDE.

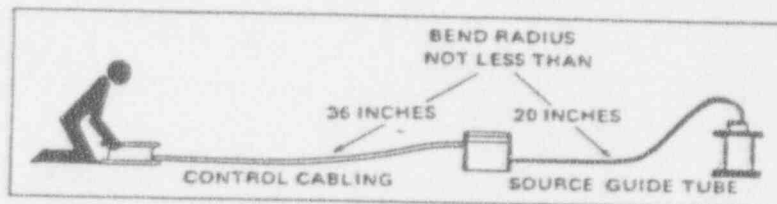


FIGURE 16-1 Typical Source Exchange Arrangement

- 16.3.1.B. Survey the exposure device and source changer on all sides and record the reference readings on the Source Transfer/Disposal Record.
- C. Connect the Control Unit to the exposure device in accordance with Section 12. Locate the control housing as far away as possible from the exposure device and the source changer and preferably behind any available radiation shielding. Always practice ALARA.
- D. Remove the outer cover from the source changer by unlocking the padlock and breaking the seal wire and removing the bolts.
- E. Remove the source hold down cap that covers the source by breaking the seal wire and unbolting. Remove the identification plate for the new source.

NOTE: WHEN THE SOURCE HOLD DOWN CAP IS REMOVED, THE SOURCE CONNECTOR IS EXPOSED. CARE MUST BE TAKEN TO ASSURE THAT THE SOURCE IS NOT DISLODGED WHEN HANDLING THE CHANGER.

- F. Connect one end of the guide tube extension to the exposure device and the other end to the fitting above the empty chamber of the source changer.
- G. Close and latch the source guides. The source guides should be taped to assure they remain closed. Assure no unauthorized personnel are in the restricted area and all access points are secured.
- H. Position a survey meter close to the operation control point so as to continuously monitor dose rate.
- I. At the exposure device controls, crank the source rapidly from the exposure device to the source changer.
- J. Approach the exposure device with a survey meter; survey the exposure device on all sides, survey the guide tube and survey the source changer on all sides to assure the source has been properly transferred and stored. The maximum radiation level should be less than 200mR/hr at the surface of the source changer and less than 10mR/hr one meter from the surface of the source changer.
- K. Open the source guides (Note the warning in Figure 16-2) and disconnect the drive cable from the source assembly.

- 16.3.1.L. Carefully remove the guide tube from the source changer to assure the source is not accidentally caught and removed. Fully retract the drive cable.
- M. Perform the exposure device required periodic maintenance in accordance with Section 13.



Connecting/Disconnecting



Testing Connection

Drive Cable Connection

WARNING

Do not move the source assembly more than 1/2 inch from its stored position when connecting and disconnecting or when testing for proper connection.

This procedure should be monitored with an operable calibrated meter.

To Engage Connector

1. Using a fingernail, move the connector pin forward (pressure on pin is downward toward stored position of source). This moves the connector sleeve away from the keyway in the female connector.
2. Slide the drive cable connector into the female connector and release the pin. Assure that the connector sleeve has returned to the original position closing the keyway.
3. Test the connection by pulling between the source and the drive cable. (NOTE: Warning)

To Disengage Connector

1. Using a fingernail, move the Connector pin forward (pressure on pin is downward toward stored position of source). This moves the connector sleeve away from the keyway in the female connector.
2. Slide the drive cable connector out of the female connector and release the pin.

CAUTION

Move connector sideways only.
Do not bend or twist.

FIGURE 16-2

Exchanging Source - From Source Changer to Exposure Device

- 16.3.1.N. Connect the control unit and to the exposure device in accordance with Section 12. Connect the guide tube to the fitting above the chamber containing the new source (Note warning in Figure 16-2).
- O. Couple the drive cable to the source by depressing the lock pin, sliding the drive cable connector into the keyway and releasing the lock pin. Assure that the connection is secure before continuing. (See Figure 16-2).
- P. Close and latch the source guides above the new source. The source guides should be taped shut to assure they remain closed. Assure no unauthorized personnel are in the restricted area.
- Q. At the exposure device controls, crank the new source from the source changer to its storage position in the exposure device.
- R. Approach the exposure device with the survey meter, survey the exposure device on all sides, the guide tube and the source changer on all sides to assure the source has been properly transferred to its storage position in the exposure device. Radiation levels should be less than 200mR/hr at the surface and less than 10mR/hr at one meter from the exposure device and 50mR/hr or less at 6 inches from the source changer.
- S. When the source is determined to be properly stored, lock the exposure device and remove the guide tube and controls. Install the threaded plug into the exposure device port. Disconnect the guide tube from the source changer.
- T. Verify that the empty source changer tube is empty using the physical probe gage.
- U. Assure all required documents are placed inside the source changer cover (see Section 8).
- V. Place the source hold down cap over the old spent source in the source changer. Attach the identification plate of the old source to the hold down cap.
- W. Bolt the source hold down cap in place and seal wire. Affix the identification plate of the new source to the exposure device.

- 16.3.1.X. Bolt the source changer cover in place and seal with seal wire. Lock the padlock in place. If an outer barrel is used as an over pack, it must be fastened with seal wire.
- Y. Survey all exterior surfaces of the package to assure that the radiation level does not exceed 200mR/hr at the surface or 10mR/hr at one meter.
- Z. Complete the Source Transfer Record (see Attachment 6) and forward it to the RSO.

2. SPEC Model C-1

Exchanging Source - From Exposure Device to Source Changer

- A. Locate the source changer and radiographic exposure device in a restricted area as established in Section 11. Always practice ALARA. Arrange them so that the short exchange tube supplied with the C-1 source changer will fit between them without any sharp bends or kinks in the tube.
- B. Open the top door to its fully extended position, exposing the outlet tubes and plungers on the top.
- C. Pull the lock plunger on the blue side (empty side) and turn to the left. This unlocks the plunger by holding it in the retracted position.

NOTE: Once a source has been fully installed within the C-1, the spring-loaded plunger secures it in place by pushing a rod against the pigtail cable directly behind the source capsule. If the plunger is not retracted, the source is able to enter the C-1, but WILL NOT be in the shielded area and WILL NOT be able to be secured in place. THE EMPTY SIDE PLUNGER OF C-1 MUST BE RETRACTED BEFORE PROCEEDING.

- D. Connect one end of the source exchange tube to the uncapped outlet tube on the top of the Source Changer. Connect the other end of the exchange tube to outlet of the exposure device.
- E. Connect the Control Unit to the exposure device in accordance with the Operating Instructions outlined in Section 12.
- F. Assure no unauthorized personnel are in the restricted area and all access points are secured.
- G. Position survey meter close to the operation control point so as to continuously monitor the dose rate.

- 16.3.2.H. At the exposure device controls, crank the source from the exposure device to the source changer.
- I. Approach the exposure device with a survey meter; survey the exposure device on all sides, survey the guide tube and survey the source changer on all sides to assure the source has been properly transferred and stored. The maximum radiation level should be less than 200mR/hr at the surface of the source changer and less than 10mR/hr one meter from the surface of the source changer.
- J. Lock the changer by turning the lock plunger 1/4 turn to the right and release. The plunger will lock down on the source. The knurled knob of the plunger has to seat on the barrel of the plunger housing. If it does not, jiggle the source with the control cable crank, until it does seat.

!! CAUTION !!

THE SOURCE COULD BE REMOVED FROM THE LOCK BOX IF THE LOCK IS NOT LOCKED

- K. Remove the exchange tube from the C-1 blue side and disconnect the control cable from the source pigtail.
- L. Carefully attempt to move the pigtail into and out of the lock box to assure the lock is depressed upon the pigtail. If the pigtail can be moved, pull the lock plunger out and shove the pigtail down into the tube and reseal the plunger.

CAUTION: Do not move the pigtail in excess of 1/2 inch, this would move the source from its shielded position.

- M. Remove protector outlet cap from outlet tube on the red side of the container and place protector cap on tube on the blue side.
- N. Perform the required periodic maintenance in accordance with Section 13. Then connect the control unit to the exposure device in accordance with Section 12.
- O. Attach the control cable to the new pigtail which is on the red side and attach the short exchange tube to the C-1 Source Changer on the red side.
- P. Pull the lock plunger on the new source side of the Source Changer and turn it 1/4 turn to the left. This unlocks the plunger and the new source is free to be extracted from the Source Changer.

- 16.3.2.Q. Assure no unauthorized personnel are in the restricted area.
- R. At the exposure device controls, crank the new source from the source changer to its storage position in the exposure device. Observe the survey meter during this operation.
- S. Approach the exposure device with the survey meter, survey the exposure device on all sides, the guide tube and the source changer on all sides to assure the source has been properly transferred to its storage position in the exposure device. Radiation levels should be less than 200mR/hr at the surface, 10mR/hr at one meter from the surface of the source changer and 50mR/hr or less at 6 inches from the exposure device.
- T. When the source is determined to be properly scored, rotate the RED side (now empty) plunger knob until the plunger snaps into its original fully engaged (closed) position.
- NOTE: Unless both plungers are in the closed position the plunger knobs will extend too far outward to allow the front door to close completely.
- U. Disconnect the exchanger tube and place inside of C-1. Close both doors, install padlock, affix tamper seal and exchange the source ID tags.
- V. Survey all exterior surfaces of the package to assure that the radiation level does not exceed 200mR/hr at the surface or 10mR/hr at one meter (3.3 feet).
- W. Complete the Source Transfer Record (see Attachment 6) and forward it to the RSO.

16.4 Records

Source Transfer/Disposal Records and Radiographic Operations Reports shall be maintained for a minimum of three years after completion.

17.0 EMERGENCY INSTRUCTIONS

17.1 Responsibility

It is the Radiographer's and/or Assistant Radiographers responsibility to notify the Centerior Energy Company of any situation in which they believe an emergency condition exists whether it be in transportation, use and/or storage of source material.

17.2 Notification

One of the following individuals shall be notified as soon as possible by telephone (collect if necessary), or by company pager.

	<u>Residence</u>	<u>Work Phone</u>
1. Jim Ewing RSO	(216) 428-2674	(216) 259-3737 Ext. 5402
2. Bill Hilkens Assistant RSO	(313) 854-1927	(419) 249-5000 Ext. 2092

The reach the above individuals by company pager, first dial 1-800-366-7243, then enter the applicable pager number below. Enter the telephone number at which you wish to be contacted, then press the # symbol before hanging up.

Jim Ewing pager 589-1701 or Bill Hilkens pager 589-1619.

In the event that the situation requires immediate response and the above individuals cannot be reached, notify the applicable NRC regional office. The telephone number can be found on NRC Form 3 (See Figure 9-2).

In the event an emergency occurs at Perry or Davis Besse, also notify the Plant Health Physicist at the facility.

17.3 Company Emergency Telephone Numbers

In the event of an injury, contact the following:

Cleveland

For major emergencies:

Cuyahoga County ----- 479-4444
Centrex System ----- 44444
All other areas ----- 1-800-589-9234

For minor emergencies:

All areas (ask for double E) ----- 1-800-686-2345
Centrex System ----- 41111

Toledo

Davis Besse only ----- 7777
All other Locations ----- 5678

17.4 Emergency Situation Assessment

If it is believed that an emergency situation exists the following actions shall be taken:

1. Suspend radiographic operations immediately;
2. Ensure the source is in its properly shielded position, if possible.
3. If the source cannot be secured, restrict and post the Radiation Area or suspected Radiation Area to a 2mR/hr level.
4. A radiographer must maintain surveillance of the radiation area. In a case where the radiation area encompasses a large area, responsible persons should be recruited to restrict access to the area.
5. Calmly gather the pertinent information available and notify the appropriate individual listed in Section 17.2 for direction and resolution.

17.5 Emergency Situation Examples

Emergency situations are defined, but not limited to the following examples:

1. Dosimeter goes off-scale.
2. Radioactive source becomes stuck in the source guide tube.
3. Damage to source material drive mechanisms or source guide tubes preventing the retraction of the source to its properly shielded position.
4. Radiographic exposure device is dropped or damaged.
5. Radiation survey instrument does not function properly.
6. An alarming ratemeter alarms and it can be determined that the alarm is not due to a weak battery.
7. Accident during transportation of source material via company vehicle. Also see paragraph 17.6.

NOTE: Never leave the scene of an accident unless you need medical attention and until you are sure of the

security of the source material. In the event medical attention is needed, placard(s) should be in an appropriate place in the vehicle, if applicable, as to inform local, state and/or civil authorities who to be contacted in case of an emergency.

- 17.5.8. Fire in an area where radiographic exposure devices are stored (temporary or permanent storage area).

NOTE: Caution Radioactive Material and Notice signs should be placed in appropriate areas as to inform local, state, civil and/or management authorities who is to be contacted in case of emergencies.

9. Lost or stolen source material.
10. Any situation in which it is believed that a radiation overexposure to an individual has occurred.
11. Any situation in which it is believed that a radiation exposure greater than 2mR/hr to an individual who is not monitored has occurred.
12. Any situation in which it is believed that a radiation exposure has occurred to a film badge or TLD and not to that individual.
13. Possible property damage that has or may occur because of source material.
14. Lost, wet or damaged TLD.

17.6 Vehicle Accidents

If involved in a traffic accident while transporting a radioactive source, including loading, unloading or temporary storage of a source:

1. The accident should first be reported to the civil authorities, the RSO and contact the above listed company telephone numbers.
2. The Department of Transportation shall be notified at 1-800-424-8802 at the earliest practicable moment if as a direct result of hazardous materials:
 - A. A person is killed.
 - B. A person receives injuries requiring his or her hospitalization.
 - C. Estimated carrier or other property damage exceeds \$50,000.

- 17.6.2.D. An evacuation of the general public occurs lasting one or more hours.
 - E. One or more major transportation arteries or facilities are shut down for one hour or more.
 - F. The operational flight pattern or routine of an aircraft is altered.
 - G. Fire, breakage, spillage or suspected radioactive contamination occurs involving shipment of radioactive material.
 - H. A situation exists of such a nature (e.g., a continuing danger to life exists at the scene of the incident) that, in the judgement of the carrier, it should be reported to the Department even though it does not meet the above criteria.
3. The following information is required to be reported to the Department of Transportation:
 - A. Name of person making the report, name and address of the carrier represented by the reporter.
 - B. Phone number where reporter can be contacted.
 - C. Date, time and location of incident.
 - D. The extent of injuries, if any.
 - E. Classification, name and quantity of radioactive source.
 - F. Type of incident and nature of hazardous material involvement and whether a continuing danger to life exists at the scene.
 4. A report shall also be submitted in writing, in duplicate, in accordance with the requirements of 49 CFR Part 171.16.

17.7 Source Retrieval

1. If a source becomes stuck in the exposed position and retrieval is necessary, the RSO will determine whether outside assistance is necessary. Assistance may be obtained from either MQS or Amersham.

NOTE: The situation will need to be evaluated to determine if a planned special exposure is necessary (see Section 10).

2. MQS can be contacted at (216) 498-9494.

17.7.3. Amersham can be contacted at 1-800-225-1383.

17.8 Post Emergency Action

1. If an individual's dosimeter is found to be off-scale (regardless of suspected cause), they shall be immediately barred from performing radiographic operations or receiving any occupational radiation exposure until:
 - A. The individual's TLD shall be immediately sent in for processing by expedited delivery.
 - B. The individual may not return to radiographic functions or receive occupational radiation exposure until the TLD results are reported, reviewed and the individual is released for work by the Radiation Safety Officer.
2. The individual's suspected radiation overexposure shall be calculated if it is determined that the cause of the off-scale dosimeter is from radiation exposure.
3. Calculation shall be based on re-enactment of the occurrence or available data, provided the information is specific concerning time, distance, shielding, type and activity of by-product material and background radiation levels, if applicable.
4. Equipment that may have been damaged during the incident shall be removed from service until an inspection, maintenance, repair and calibration (if applicable) has been performed to the satisfaction of the Radiation safety Officer.
5. The RSO shall obtain and implement formal corrective actions and actions to prevent reoccurrence of all radiographic emergencies.

17.9 Reporting

A Radiographic Incident Report (see Attachment 4) shall be completed giving detailed information required of the emergency situation within 24 hours of the occurrence.

The RSO is responsible for filing reports of incidents with the appropriate regulatory agencies.

17.10 Records

The Radiographic Incident Report shall be maintained for a minimum of three years after completion.

18.0 Abbreviations and Definitions

Absorbed dose - The energy imparted by ionizing radiation per unit mass of irradiated material. The unit of absorbed dose is the Rad.

Activity - The rate of disintegration or decay of radioactive material. The basic unit of activity is the curie.

ALARA - Making every reasonable effort to maintain exposures to radiation as far below the legal dose limits as practical.

Background radiation - Radiation from cosmic sources, naturally occurring radioactive materials and global fallout as it exists in the environment from the testing of nuclear explosive devices. This does not include the radiation from sources, byproduct or special nuclear materials, or nuclear reactors.

Access point - (see Entrance point)

Alarming ratemeter - A personal monitoring device worn while conducting radiographic activities calibrated to signal an audible alarm when in a radiation area of 500mR per hour or greater.

Assistant Radiation Safety Officer (Asst. RSO) - An individual authorized to perform the duties of the RSO in his absence.

Authorized personnel - Personnel qualified as Radiographers and Assistant Radiographers in accordance with 10 CFR Part 34 and this manual.

Byproduct material - Any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material.

Calibration - Check in the accuracy of the equipment and instruments against a known standard and correcting as required.

Camera - A radiographic exposure device containing a licensed radioactive isotope for industrial radiography applications.

Carrier - A person engaged in the transportation of passengers or property by land or water as a common, contract or private carrier.

CFR - Code of Federal Regulations.

Collective dose - The sum of the individual doses received in a given period of time by a specified group of individuals.

Collimator - A beam shaping device which utilizes shielding material to restrict the direction in which the radiation is emitted.

Committed Dose Equivalent (CDE) - Internal uptake of radioactive material equivalent to internal 50 year dosage to specific organs or tissues.

Committed Effective Dose Equivalent (CEDE) - The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues.

Contamination - The presence of unwanted radioactive material.

Curie (Ci) - The basic unit used to describe the activity in a sample of radioactive material. One curie equals 3.7 billion radioactive disintegrations per second.

Declared pregnant woman - A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

Dose (Rad) - The amount of ionizing radiation absorbed per unit of mass of irradiated material at a specific location, such as a part of the human body.

Dose equivalent - The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The unit of dose equivalent is the Rem.

Dose rate - The radiation dose delivered per unit of time.

Dosimeter - A device that measures radiation dose through discharging when in an ionizing radiation field.

Dosimeter charger - A device used to charge a dosimeter.

Dosimetry - (see Personal monitoring device)

Effective dose equivalent - The sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the organs or tissues that are irradiated.

Embryo/fetus - The developing human organism from conception to the time of birth.

Emergency instruction - Instructions to be followed by Radiographers and Assistant Radiographers in the event of an accident, equipment malfunction or uncontrolled conditions existing while engaging in radiographic activities.

Entrance point - Any location which through an individual could gain access to radiation areas or to radioactive materials.

Exposure - Being exposed to ionizing radiation or to radioactive material.

Exposure rate - Exposure to radiation intensity per unit of time.

External dose - That portion of the dose equivalent received from radiation sources outside the body.

Extremities - The human anatomy including the hand, elbow, arm below the elbow, foot, knee or leg below the knee.

Eye dose equivalent - The external exposure of the lens of the eye which is taken as the dose equivalent to a tissue depth of 0.3 centimeter (300 mg per centimeter squared).

High radiation area - An area accessible to individuals in which radiation levels could result in an individual receiving a dose equivalent in excess of 100 millirem in any hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Individual monitoring - The assessment of dose equivalent by the use of devices designed to be worn by an individual.

Individual monitoring device - (see Personal monitoring device)

Member of the public - An individual in a unrestricted area. However, an individual is not a member of the public during any period in which the individual receives an occupational dose.

millirem (mR or mr) - A unit of dose equivalent being equal to one thousandth of one Rem.

Minor - An individual less than 18 years of age.

NRC - The Nuclear Regulatory Commission or its duly authorized representatives.

Occupational dose - The dose received by an individual in a restricted area or in the course of employment in which the individual's assigned duties involves exposure to radiation and to radioactive material from licensed or unlicensed

sources of radiation. Occupational dose does not include dose received from background radiation, from medical practices or as a member of the general public.

Operating instructions - Instructions to be followed by Radiographers and Assistant Radiographers in conducting radiographic activities.

Package - The packaging together with its radioactive contents as presented for transport.

Packaging - The assembly of components necessary to ensure compliance with the packaging requirements of 10 CFR Part 71.

Personnel monitoring device - Devices designed to be worn by a single individual for the assessment of dose equivalent. These include film badges, TLD's, pocket dosimeters, extremity dosimetry and alarming ratemeters.

Physical survey - A survey to determine the location of radioactive material by the measurement of radiation intensity. Conducted when surveying an exposure device and guide tube after an exposure, to determine radiation intensities for the purposes of transportation, etc.

Planned Special Exposure (PSE) - An infrequent exposure to radiation, accounted for separately from and in addition to the annual dose limits.

Quality Factor - The modifying factor that is used to derive dose equivalent from absorbed dose. The quality factor for converting absorbed dose to dose equivalent for X-ray or gamma radiation is 1.

Rad - The unit of absorbed dose. One Rad is equal to an absorbed dose of 100 ergs/gram.

Radiation (or ionizing radiation) - Means alpha particles, beta particles, gamma rays, x-rays, neutrons, high speed electrons, high speed protons and other particles capable of producing ions.

Radiation Absorbed Dose (Rad) - The measure of ionizing radiation to any specified material in relation to the energy absorbed per unit mass of the material.

Radiation area - An area accessible to individuals in which radiation levels from a radiation source or from any surface that the radiation penetrates could result in an individual receiving a dose equivalent in excess of 2mR in 1 hour.

Radiation Safety Officer (RSO) - The representative appointed by the licensee and approved by the NRC who is responsible for the administration of the Industrial Radiography Program

and is the liaison between the licensee and the NRC.

Radiation survey - The process of using a survey meter to measure the presence and intensity of ionizing radiation.

Radioactive - Atoms which are energetically unstable and decay to a stable condition by emitting electromagnetic radiation.

Radiographer - A certified individual who performs, or who, in attendance at the site where radiographic sources are being utilized, personally supervises the radiographic operations and who is responsible to the license for assuring compliance with the requirements of federal regulations and the conditions of the license.

Radiographic exposure device - An instrument containing a sealed source within radiation shielding which may be mechanically operated for the purpose of making a radiographic exposure.

Radiography - The examination of materials by the nondestructive method utilizing sealed sources of byproduct material or other sources of ionizing radiation.

Radioisotope - An unstable isotope of an element that decays or disintegrates spontaneously, emitting electromagnetic radiation.

Recharging dosimeters - (see Zeroing dosimeters).

Rem - The unit of any of the quantities expressed as dose equivalent. The dose equivalent in Rems is equal to the absorbed dose in Rads multiplied by the quality factor.

Restricted area - Any area, in which access is limited by the licensee for the purpose of protecting individuals against undue risks to exposure to radiation or radioactive materials.

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

Shallow dose equivalent - Applies to the external exposure of the skin or to an extremity which is the dose equivalent at a tissue depth of 0.007 centimeter averaged over an area of 1 square centimeter.

Shielding - A layer or mass of material used to reduce the intensity of ionizing radiation.

Source - A radioactive material packaged so as to produce radiation for experimental or industrial applications.

Source changer - A shielded device designed for transportation of radioactive sources and used when exchanging a higher activity source for a lower activity source when depleted below useful strength.

Storage container - A container designated as a storage location for radioactive sources.

Survey - A measurement of ionizing radiation incident to the presence of radioactive materials under a specific set of conditions. When appropriate, such evaluation includes a physical survey of the location of materials and equipment and measurement of intensity of radiation.

Survey meter - An instrument to measure the dose rate of exposure to radiation.

Thermoluminescent Dosimeter (TLD) - A device worn by individuals to measure exposure to ionizing radiation for the purpose of compiling occupational radiation exposure histories.

Time of storage survey - A survey of the exposure device or source changer at the time of storage to ensure that the source is properly stored in it's shielded position and to determine whether the area must be posted as a radiation area.

Total Effective Dose Equivalent (TEDE) - The sum of the deep dose equivalent (for external exposure) and the committed effective dose equivalent (for internal exposures).

Transport Index (T.I.) - The dimensionless number (rounded up to the first decimal place) placed on the label of a package to designate the degree of control to be exercised by the carrier during transport.

Units of radioactive activity - Radioactivity is commonly measured using the following terms:

Curie = 3.7 billion disintegrations per second (dps) or 222 billion disintegrations per minute (dpm).

millicurie = 0.001 curie (one thousandth)

microcurie = 0.000001 curie (one millionth)

Unrestricted area - An area, access to which is neither limited nor controlled by the licensee.

Very high radiation area - An area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 millirem in 1 hour at 1 meter from a radiation source or from any surface that the radiation penetrates.

Whole body - Is, for the purposes of external exposure, the

head, trunk (including male gonads), arms above the elbow or legs below the knee.

Year - The calendar year beginning on January 1 and ending on December 31.

Zeroing dosimeters - Placing a dosimeter on a dosimeter charger and adjusting so that the reading is between 0 - 10 mR.

19.0 Forms

19.1 Forms

The below described forms are exhibited in the Attachments.

<u>Attachment No.</u>	<u>Form Title</u>	<u>Rev.</u>
Attachment 1	Quarterly Inventory/ Periodic Maintenance Report	0
Attachment 1a	Quarterly Inventory Log	1
Attachment 2	Dosimeter Calibration Log	0
Attachment 3	Radiographic Operation Report	1
Attachment 4	Radiographic Incident Data Report	0
Attachment 5	Radioactive Material Receipt Inspection Report	1
Attachment 6	Source Transfer Record	1
Attachment 7	Radioactive Material Shipping Record	1
Attachment 8	Leak Test Data Sheet	1
Attachment 9	Training Record for Radiography Personnel	0
Attachment 10	Annual Training Review	0
Attachment 11	Qualification Basis for Radiography Personnel	0
Attachment 12	Performance Review Checklist	0
Attachment 13	Industrial Radiography Program Update	0
Attachment 14	Industrial Radiography Program Revision Review	0
Attachment 15	Emergency Telephone Numbers	0
Attachment 16	Weekly Dosimeter Log	2
Attachment 17	Leak Test Sticker	0

Attachment 18	Section 206 of the Energy Reorganization Act of 1974	0
Attachment 19	Source Utilization Log	0
Attachment 20	Shipping Paper	0
Attachment 21	Survey Meter Calibration Log	0
Attachment 22	Alarming Ratemeter Calibration Log	0
Attachment 23	Radioactive Material Shipping Paper	0
Attachment 24	Planned Special Exposure Checklist	0

19.2 Record Retention

The record retention requirements are delineated in the specific sections as generated within this manual.

QUARTERLY INVENTORY / PERIODIC MAINTENANCE
Rev. 0

Date / /

Source: Ir192- [] Co60- [] Serial No.: _____ Curies *: _____

Exposure Device: Mfr./Model No.- _____ Serial No.- _____

Location: _____

(Choose One:)

(* - Review Source Decay Chart)

[]- A. Quarterly Inventory / Maintenance

Sat UnSat N/A

- 1. Was the exposure device and storage facility locked-----[] [] []
- 2. Was the storage area properly posted-----[] [] []
- 3. Inspect the exposure device for damage to the lock, fittings, fasteners and labels-----[] [] []
- 4. Ensure the locking mechanism operates properly-----[] [] []

Next Quarterly Inventory due / / .

[]- B. Periodic Maintenance

Sat UnSat N/A

- 1. Control unit, crank assembly and exposure device inspected, cleaned and lubricated-----[] [] []
- 2. Proper labels and stickers attached-----[] [] []
- 3. Equipment reassembled and operates properly-----[] [] []

REMARKS - _____

Physical survey results: Surface= _____ mR/hr; Three Feet= _____ mR/hr

Time of storage survey : _____ mR/hr @ 18 inches from the surface.

Survey Meter ID.: _____ Cal.Due / /

Performed By: _____ Date / / .

Performed By: _____ Date / /

Reviewed By : _____ Date / /

(RSO or Asst. RSO)

(Industrial Radiography Program - Attachment #3)

RADIOGRAPHIC OPERATIONS REPORT

Rev. 1

Page 1

Source Type - Ir192 Curies _____ Date ____/____/____
Manufacturer - Amersham Model No. - 424-9 Serial No. _____

EXPOSURE DEVICE

Manufacturer - Amersham Model No. - 660A Serial No. - A4526

INITIAL SURVEY RESULTS

_____ ^e mR/hr @ surface _____ mR/hr @ 3.3 feet
Survey Meter No. _____ Calibration Due ____/____/____

PRIOR TO USE DAILY INSPECTIONS

1. Inspect camera for damage to lock, fittings, fasteners and labels ---[]
2. Inspect crank, control cable and guide tube for cuts, breaks, damaged or loose fittings -----[]
3. Check cable connections with No-Go gage -----[]
4. Reference survey of exposure device _____ mR/hr -----[]
5. Radiation boundaries established and signs posted -----[]

Source utilized at _____

Time per exposure _____ No. of exposures _____

_____ mR/hr @ _____ feet

_____ mR/hr @ _____ feet  _____ mR/hr @ _____ feet

_____ mR/hr @ _____ feet

Final Physical Survey Results _____ mR/hr

RADIOGRAPHIC OPERATIONS REPORT

Rev. 1

Page 2

Source utilized at _____

Time per exposure _____ No. of exposures _____

_____ mR/hr @ _____ feet

_____ mR/hr @ _____ feet  _____ mR/hr @ _____ feet

_____ mR/hr @ _____ feet

Final Physical Survey Results _____ mR/hr

Source Storage - In Vehicle - In Storage Area

Time of Storage Survey _____^e mR/hr at 18 inches

Remarks: _____

The below signed individual(s) verify that the above information is accurate and has been completed in accordance with CSC's Industrial Radiography License procedures and applicable Federal Regulations.

Signed _____ Title _____

Signed _____ Title _____

Reviewed By _____ Date ____/____/____

RADIOGRAPHIC INCIDENT REPORT

Rev. 0

Radiographer: _____ Date ____ / ____ / ____ Time: _____

Work Location: _____

Who notified: (RSO) (Asst.RSO) Date ____ / ____ / ____ Time: _____

Were radiographic operations suspended immediately?-----[yes] [no]

Fill in the applicable incident block below and explain all pertinent info. in the details section.

- Lost, Wet or Damaged TLD

TLD ID No. - _____

Assigned To: _____

- TLD Possible Exposure to Radiation

TLD ID No. - _____

Assigned To: _____

Where was TLD located when it was believed to be exposed to radiation?

How much radiation (estimated) did the Film Badge/TLD receive?
under 25mR-[] 25 to 75mR-[] 75 to 150mR-[] 150 to 250mR-[]
250 to 500mR-[] above 500mR-[] unknown-[]

- Possible Overexposure of Radiation to an Individual

Individual(s) involved: _____

TLD ID No. - _____

Dosimeter Off-Scale? - (YES) (NO) When Noticed (Time): _____

How far away from the source was the individual? - _____
For how long? _____

Exposure Device - _____ Serial No. - _____

Source: (Ir192) (Co60) Serial No. - _____ Curies - _____

Survey Meter ID No. - _____ Cal. Due - ____ / ____ / ____

RADIOACTIVE MATERIAL RECEIPT INSPECTION REPORT

Rev. 1

Date Received : ___ / ___ / ___ Material : Ir 192-[] Co 60-[] Curies _____

Supplier/Mfr.- _____ Purchase Order : _____

Model No.- _____ S/N- _____ Leak Tested- ___ / ___ / ___

Container ID.- _____

Inspect for damage : None found-[] Yes-[] (explain in remarks)

Final Delivery Carrier : _____

Location Received : _____

Physical Survey

Shipping Container: _____ mR/hr @ surface; _____ mR/hr @ 3 feet

Survey Meter ID. - _____ Cal. Due ___ / ___ / ___

[] - Transferred to Exposure Device (See Source Transfer/Disposal Record)

[] - Source recieved in an Exposure Device

[] - Source stored in Source Changer

Time of Storage Survey

Storage Location - _____

Survey Results : _____ mR/hr @ 18 inches from the surface.

Storage area secured and posted correctly ? _____

Remarks : _____

Performed By : _____ Date ___ / ___ / ___

Performed By : _____ Date ___ / ___ / ___

Reviewed By : _____ Date: ___ / ___ / ___

(RSO) (Asst. RSO)

(Industrial Radiography Program - Attachment #6)

SOURCE TRANSFER/DISPOSAL RECORD

Rev. 1

Radioactive Material (1): Iridium 192: Curies- _____

Serial No. - _____ Leak Tested: ____ / ____ / ____

Transferred From : Exposure Device Mfr/Model: _____

Serial No: _____

Transferred To : Source Changer Mfr/Model: _____

Serial No: _____

Radioactive Material (2): Iridium 192: Curies- _____

Serial No. - _____ Leak Tested: ____ / ____ / ____

Transferred From : Source Changer Mfr/Model: _____

Serial No: _____

Transferred To : Exposure Device Mfr/Model: _____

Serial No: _____

Physical Survey Prior to Transfer

Exposure Device : Surface= _____ mR/hr ; Three feet= _____ mR/hr

Source Changer : Surface= _____ mR/hr ; Three feet= _____ mR/hr

Physical Survey Following Transfer

Exposure Device : Surface= _____ mR/hr ; Three feet= _____ mR/hr

Source Changer : Surface= _____ mR/hr ; Three feet= _____ mR/hr

Remarks- _____

Performed By : _____ Date ____ / ____ / ____

Performed By : _____ Date ____ / ____ / ____

Reviewed By : _____ Date ____ / ____ / ____

RADIOACTIVE MATERIAL SHIPPING RECORD

Rev. 1

Ship To : _____

Carrier - _____

Weight - _____ Date Shipped ____ / ____ / ____

Radioactive Material

- Proper Shipping Name: []- RQ - If greater than or equal to 10 curies Ir-192
[]- RADIOACTIVE MATERIAL, Special Form N.O.S, UN 2974
[]- RADIOACTIVE MATERIAL, Articles Manufactured from Depleted Uranium, UN 2909
[]- RADIOACTIVE MATERIAL, L.S.A., N.O.S., UN 2909

Radionuclide	Form	Activity	Serial No.	USNRC Identification No.

TYPE B SHIPPING CONTAINER

Mfr/Model No.	Serial No.	Cert. of Compliance No.

Physical Survey Results

Shipping Container: _____ mR/hr @ surface ; _____ mR/hr @ 3.3 ft.

"Radioactive" Label: []- White I; []- Yellow II; []- Yellow III (*)
(* - Placards required)

Transportation Index assigned: _____ (N/A to Radioactive White I)

Survey meter ID. No. - _____ Cal. Due - ____ / ____ / ____

SHIPPERS CERTIFICATION

I hereby certify that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked and labeled, and are in proper condition for carriage by air according to national governmental regulations.

This package conforms to the conditions and limitations specified in 49CFR173.424 for radioactive material, excepted package - articles manufactured from depleted uranium, UN2910.

TRANSPORTATION BY AIR

This shipment is within the limitations prescribed for Cargo-Only aircraft.

Signed: _____ Date ____ / ____ / ____

(Industrial Radiography Program - Attachment #8)

LEAK TEST DATA SHEET

Rev. 1

Radioactive Material: Ir 192--[] Co 60--[] Curies - _____

Source Serial No. - _____ Last Leak Tested - ____/____/____

Exposure Device: Mfr/Model No. - _____

Serial No. - _____

Physical Survey Results

Exposure Device: Surface= _____ mR/hr; Three Feet= _____ mR/hr

Survey Meter ID No. - _____ Cal. Due - ____/____/____

Test Sample Radiation Level: Less than 2mR/hr--[] Greater than 2mR/hr--[]

(Note: If the test sample is greater than 2mR/hr, notify the RSO immediately)

Time of Storage Survey

Storage Location - _____

Survey Results : _____ mR/hr @ 18 inches from the surface.

Remarks - _____

Leak test smear samples are counted by PNPP Health Physics personnel per Instruction HPI-12. Copies of this analysis report are attached.

Performed By: _____ Date ____/____/____

Performed By: _____ Date ____/____/____

Reviewed By: _____ Date ____/____/____

(Industrial Radiography Program - Attachment #9)

TRAINING RECORD FOR RADIOGRAPHY PERSONNEL
Rev. 0

Trainee: _____ Position: _____

Date(s) of Training : _____ Total Hours: _____

Subject: _____

Objective: _____

Training Materials: _____

Evaluation: _____

Training Conducted By:
Organization _____
Title _____
Signature _____

Trainee: _____

Reviewed By : _____
(RSO) (Asst. RSO)

(Industrial Radiography Program - Attachment #10)

ANNUAL TRAINING REVIEW

Rev. 0

Name: _____ SSN: _____

Dates of Training: _____

Topics Covered

YES N/A

Revisions to the Industrial Radiography Program ----- [] []

Items Reviewed: _____

Revisions to applicable Federal Regulations----- [] []

Items Reviewed: _____

Review of Audit Findings----- [] []

Items Reviewed: _____

Review of Radiation Incidents----- [] []

Items Reviewed: _____

Other Items Reviewed: _____

Trainee: _____ Date / /

Trainer: _____ Date / /

Reviewed By: _____ Date / /

(RSO)

(Asst. RSO)

QUALIFICATION BASIS FOR RADIOGRAPHY PERSONNEL
Rev. 0

Name: _____ SSN: _____

PRIOR TRAINING

Type: _____

Where: _____ When: _____ Hours: _____

Type: _____

Where: _____ When: _____ Hours: _____

Type: _____

Where: _____ When: _____ Hours: _____

Type: _____

Where: _____ When: _____ Hours: _____

Past Experience

Employer: _____

Where: _____ When: _____

Qualifications: _____

Employer: _____

Where: _____ When: _____

Qualifications: _____

Employer: _____

Where: _____ When: _____

Qualifications: _____

Name: _____

Has the above individual: YES N/A

Received the required training on;

- The Characteristics of Radiation and Radiation Safety -----[] []
- The Industrial Radiography Program -----[] []
- The Emergency Instructions -----[] []
- Transportation of Sources and Equipment Operation -----[] []
- Applicable Federal Regulations -----[] []

Demonstrated adequate skill, knowledge and judgment in;

- Performing Industrial Radiography -----[] []
- Performing Source Changes -----[] []
- Performing Leak Tests and Wipe Tests -----[] []
- Passed the required written examination -----[] []

Test Score: _____ %

I have reviewed the applicable training records and evaluated the individual identified above. I consider him/her qualified as a (Radiographer) or (Radiographer's Assistant) and additionally qualified to perform:

- N/A
- Leak/Wipe Tests
- Source Changes

Limitations (if any): _____

Effective Date of Qualification: _____

Evaluated By: _____ Title: _____

Reviewed By: _____ Title: _____

(Industrial Radiography Program - Attachment #12)

PERFORMANCE REVIEW CHECKLIST

Rev. 0

Date / /

Performance Review of: _____
(Radiographer) (Radiographer's Assistant)

Radiographic Location - _____

- | | <u>Sat</u> | <u>UnSat</u> | <u>N/A</u> |
|---|------------|--------------|------------|
| 1. Were all applicable prior to use (daily) inspections properly performed----- | [] | [] | [] |
| 2. Did the individual possess a copy of the Radiation Safety Manual----- | [] | [] | [] |
| 3. Was the individual wearing the proper Film badge/TLD and Dosimeter----- | [] | [] | [] |
| 4. Were all other individuals working within the restricted area wearing the proper Film badge/TLD and Dosimeter----- | [] | [] | [] |
| 5. Was the high radiation area properly posted----- | [] | [] | [] |
| 6. Was the radiation boundary properly established and posted-- | [] | [] | [] |
| 7. Was an operable and calibrated survey meter utilized----- | [] | [] | [] |
| 8. Had the source been leak tested within the previous 6 mo.'s- | [] | [] | [] |
| 9. Had the Quarterly Inventory / Maintenance been performed within the previous 90 days----- | [] | [] | [] |
| 10. Was the restricted area properly controlled to prevent unauthorized entry----- | [] | [] | [] |
| 11. Did the individual have sufficient knowledge of operating practices and safety rules----- | [] | [] | [] |
| 12. Did the individual lock the exposure device and properly survey the camera following each exposure----- | [] | [] | [] |
| 13. Was the source properly stored, locked and the Time of Storage survey performed----- | [] | [] | [] |
| 14. Was the storage area properly posted----- | [] | [] | [] |

PERFORMANCE REVIEW CHECKLIST (Cont.)

Remarks - _____

Performed By: _____

The (Radiographer) (Radiographer's Asst.) has demonstrated an (adequate) (inadequate) understanding of the Radiation Safety Manual, operating practices, safety rules and regulations.

Recommended Training - _____

Evaluated By: _____ Date ____ / ____ / ____
(RSO) (Asst. RSO)

I have read and understand the contents of this performance review.

Signed: _____ Date ____ / ____ / ____

cc: Director; Corporate Health Physicist; RSO; Asst. RSO; Individual's Training File; Performance Review File

INDUSTRIAL RADIOGRAPHY PROGRAM UPDATE
Rev. 0

To: _____ From: _____

Control No.: _____ Phone: _____

INSTRUCTIONS

Within 3 working days of receipt, please insert and/or remove the below listed items. Attach the removed documents to this transmittal and return. Please sign to acknowledge receipt of the item(s) listed.

It is the responsibility of the Assignee to personally sign this transmittal acknowledging receipt of the material.

Effective Date of: ____ / ____ / ____

INSERT

REMOVE & RETURN

I hereby attest that this manual is current to the date of this form.

Signed: _____ / /

(Industrial Radiography Program - Attachment #14)

INDUSTRIAL RADIOGRAPHY PROGRAM REVISION REVIEW
Rev. 0

To: _____ Mail Zone: _____

From: _____ Mail Zone: _____

Please review the attached proposed revision and return by ____ / ____ / ____.

Section No.- _____ Revision- _____ Recommended Effective Date- ____ / ____ / ____

Title- _____

Reason for Revision:

Audit finding/concern--[] Regulatory change--[] Organization change--[]

Program improvement--[] Change in an interfacing section--[]

Other--[] (specify) _____

Comments

Recommendation

- []---Approval - No comments
- []---Approval - Comments are minor
- []---Revision - Comments are major

Reviewed By: _____ Date ____ / ____ / ____

NOTICE
IN CASE OF AN EMERGENCY OR ACCIDENT INVOLVING
THIS VEHICLE OR RADIOACTIVE MATERIAL STORAGE AREA

NOTIFY:

CENTERIOR SERVICE COMPANY
NONDESTRUCTIVE EXAMINATION
PERRY NUCLEAR POWER PLANT
10 CENTER RD.
PERRY, OHIO 44081

EASTERN OHIO
Call: 216-259-1000
216-622-9800
800-686-2345
Ask for Perry extension 5402

WESTERN OHIO
Call: 419-249-5849
800-447-8883
Ask for extension 5849

Evenings, Weekends or Holidays Call:

James Ewing (RSO) - 216-428-2674
or
William Hilkens (A.RSO) - 313-854-1927
(CALL ANY OF THE ABOVE NUMBERS COLLECT IF NECESSARY)

The following documents are available for review
at the above listed address or the mobile laboratory.

- * 10 CFR Part(s) 19, 20, 21, 34, 71
 - * Section 206 of the Energy Reorganization Act of 1974
 - * CSC - Industrial Radiography Program
 - * USNRC License
- *****

WEEKLY DOSIMETER LOG
REV. 2

NAME: _____ SSN: _____

DATE ____ / ____ / ____ []- N/A []- Utilized at: _____

TLD No.	Dosimeter ID.	Reading @ Start	Reading @ End

Alarming Dosimeter S/N - _____ Calibration Due - ____ / ____ / ____

Possible radiation dose received from (check all that apply):
[]- X-Ray Radiography []- Source Radiography []- Nuclear Plant (RRA)

DATE ____ / ____ / ____ []- N/A []- Utilized at: _____

TLD No.	Dosimeter ID.	Reading @ Start	Reading @ End

Alarming Dosimeter S/N - _____ Calibration Due - ____ / ____ / ____

Possible radiation dose received from (check all that apply):
[]- X-Ray Radiography []- Source Radiography []- Nuclear Plant (RRA)

DATE ____ / ____ / ____ []- N/A []- Utilized at: _____

TLD No.	Dosimeter ID.	Reading @ Start	Reading @ End

Alarming Dosimeter S/N - _____ Calibration Due - ____ / ____ / ____

Possible radiation dose received from (check all that apply):
[]- X-Ray Radiography []- Source Radiography []- Nuclear Plant (RRA)

DATE ____ / ____ / ____ []- N/A []- Utilized at: _____

TLD No.	Dosimeter ID.	Reading @ Start	Reading @ End

Alarming Dosimeter S/N - _____ Calibration Due - ____ / ____ / ____

Possible radiation dose received from (check all that apply):
[]- X-Ray Radiography []- Source Radiography []- Nuclear Plant (RRA)

DATE ____ / ____ / ____ []- N/A []- Utilized at: _____

TLD No.	Dosimeter ID.	Reading @ Start	Reading @ End

Alarming Dosimeter S/N - _____ Calibration Due - ____ / ____ / ____

Possible radiation dose received from (check all that apply):
[]- X-Ray Radiography []- Source Radiography []- Nuclear Plant (RRA)

(Industrial Radiography Program - Attachment #16)

(Industrial Radiography Program - Attachment #17)

LEAK TEST

The Source contained within this Exposure Device was
Leak Tested on / / and found to have less than
0.005 microcuries of removable contamination. This
Source is due to be Leak Tested prior to / / .

Section 206 of Public Law 93-438, the Energy Reorganization Act of 1974

"NONCOMPLIANCE

Sec. 206. (a) Any individual director, or responsible officer of a firm constructing, owning, operating, or supplying the components of any facility or activity which is licensed or otherwise regulated pursuant to the Atomic Energy Act of 1954, as amended, or pursuant to this Act, who obtains information reasonably indicating that such facility or activity or basic components supplied to such facility or activity -

(1) Fails to comply with the Atomic Energy Act of 1954, as amended, or any applicable rule, regulation, order, or license of the Commission regulating to substantial safety hazards, or

(2) Contains a defect which could create a substantial safety hazard, as defined by regulations which the Commission shall promulgate, shall immediately notify the Commission of such failure to comply, or of such defect, unless such person has actual knowledge that the Commission has been adequately informed of such defect or failure to comply.

(b) Any person who knowingly and consciously fails to provide the notice required by subsection (a) of this section shall be subject to a civil penalty in an amount equal to the amount provided by section 234 of the Atomic Energy Act of 1954, as amended.

(c) The requirements of this section shall be prominently posted on the premises of any facility licensed or otherwise regulated pursuant to the Atomic Energy Act of 1954, as amended.

(d) The Commission is authorized to conduct such reasonable inspection and other enforcement activity as needed to insure compliance with the provisions of this section."

(Industrial Radiography Program - Attachment #20)

RADIOACTIVE MATERIAL SHIPPING PAPER
Rev. 0

Shipping Names: RQ, Radioactive Material, Special Form, N.O.S., UN 2974;
Radioactive Material, Articles Manufactured From
Depleted Uranium, UN 2909.

Source Type - Ir192 Curies _____ Date ____/____/____

Manufacturer - Amersham Model No. - 424-9 Serial No. _____

NOTE: A 24 HOUR EMERGENCY RESPONSE TELEPHONE NUMBER AND EMERGENCY
RESPONSE INFORMATION CAN BE FOUND ON LAMINATED CARDS DIRECTLY BEHIND
THIS FORM.

SHIPPING CONTAINER

Manufacturer - Amersham Model No. - 660A Serial No. - A4526

Certificate of Compliance No. Type B(U) Package USA / 9033 B(U)

Transported From _____

Transported To _____

Survey Results _____^① mRem/hr @ surface _____ mRem/hr @ 3.3 feet

Radioactive Label []- White I []- Yellow II []- Yellow III

Transport Index _____ Vehicle Placarded []-YES []- NOT REQUIRED

Vehicle Survey Results _____ mRem/hr @ surface

_____ mRem/hr @ Drivers/Passenger Area

Survey Meter ID No. _____ Calibration Due _____

SHIPPERS CERTIFICATION

This is to certify that the above named materials are properly
classified, described, packaged, marked and labeled, and are in proper
condition for transport according to the applicable regulations of the
Department of Transportation.

Signed _____ Title _____

Reviewed By _____ Date ____/____/____

RADIOACTIVE MATERIAL SHIPPING PAPER
Rev. 0

Shipping Names: RQ, Radioactive Material, Special Form, N.O.S., UN2974;
Radioactive Material, Articles Manufactured From
Depleted Uranium, UN2910.

Source Type - IR-192 Curies _____ Date ____/____/____

Manufacturer - Amersham Model No. - 424-9 Serial No. _____

NOTE: A 24 HOUR EMERGENCY RESPONSE TELEPHONE NUMBER AND EMERGENCY
RESPONSE INFORMATION CAN BE FOUND ON LAMINATED CARDS DIRECTLY BEHIND
THIS FORM.

SHIPPING CONTAINER

Manufacturer - Amersham Model No. - 660A Serial No. - A4526

Certificate of Compliance No. Type B(U) Package USA / 9033 B(U)

Transported From _____

Transported To _____

Survey Results _____[@] mR/hr @ surface _____ mR/hr @ 3.3 feet

Radioactive Label []- White I []- Yellow II []- Yellow III

Transport Index _____ Vehicle Placarded []-YES []- NOT REQUIRED

Vehicle Survey Results _____ mR/hr @ surface

_____ mR/hr @ Drivers/Passenger Area

Survey Meter ID No. _____ Calibration Due _____

SHIPPERS CERTIFICATION

This is to certify that the above named materials are properly
classified, described, packaged, marked and labeled, and are in proper
condition for transport according to the applicable regulations of the
Department of Transportation.

Signed _____ Title _____

Reviewed By _____ Date ____/____/____

RADIOACTIVE MATERIAL SHIPPING PAPER
Rev. 0

Shipping Names: RQ, Radioactive Material, Special Form, N.O.S., UN2974;
Radioactive Material, Articles Manufactured From
Depleted Uranium, UN2910.

Source Type - IR-192 Curies _____ Date ____/____/____

Manufacturer - Amersham Model No. - 424-9 Serial No. _____

NOTE: A 24 HOUR EMERGENCY RESPONSE TELEPHONE NUMBER AND EMERGENCY
RESPONSE INFORMATION CAN BE FOUND ON LAMINATED CARDS DIRECTLY BEHIND
THIS FORM.

SHIPPING CONTAINER

Manufacturer - Amersham Model No. - 660A Serial No. - A4526

Certificate of Compliance No. Type B(U) Package USA / 9033 B(U)

Transported From _____

Transported To _____

Survey Results _____[@] mR/hr @ surface _____ mR/hr @ 3.3 feet

Radioactive Label []- White I []- Yellow II []- Yellow III

Transport Index _____ Vehicle Placarded []-YES []- NOT REQUIRED

Vehicle Survey Results _____ mR/hr @ surface

_____ mR/hr @ Drivers/Passenger Area

Survey Meter ID No. _____ Calibration Due _____

SHIPPERS CERTIFICATION

This is to certify that the above named materials are properly
classified, described, packaged, marked and labeled, and are in proper
condition for transport according to the applicable regulations of the
Department of Transportation.

Signed _____ Title _____

Reviewed By _____ Date ____/____/____

(Industrial Radiography Program - Attachment #24)

PLANNED SPECIAL EXPOSURE AUTHORIZATION CHECKLIST

Rev. 0

Page 1

Describe the unusual circumstances which require the PSE.
Use additional pages if needed.

Name and title of the individual authorizing the PSE.

Individuals involved in the PSE are at least 18 years of age.

Names of Volunteers to be involved in the PSE.

The individuals involved have been informed of:

- The purpose of the planned operation.
- The estimated doses and associated potential risks and specific radiation levels or other hazardous conditions that might be involved in performing the task.
- Instructed in the measures to be taken to keep the dose ALARA considering other risks that may be present.

(Industrial Radiography Program - Attachment #24)

PLANNED SPECIAL EXPOSURE AUTHORIZATION CHECKLIST

Rev. 0

Page 2

Prior to permitting an individual to participate in a PSE, doses for each individual involved in the PSE shall be determined as follows:

NOTE: Any doses received during accidents or emergencies must be subtracted from the PSE limits that the individual may receive during the current year and during the individuals lifetime.

- The individuals internal and external doses from all previous PSE's. The individuals lifetime allowable PSE total effective dose is 25 REM.
- All occupational radiation dose received during the lifetime of the individual.
- The exposure history shall be recorded on NRC Form 4, or equivalent. The record must show each period in which the individual received occupational radiation exposure and must be signed by the individual who received the exposure. For any period for which the individual does not obtain a report, a notation shall be made on NRC Form 4, or equivalent, indicating the periods of time for which data are not available.

NOTE: If a complete record of the individuals current and previously accumulated occupational dose is unobtainable, that individual is not available to participate in a PSE.

The dose limit for any individual involved in any single PSE shall be no more than 5 Rem. The PSE dose and annual occupational dose shall be tracked and accounted for separately.

- Additional dosimetry may be needed in order to monitor the shallow dose equivalent for extremities.
- N/A

Describe what actions were necessary in performing the PSE, why the actions were necessary and how doses were maintained ALARA.

(continued on next page)

PLANNED SPECIAL EXPOSURE AUTHORIZATION CHECKLIST

Rev. 0

Page 3

[] The estimated individual and collective doses prior to performing the PSE, and the doses actually received during the PSE have been recorded on NRC Form 4's.

The records of doses received during PSE's, accidents and emergency conditions must include, when applicable:

[] The deep dose equivalent to the whole body, eye dose equivalent, shallow dose equivalent to the skin, and shallow dose equivalent to the extremities.

Each individual involved in a PSE shall be informed in writing of the best estimate of the dose resulting from the PSE within 30 days from the date of the PSE.

A written report of a PSE shall be submitted within 30 days to the Administrator, NRC Region III, 799 Roosevelt Road, Glen Ellyn, IL 60137, in accordance with 10 CFR 20.2105.

RSO

Date

Industrial Radiography Program

Appendix A - Applicable Federal Regulations

The below listed Federal Regulations are contained in this appendix:

- 10 CFR Part 19 - Notices, Instructions, and Reports to Workers; Inspections
- 10 CFR Part 20 - Standards for Protection Against Radiation
- 10 CFR Part 21 - Reporting of Defects and Noncompliance
- 10 CFR Part 34 - Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations
- 10 CFR Part 71 - Packaging and Transportation of Radioactive Material

Industrial Radiography Program

Appendix B - Radiation Incidents

This appendix contains information on radiation incidents and other miscellaneous information on Radiography as received in NRC Information Notices, NRC Bulletins or other sources.

UNITED STATES NUCLEAR REGULATORY COMMISSION
RULES and REGULATIONS

TITLE 10, CHAPTER 1, CODE OF FEDERAL REGULATIONS—ENERGY

§19.1

19.3

**PART
19**

**NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS:
INSPECTION AND INVESTIGATIONS**

- 19.1 Purpose.
- 19.2 Scope.
- 19.3 Definitions.
- 19.4 Interpretations.
- 19.5 Communications.
- 19.6 Information collection requirements:
OMB approval.
- 19.11 Posting of notices to workers.
- 19.12 Instructions to workers.
- 19.13 Notifications and reports to individuals.
- 19.14 Presence of representatives of licensees and workers during inspections.
- 19.15 Consultation with workers during inspections.
- 19.16 Requests by workers for inspections.
- 19.17 Inspections not warranted; informal review.
- 19.18 Sequestration of witnesses and exclusion of counsel in interviews conducted under subpoenas.
- 19.20 Employee protection.
- 19.30 Violations.
- 19.31 Application for exemptions.
- 19.32 Discrimination prohibited.
- 19.40 Criminal penalties.

§ 19.2 Scope.

The regulations in this part apply to all persons who receive, possess, use, or transfer material licensed by the Nuclear Regulatory Commission pursuant to the regulations in parts 30 through 35, 39, 40, 60, 61, or part 72 of this chapter, including persons licensed to operate a production or utilization facility pursuant to part 50 of this chapter and persons licensed to possess power reactor spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to part 72 of this chapter. The regulations regarding interviews of individuals under subpoenas apply to all investigations and inspections within the jurisdiction of the Nuclear Regulatory Commission other than those involving NRC employees or NRC contractors. The regulations in this part do not apply to subpoenas issued pursuant to 10 CFR 2.720.

§ 19.3 Definitions.

As used in this part:

"Act" means the Atomic Energy Act of 1954, (68 Stat. 919) including any amendments thereto.

"Commission" means the United States Nuclear Regulatory Commission.

"License" means a license issued under the regulations in Parts 30 through 35, 39, 40, 60, 61, 70, or 72 of this chapter, including licenses to operate a production or utilization facility pursuant to Part 50 of this chapter. "Licensee" means the holder of such a license.

Restricted area means an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

"Sequestration" means the separation or isolation of witnesses and their attorneys from other witnesses and their attorneys during an interview conducted as part of an investigation, inspection, or other inquiry.

"Worker" means an individual engaged in activities licensed by the Commission and controlled by a licensee, but does not include the licensee.

Authority: Secs. 53, 63, 81, 103, 104, 161, 166, 68 Stat. 930, 933, 935, 936, 937, 946, 955, as amended, sec. 234, 63 Stat. 444, as amended [42 U.S.C. 2073, 2093, 2111, 2133, 2134, 2201, 2236, 2262]; sec. 201, 66 Stat. 1242, as amended [42 U.S.C. 5841]; Pub. L. 95-601, sec. 10, 92 Stat. 2951 [42 U.S.C. 5851].

§ 19.1 Purpose.

The regulations in this part establish requirements for notices, instructions, and reports by licensees to individuals participating in licensed activities and options available to these individuals in connection with Commission inspections of licensees to ascertain compliance with the provisions of the Atomic Energy Act of 1954, as amended, Title II of the Energy Reorganization Act of 1974, and regulations, orders, and licenses thereunder regarding radiological working conditions. The regulations in this part also establish the rights and responsibilities of the Commission and individuals during interviews compelled by subpoenas as part of agency inspections or investigations pursuant to section 161c of the Atomic Energy Act of 1954, as amended, on any matter within the Commission's jurisdiction.

W Exclusion means the removal of counsel representing multiple interests from an interview whenever the NRC official conducting the interview has concrete evidence that the presence of the counsel would obstruct and impede the particular investigation or inspection.

PART 19 • NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS:--

§ 19.4 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

§ 19.5 Communications.

Except where otherwise specified in this part, all communications and reports concerning the regulations in this part should be addressed to the Regional Administrator of the appropriate U.S. Nuclear Regulatory Commission Regional Office listed in Appendix D of Part 20 of this chapter. Communications, reports, and applications may be delivered in person at the Commission's offices at 2120 L Street, NW., Washington, DC, or at 11555 Rockville Pike, Rockville, Maryland.

§ 19.8 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control number 3150-0044.

(b) The approved information collection requirements contained in this part appear in § 19.13.

§ 19.11 Posting of notices to workers.

(a) Each licensee shall post current copies of the following documents:

(1) The regulations in this part and in Part 20 of this chapter;

(2) The license, license conditions, or documents incorporated into a license by reference, and amendments thereto;

(3) The operating procedures applicable to licensed activities;

(4) Any notice of violation involving radiological working conditions, proposed imposition of civil penalty, or order issued pursuant to Subpart B of Part 2 of this chapter, and any response from the licensee.

(b) If posting of a document specified in paragraph (a) (1), (2) or (3) of this section is not practicable, the licensee may post a notice which describes the document and states where it may be examined.

31 FR 30481

(c) Each licensee and applicant shall post Form NRC-3, (Revision 6-82 or later) "Notice to Employees," as required by Parts 30, 40, 50, 60, 70, 72, and 150 of this chapter.

NOTE: Copies of Form NRC-3 may be obtained by writing to the Regional Administrator of the appropriate U.S. Nuclear Regulatory Commission Regional Office listed in Appendix D of Part 20 of this chapter.

(d) Documents, notices, or forms posted pursuant to this section shall appear in a sufficient number of places to permit individuals engaged in licensed activities to observe them on the way to or from any particular licensed activity location to which the document applies, shall be conspicuous, and shall be replaced if defaced or altered.

(e) Commission documents posted pursuant to paragraph (a)(4) of this section shall be posted within 2 working days after receipt of the documents from the Commission; the licensee's response, if any, shall be posted within 2 working days after dispatch by the licensee. Such documents shall remain posted for a minimum of 5 working days or until action correcting the violation has been completed, whichever is later.

§ 19.12 Instructions to workers.

All individuals working in or frequenting any portion of a restricted area shall be kept informed of the storage, transfer, or use of radioactive materials or of radiation in such portions of the restricted area; shall be instructed in the health protection problems associated with exposure to such radioactive materials or radiation, in precautions and procedures to minimize exposure, and in the purposes and functions of protective devices employed; shall be instructed in, and instructed to observe, to the extent within the worker's control, the applicable provisions of Commission regulations and licenses for the protection of personnel from exposures to radiation or radioactive materials occurring in such areas; shall be instructed of their responsibility to report promptly to the licensee any condition which may lead to or cause a violation of Commission regulations and licenses or unnecessary exposure to radiation or to radioactive material; 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 or radioactive material; and shall be advised as to the radiation exposure reports which workers may request pursuant to § 19.13. The extent of these instructions shall be commensurate with potential radiological health protection problems in the restricted area.

§ 19.13 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 Commission regulations, orders or license conditions, as shown in records maintained by the licensee pursuant to Commission regulations. Each notification and report shall be in writing; include appropriate identifying data such as the name of the licensee, the name of the individual, the individual's social security number; include the individual's exposure information; and contain the following statement:

This report is furnished to you under the provisions of the Nuclear Regulatory Commission regulation 10 CFR Part 19. You should preserve this report for further reference.

(b) Each licensee shall advise each worker annually of the worker's dose as shown in records maintained by the licensee pursuant to part 20 (§ 20.401 and § 20.601 or, for licensees implementing the provisions of §§ 20.1001-20.2401, § 20.2106). Prior to January 1, 1994, licensees operating under §§ 20.1-20.601 are required to provide this information only upon request of the worker.

(c) At the request of a worker formerly engaged in licensed activities controlled by the licensee, each licensee shall furnish to the worker a report of the worker's exposure to radiation or radioactive material for each year the worker was required to be monitored under either § 20.107 or § 20.202 or, for licensees implementing the provisions of §§ 20.1001-20.2401, under § 20.1502. Such report shall be furnished within 30 days from the time the request is made, or within 30 days after the exposure of the individual has been determined by the licensee, whichever is later. This report shall cover the period of time that the worker's activities involved exposure to radiation from radioactive materials licensed by the Commission and shall include the date and locations of licensed activities in which the worker participated during this period.

(d) When a licensee is required pursuant to § 20.405 and § 20.408 or, for licensees implementing the provisions of §§ 20.1001-20.2401, §§ 20.2202, 20.2203, 20.2204, or § 20.2206,

of this chapter to report to the Commission any exposure of an individual to radiation or radioactive material the licensee shall also provide the individual a report on his exposure data included therein. Such report shall be transmitted at a time not later than the transmittal to the Commission.

36 FR 22317

37 FR 43419

19623

36 FR 22317

30 FR 22317

36 FR 22317

37 FR 38888

36 FR 23360

[e] At the request of a worker who is terminating employment with the licensee that involved exposure to radiation or radioactive materials, during the current calendar quarter or the current year, each licensee shall provide at termination to each such worker, or to the worker's designee, a written report regarding the radiation dose received by that worker from operations of the licensee during the current year or fraction thereof. If the most recent individual monitoring results are not available at that time, a written estimate of the dose shall be provided together with a clear indication that this is an estimate. Licensees required by §§ 20.407-20.408 of §§ 20.1-20.601 to provide termination reports and statistical summaries of occupational doses to the Commission shall continue to provide these reports until they adopt the provisions of §§ 20.1001-20.2401, or until January 1, 1993.

§ 19.14 Presence of representatives of licensees and workers during inspections.

(a) Each licensee shall afford to the Commission at all reasonable times opportunity to inspect materials, activities, facilities, premises, and records pursuant to the regulations in this chapter.

(b) During an inspection, Commission inspectors may consult privately with workers as specified in § 19.15. The licensee or licensee's representative may accompany Commission 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 Commission inspections, the licensee 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 licensed activities under control of the licensee and shall have received instructions as specified in § 19.12.

(e) Different representatives of licensees and workers may accompany the inspectors during different phases of an inspection if there is no resulting interference with the conduct of the inspection. However, only one workers' representative at a time may accompany the inspectors.

(f) With the approval of the licensee and the workers' representative an individual who is not routinely engaged in licensed activities under control of the licensee, for example, a consultant to the licensee or to the workers' representative, shall be afforded the opportunity to accompany Commission inspectors during the inspection of physical working conditions.

(g) Notwithstanding the other provisions of this section, Commission inspectors are authorized to refuse to permit accompaniment by any individual who deliberately interferes with a fair and orderly inspection. With regard to areas containing information classified by an agency of the U.S. Government in the interest of national security, an individual who accompanies an inspector may have access to such information only if authorized to do so. With regard to any area containing proprietary information, the workers' representative for that area shall be an individual previously authorized by the licensee to enter that area.

§ 19.15 Consultation with workers during inspections.

(a) Commission inspectors may consult privately with workers concerning matters of occupational radiation protection and other matters related to applicable provisions of Commission regulations 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 has reason to believe may have contributed to or caused any violation of the act, the regulations in this chapter, or license condition, or any unnecessary exposure of an individual to radiation from licensed radioactive material under the licensee's control. Any such notice in writing shall comply with the requirements of § 19.16(a).

(c) The provisions of paragraph (b) of this section shall not be interpreted as authorization to disregard instructions pursuant to § 19.12.

§ 19.16 Requests by workers for inspections.

(a) Any worker or representative of workers who believes that a violation of the Act, the regulations in this chapter, or license conditions exists or has occurred in license activities 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 Administrator of the appropriate Commission Regional Office, or to Commission inspectors. 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 workers. A copy shall be provided the licensee by the Regional Office Administrator, or the inspector no later than the time of inspection except that, upon the request of the worker giving such notice, his 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 Commission, except for good cause shown.

(b) If, upon receipt of such notice, the Regional Office Administrator determines that the complaint meets the requirements set forth in paragraph (a) of this section, and that there are reasonable grounds to believe that the alleged violation exists or has occurred, he shall cause an inspection to 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.

§ 19.17 Inspections not warranted; informal review.

(a) If the Administrator of the appropriate Regional Office determines, with respect to a complaint under § 19.16, that an inspection is not warranted because there are no reasonable grounds to believe that a violation exists or has occurred, he shall notify the complainant in writing of such determination. The complainant may obtain review of such determination by submitting a written statement of position with the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, who will provide the licensee with a copy of such statement by certified mail, excluding, at the request of the complainant, the name of the complainant. The licensee may submit an opposing written statement of position with the Executive Director for Operations who will provide the complainant with a copy of such statement by certified mail. Upon the request of the complainant, the Executive Director for Operations or his designee may hold an informal conference in which the complainant and the licensee may orally present their views. An informal conference may also be held at the request of the licensee, but disclosure of the identity of the complainant will be made only following receipt of written authorization from the complainant. After considering all written and oral views presented, the Executive Director for Operations shall affirm, modify, or reverse the determination of the Administrator of the appropriate Regional Office and furnish the complainant and the licensee a written notification of his decision and the reason therefor.

(b) If the Administrator of the appropriate Regional Office determines that an inspection is not warranted because the requirements of § 19.16(a) have not been met, he 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 § 19.16(a).

PART 19 - NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS:---

§ 19.18 Sequestration of witnesses and exclusion of counsel in interviews conducted under subpoenas.

(a) All witnesses compelled by subpoena to submit to agency interviews shall be sequestered unless the official conducting the interviews permits otherwise.

(b) Any witness compelled by subpoena to appear at an interview during an agency inquiry may be accompanied, represented, and advised by counsel of his or her choice. However, when the agency official conducting the inquiry determines, after consultation with the Office of the General Counsel, that the agency has concrete evidence that the presence of an attorney representing multiple interests would obstruct and impede the investigation or inspection, the agency official may prohibit that counsel from being present during the interview.

(c) The interviewing official is to provide a witness whose counsel has been excluded under paragraph (b) of this section and the witness's counsel a written statement of the reasons supporting the decision to exclude. This statement, which must be provided no later than five working days after exclusion, must explain the basis for the counsel's exclusion. This statement must also advise the witness of the witness' right to appeal the exclusion decision and obtain an automatic stay of the effectiveness of the subpoena by filing a motion to quash the subpoena with the Commission within five days of receipt of this written statement.

(d) Within five days after receipt of the written notification required in paragraph (c) of this section, a witness whose counsel has been excluded may appeal the exclusion decision by filing a motion to quash the subpoena with the Commission. The filing of the motion to quash will stay the effectiveness of the subpoena pending the Commission's decision on the motion.

(e) If a witness' counsel is excluded under paragraph (b) of this section, the interview may, at the witness' request, either proceed without counsel or be delayed for a reasonable period of time to permit the retention of new counsel. The interview may also be rescheduled to a subsequent date established by the NRC, although the interview shall not be rescheduled by the NRC to a date that precedes the expiration of the time provided under § 19.18(d) for appeal of the exclusion of counsel, unless the witness consents to an earlier date.

§ 19.20 Employee protection.

Employment discrimination by a licensee or a contractor or subcontractor of a licensee against an employee for engaging in protected activities under this part or Parts 30, 40, 50, 60, 70, 72, or 150 of this chapter is prohibited.

§ 19.30 Violations.

(a) The Commission may obtain an injunction or other court order to prevent a violation of the provisions of—

- (1) The Atomic Energy Act of 1954, as amended;
- (2) Title II of the Energy Reorganization Act of 1974, as amended; or
- (3) A regulation or order issued pursuant to those Acts.

(b) The Commission may obtain a court order for the payment of a civil penalty imposed under section 234 of the Atomic Energy Act:

- (1) For violations of—
 - (i) Sections 53, 57, 62, 63, 61, 62, 101, 103, 104, 107, or 109 of the Atomic Energy Act of 1954, as amended;
 - (ii) Section 206 of the Energy Reorganization Act;
 - (iii) Any rule, regulation, or order issued pursuant to the sections specified in paragraph (b)(1)(i) of this section;
 - (iv) Any term, condition, or limitation of any license issued under the sections specified in paragraph (b)(1)(i) of this section.
- (2) For any violation for which a license may be revoked under section 186 of the Atomic Energy Act of 1954, as amended.

§ 19.31 Application for exemptions.

The Commission may upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

§ 19.32 Discrimination prohibited.

No person shall on the ground of sex be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity licensed by the Nuclear Regulatory Commission. This provision will be enforced through agency provisions and rules similar to those already established, with respect to racial and other discrimination, under Title VI of the Civil Rights Act of 1964. This remedy is not exclusive, however, and will not prejudice or cut off any other legal remedies available to a discriminatee.

§ 19.40 Criminal penalties.

(a) Section 223 of the Atomic Energy Act of 1954, as amended, provides for criminal sanctions for willful violation of, attempted violation of, or conspiracy to violate, any regulation issued under sections 161b, 161i, or 161o of the Act. For purposes of section 223, all the regulations in part 19 are issued under one or more of sections 161b, 161i, or 161o, except for the sections listed in paragraph (b) of this section.

(b) The regulations in part 19 that are not issued under sections 161b, 161i, or 161o for the purposes of section 223 are as follows: §§ 19.1, 19.2, 19.3, 19.4, 19.5, 19.8, 19.16, 19.17, 19.18, 19.30, 19.31, and 19.40.

UNITED STATES NUCLEAR REGULATORY COMMISSION
RULES and REGULATIONS
TITLE 10, CHAPTER 1, CODE OF FEDERAL REGULATIONS—ENERGY

**PART
20**

STANDARDS FOR PROTECTION AGAINST RADIATION

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PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

Authority: Secs 53, 63, 65, 81, 103, 304, 161, 162, 166, 68 Stat. 930, 933, 935, 936, 937, 948, 953, 955, as amended (42 U.S.C. 2073, 2093, 2095, 2111, 2133, 2134, 2201, 2232, 2236), secs 201, as amended, 202, 206, 68 Stat. 1242, as amended, 1244, 1246 (42 U.S.C. 5841, 5842, 5546)

Section 20.408 also issued under secs. 135, 141, Pub. L. 87-425, 96 Stat. 2232, 2241 (42 U.S.C. 10155, 10161)

For the purposes of sec. 233, 68 Stat. 958, as amended (42 U.S.C. 2273), §§ 20.101, 20.102, 20.103 (a), (b), and (f), 20.104 (a) and (b), 20.105(b), 20.106(a), 20.201, 20.202(a), 20.205, 20.207, 20.301, 20.303, 20.304, 20.305, 20.1102, 20.1201-20.1204, 20.1206, 20.1207, 20.1208, 20.1301, 20.1302, 20.1501, 20.1502, 20.1601 (a) and (d), 20.1602, 20.1603, 20.1701, 20.1704, 20.1801, 20.1802, 20.1901(a), 20.1902, 20.1904, 20.1906, 20.2001, 20.2002, 20.2003, 20.2004, 20.2005 (b) and (c), 20.2006, 20.2101-20.2110, 20.2201-20.2206, and 20.2301 are issued under sec. 161b, 68 Stat. 946, as amended, (42 U.S.C. 2201(b)) and § 20.2106(d) is issued under the Privacy Act of 1974, Pub. L. 93-579, 5 U.S.C. 552a; and §§ 20.102, 20.103(a), 20.401-20.407, 20.408(b), 20.409, 20.1102(a) (2) and (4), 20.1204(c), 20.1206 (g) and (h), 20.1904(c)(4), 20.1905 (c) and (d), 20.2004(b), 20.2005(c), 20.2006 (b)-(d), 20.2101-20.2103, 20.2104 (b)-(d), 20.2105-20.2106, and 20.2201-20.2207 are issued under sec. 161c, 68 Stat. 950, as amended (42 U.S.C. 2201(c))

GENERAL PROVISIONS

§ 20.1 Purpose.

(a) The regulations in this part establish standards for protection against radiation hazards arising out of activities under licenses issued by the Nuclear Regulatory Commission and are issued pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974.

(b) The use of radioactive material or other sources of radiation not licensed by the Commission is not subject to the regulations in this part. However, it is the purpose of the regulations in this part to control the possession, use, and transfer of licensed material by any licensee in such a manner that the total dose to an individual (including exposures to licensed and unlicensed radioactive material and to other unlicensed sources of radiation, whether in the possession of the licensee or any other person, but not including exposures to radiation from natural background sources or medical diagnosis and therapy) does not exceed the standards of radiation protection prescribed in the regulations in this part.

(c) In accordance with recommendations of the Federal Radiation Council, approved by the President, persons engaged in activities under licenses issued by the Nuclear Regulatory Commission pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974 should, in addition to complying with

the requirements set forth in this part, make every reasonable effort to maintain radiation exposures, and releases of radioactive materials in effluents to unrestricted areas, as low as is reasonably achievable. The term "as low as is reasonably achievable" means as low as is reasonably achievable taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest.

§ 20.2 Scope.

The regulations in this part apply to all persons who receive, possess, use, or transfer material licensed pursuant to the regulations in Parts 30 through 35, 39, 40, 60, 61, 70, or 72 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter.

§ 20.3 Definitions.

(a) As used in this part:

(1) "Act" means the Atomic Energy Act of 1954 (68 Stat. 919) including any amendments thereto;

(2) "Airborne radioactive material" means any radioactive material dispersed in the air in the form of dusts, fumes, mists, vapors, or gases;

(3) "Byproduct material" means any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material;

(4) "Calendar quarter" means not less than 12 consecutive weeks nor more than 14 consecutive weeks. The first calendar quarter of each year shall begin in January and subsequent calendar quarters shall be such that no day is included in more than one calendar quarter or omitted from inclusion within a calendar quarter. No licensee shall change the method observed by him of determining calendar quarters except at the beginning of a calendar year.

(5) "Commission" means the Nuclear Regulatory Commission or its duly authorized representatives;

(6) "Government agency" means any executive department, commission, independent establishment, corporation, wholly or partly owned by the United States of America which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government;

(7) "Individual" means any human being;

(8) "Licensed material" means source material, special nuclear material, or by-product material received, possessed, used, or transferred under a general or specific license issued by the Commission pursuant to the regulations in this chapter;

(9) "License" means a license issued under the regulations in Parts 30 through 35, 39, 40, 60, 61, 70, or Part 72 of this chapter. "Licensee" means the holder of such license;

(10) "Occupational dose" includes exposure of an individual to radiation (i) in a restricted area; or (ii) in the course of employment in which the individual's duties involve exposure to radiation, provided, that "occupational dose" shall not be deemed to include any exposure of an individual to radiation for the purpose of medical diagnosis or medical therapy of such individual.

(11) "Person" means: (i) Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission or the Department (except that the Department shall be considered a person within the meaning of the regulations in this part to the extent that its facilities and activities are subject to the licensing and related regulatory authority of the Commission pursuant to section 202 of the Energy Reorganization Act of 1974 (68 Stat. 1244)), any State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and (ii) any legal successor, representative, agent, or agency of the foregoing.

(12) "Radiation" means any or all of the following: alpha rays, beta rays, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other atomic particles; but not sound or radio waves, or visible, infrared, or ultraviolet light;

(13) "Radioactive material" includes any such material whether or not subject to licensing control by the Commission;

(14) "Restricted area" means any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include any areas used as residential quarters, although a separate room or rooms in a residential building may be set apart as a restricted area;

(15) "Source material" means: (i) Uranium or thorium, or any combination thereof, in any physical or chemical form; or (ii) ores which contain by weight one-twentieth of one percent

57 FR 57689

40 FR 58847

53 FR 31651

40 FR 8774

40 FR 8774

44 FR 32352

40 FR 4257

40 FR 5667

45 FR 10064

77 FR 5636

25 FR 10914

32 FR 6920

25 FR 10914

40 FR 8774

40 FR 10914

25 FR 10064

77 FR 5636

0.05%) or more of (a) uranium, (b) thorium or (c) any combination thereof. Source material does not include special nuclear material.

(16) "Special nuclear material" means: (i) Plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51 of the act, determines to be special nuclear material; or (ii) any material artificially enriched by any of the foregoing but does not include source material;

(17) "Unrestricted area" means any area access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters.

(18) "Department" means the Department of Energy established by the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565, 42 U.S.C. 7101 et seq.) to the extent that the Department, or its duly authorized representatives, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to sections 104 (b), (c) and (d) of the Energy Reorganization Act of 1974 (Pub. L. 93-438, 88 Stat. 1233 at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to section 301(a) of the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565 at 577-578, 42 U.S.C. 7151).

(19) "Termination" means the end of employment with the licensee or, in the case of individuals not employed by the licensee, the end of a work assignment in the licensee's restricted areas in a given calendar quarter, without expectation or specific scheduling of reentry into the licensee's restricted areas during the remainder of that calendar quarter.

(20) "Dosimetry processor" means an individual or an organization that processes and evaluates personnel monitoring equipment in order to determine the radiation dose delivered to the equipment.

(b) Definitions of certain other words and phrases as used in this part are set forth in other sections, including:

- (1) "Airborne radioactivity area" defined in § 20.203;
- (2) "Radiation area" and "high radiation area" defined in § 20.202;

- (3) "Personnel monitoring equipment" defined in § 20.202;
- (4) "Survey" defined in § 20.201;
- (5) Units of measurement of dose (rad, rem) defined in § 20.4;
- (6) Units of measurement of radioactivity defined in § 20.5.

§ 20.4 Units of radiation dose.

(a) "Dose," as used in this part, is the quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body. When the regulations in this part specify a dose during a period of time, the dose means the total quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body during such period of time. Several different units of dose are in current use. Definitions of units as used in this part are set forth in paragraphs (b) and (c) of this section.

(b) The rad, as used in this part, is a measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit mass of the tissue. One rad is the dose corresponding to the absorption of 100 ergs per gram of tissue. (One millirad (mrad)=0.001 rad.)

(c) The rem, as used in this part, is a measure of the dose of any ionizing radiation to body tissues in terms of its estimated biological effect relative to a dose of one roentgen (r) of X-rays. (One millirem (mrem)=0.001 rem.) The relation of the rem to other dose units depends upon the biological effect under consideration and upon the conditions of irradiation. For the purpose of the regulations in this part, any of the following is considered to be equivalent to a dose of one rem:

- (1) A dose of 1 r due to X- or gamma radiation;
- (2) A dose of 1 rad due to X-, gamma, or beta radiation;
- (3) A dose of 0.1 rad due to neutrons or high energy protons;
- (4) A dose of 0.05 rad due to particles heavier than protons and with sufficient energy to reach the lens of the eye; if it is more convenient to measure the neutron flux, or equivalent, than to determine the neutron dose in rads, as provided in paragraph (c)(3) of this section, one rem of neutron radiation may, for purposes of the regulations in this part, be assumed to be equivalent to 14 million neutrons per square centimeter incident upon the body; or, if there exists sufficient information to estimate with reasonable accuracy the approximate distribution in energy of the neutrons, the incident number of neutrons per square centimeter equivalent to one rem may be estimated from the following table:

NEUTRON FLUX DOSE EQUIVALENTS

Neutron energy (MeV)	Number of neutrons per square centimeter (dose of 1 rem) (neutrons/cm ²)	Average fluence to deliver 100 rad/hour in 40 hours (neutrons/cm ² sec.)
Thermal	970 x 10 ⁴	870
0.001	720 x 10 ⁴	860
0.005	820 x 10 ⁴	870
0.01	400 x 10 ⁴	880
0.1	130 x 10 ⁴	80
0.5	43 x 10 ⁴	80
1.0	26 x 10 ⁴	78
2.5	26 x 10 ⁴	80
5.0	26 x 10 ⁴	78
7.5	24 x 10 ⁴	77
10	24 x 10 ⁴	77
10 to 20	14 x 10 ⁴	90

(d) For determining exposures to X or gamma rays up to 3 Mev, the dose limits specified in §§ 20.101 to 20.104, inclusive, may be assumed to be equivalent to the "air dose". For the purpose of this part "air dose" means that the dose is measured by a properly calibrated appropriate instrument in air at or near the body surface in the region of highest dosage rate.

§ 20.5 Units of radioactivity.

(a) Radioactivity is commonly, and for purposes of the regulations in this part shall be, measured in terms of disintegrations per unit time or in curies. One curie=3.7x10¹⁰ disintegrations per second (dps)=2.2x10¹¹ disintegrations per minute (dpm). Commonly used submultiples of the curie are the millicurie and the microcurie:

- (1) One millicurie (mCi) =0.001 curie (Ci) =3.7x10⁷ dps.
- (2) One microcurie (µCi) =0.000001 curie=3.7x10⁴ dps.

- (b) (Deleted 40 FR 50704.)
- (c) (Deleted 39 FR 13990.)

§ 20.6 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

§ 20.7 Communications.

Except where otherwise specified in this part, all communications and reports concerning the regulations in this part should be addressed to the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, DC 20555. Communications, reports, and applications may be delivered in person at the Commission's offices at 2120 L Street NW., Washington, DC, or at 11555 Rockville Pike, Rockville, Maryland.

§ 20.6 Information collection requirements. NRC approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control number 1550-0014.

(b) The approved information collection requirements contained in this part appear in §§ 20.102, 20.103, 20.106, 20.108, 20.203, 20.205, 20.302, 20.311, 20.401, 20.402, 20.603, 20.605, 20.607, 20.608, and 20.609.

(c) This part contains information collection requirements in addition to those approved under the control number specified in paragraph (a) of this section. These information collection requirements and the control numbers under which they are approved are as follows:

- (1) In §§ 20.101 and 20.102, Form NRC-4 is approved under control number 1550-0005.
- (2) In § 20.401, Form NRC-5 is approved under control number 1550-0006.

PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

§ 20.101 Radiation dose standards for individuals in restricted areas.

(a) In accordance with the provisions of § 20.102(a), and except as provided in paragraph (b) of this section, no licensee shall possess, use, or transfer licensed material in such a manner as to cause any individual in a restricted area to receive in any period of one calendar quarter from radioactive material and other sources of radiation a total occupational dose in excess of the standards specified in the following table:

REMS PER CALENDAR QUARTER

1. Whole body, head and trunk, active blood-forming organs, lens of eye, or gonads.....	5R
2. Hands and forearms, feet and ankles.....	15R
3. Skin of whole body.....	7R

(b) A licensee may permit an individual in a restricted area to receive a total occupational dose to the whole body greater than that permitted under paragraph (a) of this section, provided:

(1) During any calendar quarter the total occupational dose to the whole body shall not exceed 3 rems; and

(2) The dose to the whole body, when added to the accumulated occupational dose to the whole body, shall

not exceed 5 (N-18) rems where "N" equals the individual's age in years at his last birthday; and

(3) The licensee has determined the individual's accumulated occupational dose to the whole body on Form NRC-4, or on a clear and legible record containing all the information required in that form; and has otherwise complied with the requirements of § 20.102. As used in paragraph (b), "Dose to the whole body" shall be deemed to include any dose to the whole body, gonads, active blood-forming organs, head and trunk, or lens of eye.

§ 20.102 Determination of prior dose.

(a) Each licensee shall require any individual, prior to first entry of the individual into the licensee's restricted area during each employment or work assignment under such circumstances that the individual will receive or is likely to receive in any period of one calendar quarter an occupational dose in excess of 25 percent of the applicable standards specified in § 20.101(a) and § 20.104(a), to disclose in a written, signed statement, either: (1) That the individual had no prior occupational dose during the current calendar quarter, or (2) the nature and amount of any occupational dose which the individual may have received during that specifically identified current calendar quarter from sources of radiation possessed or controlled by other persons. Each licensee shall maintain records of such statements until the Commission authorizes their disposition.

(b) Before permitting, pursuant to § 20.101(b), any individual in a restricted area to receive an occupational radiation dose in excess of the standards specified in § 20.101(a), each licensee shall:

(1) Obtain a certificate on Form NRC-4, or on a clear and legible record containing all the information required in that form, signed by the individual showing each period of time after the individual attained the age of 18 in which the individual received an occupational dose of radiation; and

(2) Calculate on Form NRC-4 in accordance with the instructions appearing therein, or on a clear and legible record containing all the information required in that form, the previously accumulated occupational dose received by the individual and the additional dose allowed for that individual under § 20.101(b).

(c)(1) In the preparation of Form NRC-4, or a clear and legible record containing all the information required in that form, the licensee shall make a reasonable effort to obtain reports of the individual's previously accumulated occupational dose. For each period for which the licensee obtains

such reports, the licensee shall use the dose shown in the report in preparing the form. In any case where a licensee is unable to obtain reports of the individual's occupational dose for a previous complete calendar quarter, it shall be assumed that the individual has received the occupational dose specified in whichever of the following columns apply:

Part of body	Column 1— Assumed exposure in terms for calendar quarters prior to Jan. 1, 1951	Column 2— Assumed exposure in terms for calendar quarters beginning on or after Jan. 1, 1951
Whole body, gonads, active blood-forming organs, head and trunk, lens of eye	2%	1%

(2) The licensee shall retain and preserve records used in preparing Form NRC-4 until the Commission authorizes their disposition.

If calculation of the individual's accumulated occupational dose for all periods prior to January 1, 1951 yields a result higher than the applicable accumulated dose value for the individual as of that date, as specified in paragraph (b) of § 20.101, the excess may be disregarded.

§ 20.103 Exposure of individuals to concentrations of radioactive materials in air in restricted areas.

(a)(1) No licensee shall possess, use, or transfer licensed material in such a manner as to permit any individual in a restricted area to inhale a quantity of radioactive material in any period of one calendar quarter greater than the quantity which would result from inhalation for 40 hours per week for 13 weeks at uniform concentrations of radioactive material in air specified in Appendix B, Table I, Column 1.

If the radioactive material is of such form that intake by absorption through the skin is likely, individual exposures to radioactive material shall be controlled so that the uptake of radioactive material by any organ from either inhalation or absorption or both routes of intake in any calendar quarter does not exceed that which would result from inhaling such radioactive material for 40 hours per week for 13 weeks at uniform concentrations specified in Appendix B, Table I, Column 1.

(2) No licensee shall possess, use, or transfer mixtures of U-234, U-235, and U-238 in soluble form in such a

manner as to permit any individual in a restricted area to inhale a quantity of such material in excess of the intake limits specified in Appendix B, Table I, Column 1 of this part. If such soluble uranium is of a form such that absorption through the skin is likely, individual exposures to such material shall be controlled so that the uptake of such material by any organ from

either inhalation or absorption or both routes of intake does not exceed that which would result from inhaling such material at the limits specified in Appendix B, Table I, Column 1 and footnote 4 thereto.

(3) For purposes of determining compliance with the requirements of this section the licensee shall use suitable measurements of concentrations of radioactive materials in air for detecting and evaluating airborne radioactivity in restricted areas and in addition, as appropriate, shall use measurements of radioactivity in the body, measurements of radioactivity excreted from the body, or any combination of such measurements as may be necessary for timely detection and assessment of individual intakes of radioactivity by exposed individuals. It is assumed that an individual inhales radioactive material at the airborne concentration in which he is present unless he uses respiratory protective equipment pursuant to paragraph (c) of this section. When assessment of a particular individual's intake of radioactive material is necessary, intakes less than those which would result from inhalation for 2 hours in any one day or for 10 hours in any one week at uniform concentrations specified in Appendix B, Table I, Column 1 need not be included in such assessment, provided that for any assessment in excess of these amounts the entire amount is included.

(b)(1) The licensee shall, as a precautionary procedure, use process or other engineering controls, to the extent practicable, to limit concentrations of radioactive materials in air to levels below those which delimit an airborne radioactivity area as defined in § 20.203(d)(1)(ii).

(2) When it is impracticable to apply process or other engineering controls to limit concentrations of radioactive material in air below those defined in § 20.203(d)(1)(ii), other precautionary procedures, such as increased surveillance, limitation of working times, or provision of respiratory protective equipment, shall be used to maintain intake of radioactive material by any individual within any period of seven consecutive days as far below that intake of radioactive material which

would result from inhalation of such material for 40 hours at the uniform concentrations specified in Appendix B, Table I, Column 1 as is reasonably achievable. Whenever the intake of radioactive material by any individual exceeds this 40-hour control measure, the licensee shall make such evaluations and take such actions as are necessary to assure against recurrence. The licensee shall maintain records of such occurrences, evaluations, and actions taken in a clear and readily identifiable form suitable for summary review and evaluation.

(c) When respiratory protective equipment is used to limit the inhalation of airborne radioactive material pursuant to paragraph (b)(2) of this section, the licensee shall use equipment that is certified or had certification extended by the National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA). The licensee may make allowance for this use of respiratory protective equipment in estimating exposures of individuals to this material provided that:

*Since the concentration specified for tritium oxide vapor assumes equal intakes by skin absorption and inhalation, the total intake permitted is twice that which would result from inhalation alone at the concentration specified for H 3 E in Appendix B, Table I, Column 1 for 40 hours per week for 13 weeks.

*For radon-222, the limiting quantity is that inhaled in a period of one calendar year. For radioactive materials designated "Sub" in the "Isotope" column of the table, the concentration value specified is based

upon exposure to the material as an external radiation source. Individual exposures to these materials may be accounted for as part of the limitation on individual dose in § 20.101. These nuclides shall be subject to the precautionary procedures required by § 20.103(b)(1).

*Multiply the concentration values specified in Appendix B, Table I, Column 1, by 6.3 x 10³ ml to obtain the quarterly quantity limit. Multiply the concentration value specified in Appendix B, Table I, Column 1, by 2.5 x 10³ ml to obtain the annual quantity limit for Rn-222.

*Significant intake by ingestion or injection is presumed to occur only as a result of circumstances such as accident, inadvertence, poor procedure, or similar special conditions. Such intakes must be evaluated and accounted for by techniques and procedures as may be appropriate to the circumstances of the occurrence. Exposures so evaluated shall be included in determining whether the limitation on individual exposures in § 20.103(a)(1) has been exceeded.

*Regulatory guidance on assessment of individual intakes of radioactive material is given in Regulatory Guide 8.8, "Acceptable Concepts, Models, Equations and Assumptions for a Bioassay Program," single copies of which are available from the Office of Nuclear Regulatory Research U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, upon written request.

(1) The licensee selects respiratory protective equipment that provides a protection factor greater than the multiple by which peak concentrations of airborne radioactive materials in the working area are expected to exceed the values specified in Appendix B, Table I, Column 1 of this part. The equipment so selected shall be used so that the average concentration of radioactive material in the air that is inhaled during any period of uninterrupted use in an airborne radioactivity area, on any day, by any individual using the equipment, does not exceed the values specified in Appendix B, Table I, Column 1 of this part. For the purposes of this paragraph, the concentration of radioactive material in the air that is inhaled when respirators are worn may be estimated by dividing the ambient concentration in air by the protection factor specified in Appendix A of this part. If the exposure is later found to be greater than estimated, the corrected value shall be used; if the exposure is later found to be less than estimated, the corrected value may be used.

(2) The licensee maintains and implements a respiratory protection program that includes, as a minimum: air sampling sufficient to identify the hazard, permit proper equipment selection and estimate exposures; surveys and bioassays as appropriate to evaluate actual exposures; written procedures regarding selection, fitting, and maintenance of respirators, and testing of respirators for operability immediately prior to each use; written procedures regarding supervision and training of personnel and issuance records; and determination by a physician prior to initial use of respirators, and at least every 12 months thereafter, that the individual user is physically able to use the respiratory protective equipment.

(3) A written policy statement on respirator usage shall be issued covering such things as: use of practicable engineering controls instead of respirators; routine, nonroutine, and emergency use of respirators; and periods of respirator use and relief from respirator use. The licensee shall advise each respirator user that the user may leave the area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other condition that might require such relief.

(4) The licensee uses equipment within limitations for type and mode of use and provides proper visual, communication, and other special capabilities (such as adequate skin protection) when needed.

(d) Unless otherwise authorized by the Commission, the licensee shall not assign protection factors in excess of

those specified in Appendix A of this part in selecting and using respiratory protective equipment. The Commission may authorize a licensee to use higher protection factors on receipt of an application (1) describing the situation for which a need exists for higher protection factors, and (2) demonstrating that the respiratory protective equipment will provide these higher protection factors under the proposed conditions of use.

(e) Where equipment of a particular type has not been tested and certified, or had certification extended, by NIOSH/MSHA, or where there is no existing schedule for test and certification of certain equipment, the licensee shall not make allowance for this equipment without specific authorization by the Commission. An application for this authorization must include a demonstration by testing, or on the basis of reliable test information, that the material and performance characteristics of the equipment are capable of providing the proposed degree of protection under anticipated conditions of use.

(f) Only equipment that has been specifically certified or had certification extended for emergency use by NIOSH/MSHA shall be used as emergency devices.

(g) The licensee shall notify, in writing, the Regional Administrator

of the appropriate Nuclear Regulatory Commission Regional Office listed in Appendix D at least 30 days before the date that respiratory protective equipment is first used under the provisions of this section.

§ 20.104 Exposure of minors.

(a) No licensee shall possess, use, or transfer licensed material in such a manner as to cause any individual within a restricted area who is under 18 years of age, to receive in any period of one calendar quarter from radioactive material and other sources of radiation in the licensee's possession a dose in excess of 10 percent of the limits specified in the table in paragraph (a) of § 20.101.

(b) No licensee shall possess, use or transfer licensed material in such a manner as to cause any individual within a restricted area, who is under 18 years of age to be exposed to airborne radioactive material possessed by the licensee in an average concentration in excess of the limits specified in Appendix B, Table II of this part. For purposes of this paragraph, concentrations may be averaged over periods not greater than a week.

(c) The provisions of §§ 20.103(b)(2) and 20.103(c) shall apply to exposures subject to paragraph (b) of this section except that the references in §§ 20.103(b)(2) and 20.103(c) to Appendix B, Table I, Column 1 shall be deemed to be references to Appendix B, Table II, Column 1.

§ 20.105 Permissible levels of radiation in unrestricted areas.

(a) There may be included in any application for a license or for amendment of a license proposed limits upon levels of radiation in unrestricted areas resulting from the applicant's possession or use of radioactive material and other sources of radiation. Such applications should include information as to anticipated average radiation levels and anticipated occupancy times for each unrestricted area involved. The Commission will approve the proposed limits if the applicant demonstrates that the proposed limits are not likely to cause any individual to receive a dose to the whole body in any period of one calendar year in excess of 0.5 rem.

(b) Except as authorized by the Commission pursuant to paragraph (a) of this section, no licensee shall possess, use or transfer licensed material in such a manner as to create in any unrestricted area from radioactive material and other sources of radiation in his possession:

(1) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of two millirems in any one hour, or

(2) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of 100 millirems in any seven consecutive days.

(c) In addition to other requirements of this part, licensees engaged in uranium fuel cycle operations subject to the provisions of 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," shall comply with that part.

§ 20.106 Radioactivity in effluents to unrestricted areas.

(a) A licensee shall not possess, use, or transfer licensed material so as to release to an unrestricted area radioactive material in concentrations which exceed the limits specified in Appendix B, Table II of this part, except as authorized pursuant to § 20.302 or paragraph (b) of this section. For purposes of this section concentrations may be averaged over a period not greater than one year.

(b) An application for a license or amendment may include proposed limits higher than those specified in paragraph (a) of this section. The Commission will approve the proposed limits if the applicant demonstrates:

(1) That the applicant has made a reasonable effort to minimize the radioactivity contained in effluents to unrestricted areas; and

(2) That it is not likely that radioactive material discharged in the effluent would result in the exposure of an individual to concentrations of radioactive material in air or water exceeding the limits specified in Appendix B, Table II of this part.

(c) An application for higher limits pursuant to paragraph (b) of this section shall include information demonstrating that the applicant has made a reasonable effort to minimize the radioactivity discharged in effluents to unrestricted areas, and shall include, as pertinent:

(1) Information as to flow rates, total volume of effluent, peak concentration of each radionuclide in the effluent, and concentration of each radionuclide in the effluent averaged over a period of one year at the point where the effluent leaves a stack, tube, pipe, or similar conduit;

(2) A description of the properties of the effluents, including:

(i) Chemical composition;

(ii) Physical characteristics, including suspended solids content in liquid effluents, and nature of gas or aerosol for air effluents;

(iii) The hydrogen ion concentrations (pH) of liquid effluents; and

(iv) The size range of particulates in effluents released into air.

(3) A description of the anticipated human occupancy in the unrestricted area where the highest concentration of radioactive material from the effluent is expected, and, in the case of a river or stream, a description of water uses downstream from the point of release of the effluent.

(4) Information as to the highest concentration of each radionuclide in an unrestricted area, including anticipated concentrations averaged over a period of one year:

(i) In air at any point of human occupancy; or

(ii) In water at points of use downstream from the point of release of the effluent.

(5) The background concentration of radionuclides in the receiving river or stream prior to the release of liquid effluent.

(6) A description of the environmental monitoring equipment, including sensitivity of the system, and procedures and calculations to determine concentrations of radionuclides in the unrestricted area and possible recon-

centrations of radionuclides.

(7) A description of the waste treatment facilities and procedures used to reduce the concentration of radionuclides in effluents prior to their release.

(d) For the purposes of this section the concentration limits in Appendix B, Table II of this part shall apply at the boundary of the restricted area. The concentration of radioactive material discharged through a stack, pipe or similar conduit may be determined with respect to the point where the material leaves the conduit. If the conduit discharges within the restricted area, the concentration at the boundary may be determined by applying appropriate factors for dilution, dispersion, or decay between the point of discharge and the boundary.

(e) In addition to limiting concentrations in effluent streams, the Commission may limit quantities of radioactive materials released in air or water during a specified period of time if it appears that the daily intake of radioactive material from air, water, or food by a suitable sample of an exposed population group, averaged over a period not exceeding one year, would otherwise exceed the daily intake resulting from continuous exposure to air or water containing one-third the concentration of radioactive materials specified in Appendix B, Table II of this part.

(f) The provisions of paragraphs (a) through (e) of this section do not apply to disposal of radioactive material into sanitary sewerage systems, which is governed by § 20.303.

(g) In addition to other requirements of this part, licensees engaged in uranium fuel cycle operations subject to the provisions of 40 CFR Part 190, "Environmental Radiation Protection Standard for Nuclear Power Operations," shall comply with that part.

§ 20.107 Medical diagnosis and therapy.

Nothing in the regulations in this part shall be interpreted as limiting the intentional exposure of patients to radiation for the purpose of medical diagnosis or medical therapy.

§ 20.108 Orders requiring furnishing of bio-assay services.

Where necessary or desirable in order to aid in determining the extent of an individual's exposure to concentrations of radioactive material, the Commission may incorporate appropriate provisions in any license, directing the licensee to make available to the individual appropriate bio-assay services and to furnish a copy of the reports of such services to the Commission.

PRECAUTIONARY PROCEDURES

§ 20.201 Surveys.

(a) As used in the regulations in this part, "survey" means an evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of radiation under a specific set of conditions. When appropriate, such evaluation includes a physical survey of the location of materials and equipment, and measurements of levels of radiation or concentrations of radioactive material present.

(b) Each licensee shall make or cause to be made such surveys as (1) may be necessary for the licensee to comply with the regulations in this part, and (2) are reasonable under the circumstances to evaluate the extent of radiation hazards that may be present.

§ 20.202 Personnel monitoring.

(a) Each licensee shall supply appropriate personnel monitoring equipment to, and shall require the use of such equipment by:

(1) Each individual who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 25 percent of the applicable value specified in paragraph (a) of § 20.101.

(2) Each individual under 18 years of age who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 5 percent of the applicable value specified in paragraph (a) of § 20.101.

(3) Each individual who enters a high radiation area.

(b) As used in this part,

(1) "Personnel monitoring equipment" means devices designed to be worn or carried by an individual for the purpose of measuring the dose received (e.g., film badges, pocket chambers, pocket dosimeters, film rings, etc.);

(2) "Radiation area" means any area, accessible to personnel, in which there exists radiation, originating in whole or in part within licensed material, at such levels that a major portion of the body could receive in any one hour a dose in excess of 5 millirem, or in any 5 consecutive days a dose in excess of 100 millirems;

(3) "High radiation area" means any area, accessible to personnel, in which there exists radiation originating in whole or in part within licensed material at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 millirem.

(c) All personnel dosimeters (except for direct and indirect reading pocket ionization chambers and those dosimeters used to measure the dose to hands and forearms, feet and ankles) that require processing to determine the radiation dose and that are utilized by licensees to comply with paragraph (a) of this section, with other applicable provisions of 10 CFR Chapter I, or with conditions specified in a licensee's license must be processed and evaluated by a dosimetry processor.

(1) Holding current personnel dosimetry accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Bureau of Standards, and

(2) Approved in this accreditation process for the type of radiation or radiations included in the NVLAP program that most closely approximate the type of radiation or radiations for which the individual wearing the dosimeter is monitored.

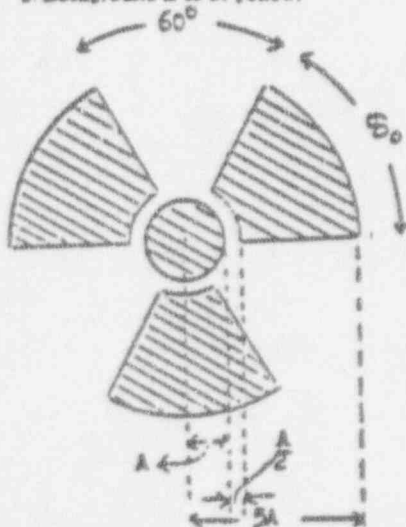
Note: (c) effective 2/12/78.

§ 20.203 Caution signs, labels, signals and controls.

(a) General (1) Except as otherwise authorized by the Commission, symbols prescribed by this section shall use the conventional radiation caution colors (magenta or purple on yellow background). The symbol prescribed by this section is the conventional three-bladed design:

RADIATION SYMBOL

1. Cross-hatched area is to be magenta or purple.
2. Background is to be yellow.



(2) In addition to the contents of signs and labels prescribed in this section, licensees may provide on or near such signs and labels any additional information which may be appropriate in aiding individuals to minimize exposure to radiation or to radioactive material.

(b) Radiation areas. Each radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION
RADIATION AREA

(c) High radiation areas. (1) Each high radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION
HIGH RADIATION AREA

(2) Each entrance or access point to a high radiation area shall be:

(i) Equipped with a control device which shall cause the level of radiation to be reduced below that at which an individual might receive a dose of 100 millirems in 1 hour upon entry into the area; or

(ii) Equipped with a control device which shall energize a conspicuous visible or audible alarm signal in such a manner that the individual entering the high radiation area and the licensee or a supervisor of the activity are made aware of the entry; or

(iii) Maintained locked except during periods when access to the area is required, with positive control over each individual entry.

(3) The controls required by paragraph (c)(2) of this section shall be established in such a way that no individual will be prevented from leaving a high radiation area.

(4) In the case of a high radiation area established for a period of 30 days or less, direct surveillance to prevent unauthorized entry may be substituted for the controls required by paragraph (c)(2) of this section.

(5) Any licensee, or applicant for a license, may apply to the Commission for approval of methods not included in paragraphs (c)(2) and (4) of this section for controlling access to high radiation areas. The Commission will approve the proposed alternatives if the licensee or applicant demonstrates that the alternative methods of control will prevent unauthorized entry into a high radiation area, and that the requirement of paragraph (c)(3) of this section is met.

(6) Each area in which there may exist radiation levels in excess of 500 rems in one hour at one meter from a sealed radioactive source¹ that is used to irradiate materials shall:

¹ Or "Danger".

² This paragraph (c)(6) does not apply to radioactive sources that are used in teletherapy, in 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, is always physically inaccessible to any individual and cannot create high levels of radiation in an area that is accessible to any individual. This paragraph (c)(6) also does not apply to sources from which the radiation is incidental to some other use nor to nuclear reactor generated radiation other than radiation from byproduct, source, or special nuclear materials that are used in sealed

(i) Have each entrance or access point equipped with entry control devices which shall function automatically to prevent any individual from inadvertently entering the area when such radiation levels exist; permit deliberate entry into the area only after a control device is actuated that shall cause the radiation level within the area, from the sealed source, to be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and prevent operation of the source if the source would produce radiation levels in the area that could result in a dose to an individual in excess of 100 mrem in one hour. The entry control devices required by this paragraph (c)(6) shall be established in such a way that no individual will be prevented from leaving the area.

(ii) Be equipped with additional control devices such that upon failure of the entry control devices to function as required by paragraph (c)(6)(i) of this section the radiation level within the area, from the sealed source, shall be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and visible and audible alarm signals shall be generated to make an individual attempting to enter the area aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of such failure of the entry control devices.

(iii) Be equipped with control devices such that upon failure or removal of physical radiation barriers other than the source's shielded storage container the radiation level from the source shall be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and visible and audible alarm signals shall be generated to make potentially affected individuals aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of the failure or removal of the physical barrier. When the shield for the stored source is a liquid, means shall be provided to monitor the integrity of the shield and to signal, automatically, loss of adequate shielding. Physical radiation barriers that com-

sources in non-self-shielded irradiators.

³ These requirements apply after Mar. 14, 1978. Each person licensed to conduct activities to which this paragraph (c)(6) applies and who is not in compliance with the provisions of this paragraph on Mar. 14, 1978, shall file with the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, on or before June 14, 1978, information describing in detail the actions taken or to be taken to achieve compliance with this paragraph by Dec. 14, 1978, and may continue activities in conformance with present license conditions and the provisions of the previously effective § 20.2034 until such compliance is achieved. For such persons compliance must be achieved not later than Dec. 14, 1978.

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permanent structural components such as walls, that have no credible probability of failure or removal in ordinary circumstances need not meet the requirements of this paragraph (c)(5)(III).

(iv) Be equipped with devices that will automatically generate visible and audible alarm signals to alert personnel in the area before the source can be put into operation and in sufficient time for any individual in the area to operate a clearly identified control device which shall be installed in the area and which can prevent the source from being put into operation.

(v) Be controlled by use of such administrative procedure and such devices as are necessary to assure that the area is cleared of personnel prior to each use of the source preceding which use it might have been possible for an individual to have entered the area.

(vi) Be checked by a physical radiation measurement to assure that prior to the first individual's entry into the area after any use of the source, the radiation level from the source in the area is below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour.

(vii) Have entry control devices required in paragraph (c)(6)(i) of this section which have been tested for proper functioning prior to initial operation with such source of radiation on any day that operations are not uninterruptedly continued from the previous day or before resuming operations after any unintended interruption, and for which records are kept of the dates, times, and results of such tests of function. No operations other than those necessary to place the source in safe condition or to effect repairs on controls shall be conducted with such source unless control devices are functioning properly. The licensee shall submit an acceptable schedule for more complete periodic tests of the entry control and warning systems to be established and adhered to as a condition of the license.

(viii) Have those entry and exit portals that are used in transporting materials to and from the irradiation area, and that are not intended for use by individuals, controlled by such devices and administrative procedures as are necessary to physically protect and warn against inadvertent entry by any individual through such portals. Exit portals for processed materials shall be equipped to detect and signal the presence of loose radiation sources that are carried toward such an exit and to automatically prevent such loose sources from being carried out of the area.

(7) Licensees with, or applicants for, licenses for radiation sources that are within the purview of paragraph (c)(6) of this section, and that must be used in a variety of positions or in peculiar locations, such as open fields or forests, that make it impracticable to comply with certain requirements of paragraph (c)(6) of this section, such as those for the automatic control of radiation levels, may apply to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, for approval, prior to use of safety measures that are alternative to those specified in paragraph (c)(6) of this section, and that will provide at least an equivalent degree of personnel protection in the use of such sources. At least one of the alternative measures must include an entry-preventing interlock control based on a physical measurement of radiation that assures the absence of high radiation levels before an individual can gain access to an area where such sources are used.

(d) Airborne radioactivity areas. (1) As used in the regulations in this part "airborne radioactivity area" means (i) any room, enclosure, or operating area in which airborne radioactive materials composed wholly or partly of licensed material, exist in concentrations in excess of the amounts specified in Appendix B, Table 1, Column 1 of this part; or (ii) any room, enclosure, or operating area in which airborne radioactive material composed wholly or partly of licensed material exists in concentrations which, averaged over the number of hours in any week during which individuals are in the area, exceed 25 percent of the amounts specified in Appendix B, Table 1, Column 1 of this part.

(2) Each airborne radioactivity area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION

AIRBORNE RADIOACTIVITY AREA

(e) Additional requirements. (1) Each area or room in which licensed material is used or stored and which contains any radioactive material (other than natural uranium or thorium) in an amount exceeding 10 times the quantity of such material specified in Appendix C of this part shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

"Or "Danger".

As appropriate, the information will include radiation levels, kinds of material, estimate of activity, date for which activity is estimated, mass enrichment, etc.

CAUTION

RADIOACTIVE MATERIAL(S)

(2) Each area or room in which natural uranium or thorium is used or stored in any amount exceeding one hundred times the quantity specified in Appendix C of this part shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION

RADIOACTIVE MATERIAL(S)

(f) Containers. (1) Except as provided in paragraph (f)(3) of this section, each container of licensed material shall bear a durable, clearly visible label identifying the radioactive contents.

(2) A label required pursuant to paragraph (f)(1) of this section shall bear the radiation caution symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL". It shall also provide sufficient information to permit individuals handling or using the containers, or working in the vicinity thereof, to take precautions to avoid or minimize exposures.

(3) Notwithstanding the provisions of paragraph (f)(1) of this section labeling is not required:

(i) For containers that do not contain licensed materials in quantities greater than the applicable quantities listed in Appendix C of this part.

(ii) For containers containing only natural uranium or thorium in quantities no greater than 10 times the applicable quantities listed in Appendix C of this part.

(iii) For containers that do not contain licensed materials in concentrations greater than the applicable concentrations listed in Appendix B, Table 1, Column 2, of this part.

(iv) For containers when they are attended by an individual who takes the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established by the regulations in this part.

(v) For containers when they are in transport and packaged and labeled in accordance with regulations of the Department of Transportation.

(vi) For containers which are accessible only to individuals authorized to handle or use them, or to work in the vicinity thereof, provided that the contents are identified to such individuals by a readily available written record.

(vii) For manufacturing or process equipment, such as nuclear reactors, reactor components, piping, and tanks.

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(4) Each licensee shall, prior to disposal of an empty uncontaminated container to unrestricted areas, remove or deface the radioactive material label or otherwise clearly indicate that the container no longer contains radioactive materials.

§ 20.204 Same exceptions. Notwithstanding the provisions of § 20.203.

(a) A room or area is not required to be posted with a caution sign because of the presence of a sealed source provided the radiation level twelve inches from the surface of the source container or housing does not exceed five millirem per hour.

(b) Rooms or other areas in hospitals are not required to be posted with caution signs, and control of entrance or access thereto pursuant to § 20.203(c) is not required, because of the presence of patients containing by-product material provided that there are personnel in attendance who will take the precautions necessary to prevent the exposure of any individual to radiation or radioactive material in excess of the limits established in the regulations in this part.

(c) Caution signs are not required to be posted at areas or rooms containing radioactive materials for periods of less than eight hours provided that (1) the materials are constantly attended during such periods by an individual who shall take the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established in the regulations in this part and; (2) such area or room is subject to the licensee's control.

(d) A room or other area is not required to be posted with a caution sign, and control is not required for each entrance or access point to a room or other area which is a high radiation area solely because of the presence of radioactive materials prepared for transport and packaged and labeled in accordance with regulations of the Department of Transportation.

§ 20.205 Procedures for picking up, receiving, and opening packages.

(a)(1) Each licensee who expects to receive a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section shall:

(i) If the package is to be delivered to the licensee's facility by the carrier, make arrangements to receive the package when it is offered for delivery by the carrier; or

(ii) If the package is to be picked up by the licensee at the carrier's terminal, make arrangements to receive notification from the carrier of the arrival of the package, at the time of arrival.

(2) Each licensee who picks up a package of radioactive material from a carrier's terminal shall pick up the package expeditiously upon receipt of notification from the carrier of its arrival.

(b)(1) Each licensee, upon receipt of a package of radioactive material, shall monitor the external surfaces of the package for radioactive contamination caused by leakage of the radioactive contents, except:

(i) Packages containing no more than the exempt quantity specified in the table in this paragraph;

(ii) Packages containing no more than 10 millicuries of radioactive material consisting solely of tritium, carbon-14, sulfur-35, or iodine-125;

(iii) Packages containing only radioactive material as gases or in special form;

(iv) Packages containing only radioactive material in other than liquid form (including Mo-99/Tc-99m generators) and not exceeding the Type A quantity limit specified in the table in this paragraph; and

(v) Packages containing only radionuclides with half-lives of less than 30 days and a total quantity of no more than 100 millicuries.

The monitoring shall be performed as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or eighteen hours if received after normal working hours.

(2) If removable radioactive contamination in excess of 0.01 microcuries (22,000 disintegrations per minute) per 100 square centimeters of package surface is found on the external surfaces of the package, the licensee shall immediately notify the final delivering carrier and, by telephone and telegraph, mailgram or facsimile, the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office shown in Appendix D of this part.

TABLE OF EXEMPT AND TYPE A QUANTITIES

Transport group ¹	Exempt quantity limit (in millicuries)	Type A quantity limit (in millicuries)
L	0.1	0.801
A	0.1	0.800
M	1	8
T/	1	80
V	1	80
VI	1	1000
VI	25,000	1000
Special Form	1	80

¹The definition of "transport group" and "special form" are specified in § 171.4 of this chapter.

[Footnote 1 removed 49 FR 19623]

(c)(1) Each licensee, upon receipt of a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section, other than those transported by exclusive use vehicle, shall monitor the radiation levels external to the package. The package shall be monitored as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or 18 hours if received after normal working hours.

(2) If radiation levels are found on the external surface of the package in excess of 200 millirem per hour, or at three feet from the external surface of the package in excess of 10 millirem per hour,

the licensee shall immediately notify by telephone and telegraph mailgram, or facsimile, the director of the appropriate NRC Regional Office listed in Appendix D, and the final delivering carrier.

(d) Each licensee shall establish and maintain procedures for safely opening packages in which licensed material is received, and shall assure that such procedures are followed and that due consideration is given to special instructions for the type of package being opened.

§ 20.206 Instruction of personnel.

Instructions required for individuals working in or frequenting any portion of a restricted area are specified in § 19.12 of this chapter.

§ 20.207 Storage and control of licensed materials in unrestricted areas.

(a) Licensed materials stored in an unrestricted area shall be secured from unauthorized removal from the place of storage.

(b) Licensed materials in an unrestricted area and not in storage shall b

¹For example, containers in locations such as water-filled canals, storage vaults, or hot cells.

tended under the constant surveillance and immediate control of the licensee.

WASTE DISPOSAL

§ 20.301 General requirement.

No licensee shall dispose of licensed material except:

(a) By transfer to an authorized recipient as provided in the regulations in Parts 30, 40, 60, 61, 70 or 72 of this chapter, whichever may be applicable; or

(b) As authorized under § 20.302 or Part 61 of this chapter; or

(c) As provided in § 20.303, applicable to the disposal of licensed material by release into sanitary sewerage systems, or in § 20.306 for disposal of specific wastes, or in § 20.106 (Radioactivity in effluents to unrestricted areas).

§ 20.302 Method for obtaining approval of proposed disposal procedures.

(a) Any licensee or applicant for a license may apply to the Commission for approval of proposed procedures to dispose of licensed material in a manner not otherwise authorized in the regulations in this chapter. Each application should include a description of the licensed material and any other radioactive material involved, including the quantities and kinds of such material and the levels of radioactivity involved, and the proposed manner and conditions of disposal. The application should also include an analysis and evaluation of pertinent information as to the nature of the environment, including topographical, geological, meteorological, and hydrological characteristics; usage of ground and surface waters in the general area; the nature and location of other potentially affected facilities; and procedures to be observed to minimize the risk of unexpected or hazardous exposures.

(b) The Commission will not approve any application for a license for disposal of licensed material at sea unless the applicant shows that sea disposal offers less harm to man or the environment than other practical alternative methods of disposal.

§ 20.303 Disposal by release into sanitary sewerage systems.

No licensee shall discharge licensed material into a sanitary sewerage system unless:

(a) It is readily soluble or dispersible in water; and

(b) The quantity of any licensed or other radioactive material released into the system by the licensee in any one day does not exceed the larger of paragraphs (b)(1) or (2) of this section.

(1) The quantity which, if diluted by the average daily quantity of sewage released into the sewer by the licensee, will result in an average concentration equal to the limits specified in Appendix B, Table 1, Column 2 of this part; or

(2) Ten times the quantity of such material specified in Appendix C of this part; and

(c) The quantity of any licensed or other radioactive material released in any one month, if diluted by the average monthly quantity of water released by the licensee, will not result in an average concentration exceeding the limits specified in Appendix B, Table 1, Column 2 of this part; and

(d) The gross quantity of licensed and other radioactive material, excluding hydrogen-3 and carbon-14, released into the sewerage system by the licensee does not exceed one curie per year. The quantities of hydrogen-3 and carbon-14 released into the sanitary sewerage system may not exceed 5 curies per year for hydrogen-3 and 1 curie per year for carbon-14. Excreta from individuals undergoing medical diagnosis or therapy with radioactive material shall be exempt from any limitations contained in this section.

§ 20.305 Treatment or disposal by incineration.

(a) A licensee may treat or dispose of licensed material by incineration only:

(1) As authorized by paragraph (b) of this section; or

(2) If the material is in a form and concentration specified in § 20.306; or

(3) As specifically approved by the Commission pursuant to § 20.106(b) or § 20.302.

(b) (1) Waste oils (petroleum derived or synthetic oils used principally as lubricants, coolants, hydraulic or insulating fluids, or metalworking oils) that have been radioactively contaminated in the course of the operation or maintenance of a nuclear power reactor licensed under part 50 of this chapter may be incinerated on the site where generated provided that the total radioactive effluents from the facility, including the effluents from such incineration, conform to the requirements of Appendix I to part 50 of this chapter and the effluent release limits contained in applicable license conditions other than effluent limits specifically related to incineration of waste oil. The licensee shall report any changes or additions to the information supplied under §§ 50.34 and 50.34a of this chapter associated with this incineration pursuant to § 50.71 of this chapter, as appropriate.

The licensee shall also follow the procedures of § 50.59 of this chapter with respect to such changes to the facility or procedures.

(2) Solid residues produced in the process of incinerating waste oils must be disposed of as provided by § 20.301.

(3) The provisions of this section authorize onsite waste incineration under the terms of this section and supersede any provision in an individual plant license or technical specification that may be inconsistent.

(c) Nothing in paragraph (b) of this section relieves the licensee from complying with other applicable Federal, State, and local regulations governing any other toxic or hazardous property of these materials.

§ 20.306 Disposal of specific wastes.

Any licensee may dispose of the following licensed material without regard to its radioactivity:

(a) 0.05 microcuries or less of hydrogen-3 or carbon-14, per gram of medium, used for liquid scintillation counting; and

(b) 0.05 microcuries or less of hydrogen-3 or carbon-14, per gram of animal tissue averaged over the weight of the entire animal; provided however, tissue may not be disposed of under this section in a manner that would permit its use either as food for humans or as animal feed.

(c) Nothing in this section, however, relieves the licensee of maintaining records showing the receipt, transfer and disposal of such byproduct material as specified in § 30.51 of this chapter; and

(d) Nothing in this section relieves the licensee from complying with other applicable Federal, State and local regulations governing any other toxic or hazardous property of these materials.

§ 20.311 Transfer for disposal and manifests.

(a) Purpose. The requirements of this section are designed to control transfers of radioactive waste intended for disposal at a land disposal facility and establish a manifest tracking system and supplement existing requirements concerning transfers and recordkeeping for such wastes. The reporting and recordkeeping requirements contained in this section have been approved by the Office of Management and Budget; OMB approval No. 3150-0014.

(b) Each shipment of radioactive waste to a licensed land disposal facility must be accompanied by a shipment manifest that contains the name, address, and telephone number of the person generating the waste. The manifest shall also include the name, address, and telephone number or the name and EPA hazardous waste identification number of the person transporting the waste to the land disposal facility. The manifest must also indicate as completely as practicable: a physical description of the waste; the volume; radionuclide identity and quantity; the total radioactivity; and the principal chemical form. The solidification agent must be specified. Waste containing more than 0.1% chelating agents by weight must be identified and the weight percentage of the chelating agent estimated. Wastes classified as Class A, Class B, or Class C in § 61.55 of this chapter must be clearly identified as such in the manifest. The total quantity of the radionuclides H-3, C-14, Tc-99 and I-129 must be shown. The manifest required by this paragraph may be shipping papers used to meet Department of Transportation or

Environmental Protection Agency regulations or requirements of the receiver, provided all the required information is included. Copies of manifests required by this section may be legible carbon copies or legible photocopies.

(c) Each manifest must include a certification by the waste generator that the transported materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and the Commission. An authorized representative of the waste generator shall sign and date the manifest.

(d) Any generating licensee who transfers radioactive waste to a land disposal facility or a licensed waste collector shall comply with the requirements in paragraphs (d)(1) through (8) of this section. Any generating licensee who transfers waste to a licensed waste processor who treats or repackages waste shall comply with the requirements of paragraphs (d)(4) through (8) of this section. A licensee shall:

(1) Prepare all wastes so that the waste is classified according to § 61.55 and meets the waste characteristics requirements in § 61.56 of this chapter;

(2) Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with § 61.55 of this chapter;

(3) Conduct a quality control program to assure compliance with §§ 61.55 and 61.56 of this chapter; the program must include management evaluation of audits;

(4) Prepare shipping manifests to meet the requirements of §§ 20.311 (b) and (c) of this part;

(5) Forward a copy of the manifest to the intended recipient, at the time of shipment; or, deliver to a collector at the time the waste is collected, obtaining acknowledgement of receipt in the form of a signed copy of the manifest or equivalent documentation from the collector;

(6) Include one copy of the manifest with the shipment;

(7) Retain a copy of the manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by Parts 30, 40, and 70 of this chapter; and,

(8) For any shipments or any part of a shipment for which acknowledgement of receipt has not been received within the times set forth in this section, conduct an investigation in accordance with paragraph (b) of this section.

(e) Any waste collector licensee who handles only prepackaged waste shall:

(1) Acknowledge receipt of the waste from the generator within one week of receipt by returning a signed copy of the manifest or equivalent documentation;

(2) Prepare a new manifest to reflect consolidated shipments; the new manifest shall serve as a listing or index for the detailed generator manifests. Copies of the generator manifests shall be a part of the new manifest. The waste collector may prepare a new manifest without attaching the generator manifests, provided the new manifest contains for each package the information specified in paragraph (b) of this section. The collector licensee shall certify that nothing has been done to the waste which would invalidate the generator's certification;

(3) Forward a copy of the new manifest to the land disposal facility operator at the time of shipment;

(4) Include the new manifest with the shipment to the disposal site;

(5) Retain a copy of the manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by Parts 30, 40, and 70 of this chapter, and retain information from generator manifests until disposition is authorized by the Commission; and

(6) For any shipments or any part of a shipment for which acknowledgement of receipt is not received within the times set forth in this section, conduct an investigation in accordance with paragraph (h) of this section.

(f) Any licensed waste processor who treats or repackages wastes shall:

(1) Acknowledge receipt of the waste from the generator within one week of receipt by returning a signed copy of the manifest or equivalent documentation;

(2) Prepare a new manifest that meets the requirements of paragraphs (b) and (c) of this section. Preparation of the new manifest reflects that the processor is responsible for the waste;

(3) Prepare all wastes so that the waste is classified according to § 61.55 and meets the waste characteristics requirements in § 61.56 of this chapter;

(4) Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with §§ 61.55 and 61.57 of this chapter;

(5) Conduct a quality control program to assure compliance with §§ 61.55 and 61.56 of this chapter. The program shall include management evaluation of audits;

(6) Forward a copy of the new manifest to the disposal site operator or waste collector at the time of shipment, or deliver to a collector at the time the waste is collected, obtaining acknowledgement of receipt in the form of a signed copy of the manifest or

equivalent documentation by the collector;

(7) Include the new manifest with the shipment;

(8) Retain copies of original manifests and new manifests and documentation of acknowledgement of receipt as the record of transfer of licensed material required by Parts 30, 40, and 70 of this chapter; and

(9) For any shipment or part of a shipment for which acknowledgement is not received within the times set forth in this section, conduct an investigation in accordance with paragraph (h) of this section.

(g) The land disposal facility operator shall:

(1) Acknowledge receipt of the waste within one week of receipt by returning a signed copy of the manifest or equivalent documentation to the shipper. The shipper to be notified is the licensee who last possessed the waste and transferred the waste to the operator. The returned copy of the manifest or equivalent documentation shall indicate any discrepancies between materials listed on the manifest and materials received;

(2) Maintain copies of all completed manifests or equivalent documentation until the Commission authorizes their disposition; and

(3) Notify the shipper (i.e., the generator, the collector, or processor) and the Regional Administrator of the nearest Commission Regional Office listed in Appendix D of this part when any shipment or part of a shipment has not arrived within 60 days after the advance manifest was received.

(h) Any shipment or part of a shipment for which acknowledgement is not received within the times set forth in this section, must:

(1) Be investigated by the shipper if the shipper has not received notification of receipt within 20 days after transfer; and

(2) Be traced and reported. The investigation shall include tracing the shipment and filing a report with the nearest Commission Regional Office listed in Appendix D of this part. Each licensee who conducts a trace investigation shall file a written report with the nearest Commission's Regional office within 2 weeks of completion of the investigation.

RECORDS, REPORTS, AND NOTIFICATION

§ 20.401 Records of surveys, radiation monitoring, and disposal.

(a) Each licensee shall maintain records showing the radiation exposures of all individuals for whom personnel monitoring is required under § 20.202 of the regulations in this part. Such records shall be kept on Form NRC-5, in accordance with the instructions contained in that form or on clear and legible records containing all the information required by Form NRC-5. The doses entered on the forms or records shall be for periods of time not exceeding one calendar quarter.

(b) Each licensee shall maintain records in the same units used in this part, showing the results of surveys required by § 20.201(b), monitoring required by §§ 20.205(b) and 20.206(c), and disposals made under §§ 20.302, 20.303, removed § 20.304, and Part 61 of this chapter.

(c)(1) Records of individual exposure to radiation and to radioactive material which must be maintained pursuant to the provisions of paragraph (a) of this section and records of bioassays, including results of whole body counting examinations, made pursuant to § 20.108, shall be preserved until the Commission authorizes disposition.

(2) Records of the results of surveys and monitoring which must be maintained pursuant to paragraph (b) of this section shall be preserved for two years after completion of the survey except that the following records shall be maintained until the Commission authorizes their disposition: (i) Records of the results of surveys to determine compliance with § 20.103(a); (ii) in the absence of personnel monitoring data, records of the results of surveys to determine external radiation dose; and (iii) records of the results of surveys used to evaluate the release of radioactive effluents to the environment.

¹Section 20.304 provided for burial of small quantities of licensed materials in "soil." Notice of its removal appears in the Federal Register of October 30, 1980 (45 FR 71762).
²See footnote 1 to paragraph (b) of this section.

(3) Records of disposal of licensed materials made pursuant to §§ 20.302, 20.303, removed § 20.304,¹ and Part 61 of this chapter are to be maintained until the Commission authorizes their disposition.

(4) Records which must be maintained pursuant to this part 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 Commission regulations.

(5) If there is a conflict between the Commission's regulations in this part, license condition, or technical specification, or other written Commission approval or authorization pertaining to the retention period for the same type of record, the retention period specified in the regulations in this part for such records shall apply unless the Commission pursuant to § 20.501, has granted a specific exemption from the record retention requirements specified in the regulations in this part.

§ 20.402 Reports of theft or loss of licensed material.

(a)(1) Each licensee shall report to the Commission, by telephone, immediately after it determines that a loss or theft of licensed material has occurred in such quantities and under such circumstances that it appears to the licensee that a substantial hazard may result to persons in unrestricted areas.

(2) Reports must be made as follows:

(i) Licensees having an installed Emergency Notification System shall make the reports to the NRC Operations Center in accordance with § 50.72 of this chapter.

(ii) All other licensees shall make reports to the Administrator of the appropriate NRC Regional Office listed in Appendix D of this part.

(b) Each licensee who makes a report under paragraph (a) of this section shall, within 30 days after learning of the loss or theft, make a report in writing to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington, D.C. 20555, with a copy to the appropriate NRC Regional Office listed in Appendix D of this part. The report shall include the following information:

- (1) A description of the licensed material involved, including kind, quantity, chemical, and physical form;
- (2) A description of the circumstances under which the loss or theft occurred;
- (3) A statement of disposition or probable disposition of the licensed material involved;
- (4) Radiation exposures to individ-

uals, circumstances under which the exposures occurred, and the extent of possible hazard to persons in unrestricted areas;

(5) Actions which have been taken, or will be taken, to recover the material; and

(6) Procedures or measures which have been or will be adopted to prevent a recurrence of the loss or theft of licensed material.

(c) Subsequent to filing the written report the licensee shall also report any substantive additional information on the loss or theft which becomes available to the licensee, within 30 days after he learns of such information.

(d) Any report filed with the Commission pursuant to this section shall be so prepared that names of individuals who may have received exposure to radiation are stated in a separate part of the report.

(e) For holders of an operating license for a nuclear power plant, the events included in paragraph (b) of this section must be reported in accordance with the procedures described in § 50.73 (b), (c), (d), (e), and (g) of this chapter and must include the information required in paragraph (b) of this section. Events reported in accordance with § 50.73 of this chapter need not be reported by a duplicate report under paragraph (b) of this section.

§ 20.403 Notifications of incidents.

(a) *Immediate notification.* Each licensee shall immediately report any events involving byproduct source, or special nuclear material possessed by the licensee that may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 25 rems or more of radiation; exposure of the skin of the whole body of any individual of 150 rems or more of radiation; or exposure of the feet, ankles, hands or forearms of any individual to 375 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 5,000 times the limits specified for such materials in Appendix B, Table II of this part.

(3) [Removed 56 FR 40757.]

(4) [Removed 56 FR 40757.]

(b) *Twenty-four hour notification.* Each licensee shall within 24 hours of discovery of the event, report any event involving licensed material possessed by the licensee that may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 5 rems or more of radiation; exposure of the skin of the whole body of any individual to 30 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms to 75 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 500 times the limits specified for such materials in Appendix B, Table II of this part.

(3) [Removed 56 FR 40757.]

(4) [Removed 56 FR 40757.]

(c) Any report filed with the Commission pursuant to this section shall be prepared so that names of individuals who have received exposure to radiation will be stated in a separate part of the report.

(d) Reports made by licensees in response to the requirements of this section must be made as follows:

(1) Licensees that have an installed Emergency Notification System shall make the reports required by paragraphs (a) and (b) of this section to the NRC Operations Center in accordance with § 50.72 of this chapter.

(2) All other licensees shall make the reports required by paragraphs (a) and (b) of this section by telephone to the NRC Operations Center¹ and by telegram, mailgram, or facsimile to the Administrator of the appropriate NRC Regional Office listed in Appendix D of this part.

§ 20.404 [Reserved]

§ 20.405 Reports of overexposures and excessive levels and concentrations.

(a)(1) In addition to any notification required by § 20.403 of this part, each licensee shall make a report in writing concerning any one of the following types of incidents within 30 days of its occurrence:

(i) Each exposure of an individual to radiation in excess of the applicable limits in §§ 20.101 or 20.104(a) of this part, or the license;

(ii) Each exposure of an individual to radioactive material in excess of the applicable limits in §§ 20.103(a)(1), 20.103(a)(2), or 20.104(b) of this part, or in the license;

¹ Commercial telephone number of the NRC Operations Center is (301) 951-0530.

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(iii) Levels of radiation or concentrations of radioactive material in a restricted area in excess of any other applicable limit in the license;

(iv) Any incident for which notification is required by § 20.403 of this part or

(v) Levels of radiation or concentrations of radioactive material (whether or not involving excessive exposure of any individual) in an unrestricted area in excess of ten times any applicable limit set forth in this part or in the license.

(2) Each report required under paragraph (a)(1) of this section must describe the extent of exposure of individuals to radiation or to radioactive material, including:

(i) Estimates of each individual's exposure as required by paragraph (b) of this section;

(ii) Levels of radiation and concentrations of radioactive material involved;

(iii) The cause of the exposure, levels or concentrations; and

(iv) Corrective steps taken or planned to prevent a recurrence.

(b) Any report filed with the Commission pursuant to paragraph (a) of this section shall include for each individual exposed the name, social security number, and date of birth, and an estimate of the individual's exposure. The report shall be prepared so that this information is stated in a separate part of the report.

(c)(1) In addition to any notification required by § 20.403 of this part, each licensee shall make a report in writing of levels of radiation or releases of radioactive material in excess of limits specified by 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," or in excess of license conditions related to compliance with 40 CFR Part 190.

(2) Each report submitted under paragraph (c)(1) of this section must describe:

(i) The extent of exposure of individuals to radiation or to radioactive material;

(ii) Levels of radiation and concentrations of radioactive material involved;

(iii) The cause of the exposure, levels, or concentrations; and

(iv) Corrective steps taken or planned to assure against a recurrence, including the schedule for achieving conformance with 40 CFR Part 190 and with associated license conditions.

(d) For holders of an operating license for a nuclear power plant, the incidents included in paragraphs (a) or (c) of this section must be reported in accordance

with the procedures described in paragraphs 20.73 (b), (c), (d), (e), and (g) of this chapter and must also include the information required by paragraphs (a) and (c) of this section. Incidents reported in accordance with § 20.73 of this chapter need not be reported by a duplicate report under paragraphs (a) or (c) of this section.

(e) All other licensees who make reports under paragraphs (a) or (c) of this section shall, within 30 days after learning of the overexposure or excessive level or concentration, make a report in writing to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington, D.C. 20555, with a copy to the appropriate NRC Regional Office listed in Appendix D of this part.

§ 20.406 [Reserved]

§ 20.407 Personnel monitoring reports.

Each person described in § 20.406 of this part shall, within the first quarter of each calendar year, submit to the Director, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555, the reports specified in paragraphs (a) and (b) of this section, covering the preceding calendar year.¹

(a) A report of either (1) the total number of individuals for whom personnel monitoring was required under § 20.202(a) or § 34.33(a) of this chapter during the calendar year; or (2) the total number of individuals for whom personnel monitoring was provided during the calendar year. Provided, however, That such total includes at least the number of individuals required to be reported under paragraph (a)(1) of this section. The report shall indicate whether it is submitted in accordance with paragraph (a)(1) or (a)(2) of this section. If personnel monitoring was not required to be provided to an individual by the licensee under §§ 20.202(a) or 34.33(a) of this chapter during the calendar year, the licensee shall submit a negative report indicating that such personnel monitoring was not required.

(b) A statistical summary report of the personnel monitoring information recorded by the licensee for individuals for whom personnel monitoring was either required or provided, as described in paragraph (a) of this section, indicating the number of individuals whose total whole body exposure recorded during the previous calendar

¹ A licensee whose license expires or termination prior to, or on the last day of the calendar year, shall submit reports at the expiration or termination of the license, covering that part of the year during which the license was in effect.

year was in each of the following estimated exposure ranges:

Estimated whole body exposure range (rem)	Number of individuals in each range
No measurable exposure	
Measurable exposure less than 0.1	
0.1 to 0.25	
0.25 to 0.5	
0.5 to 0.75	
0.75 to 1	
1 to 2	
2 to 3	
3 to 4	
4 to 6	
6 to 8	
8 to 10	
10 to 11	
11 to 12	
12+	

¹Individual values exactly equal to the values separating exposure ranges shall be reported in the higher range.

The low exposure range data are required in order to obtain better information about the exposures actually recorded. This section does not require improved measurements.

§ 20.408 Reports of personnel monitoring on termination of employment or work.

(a) This section applies to each person licensed by the Commission to:

(1) Operate a nuclear reactor designed to produce electrical or heat energy pursuant to § 20.21(b) or § 20.22 of this chapter or a testing facility as defined in § 20.2 of this chapter.

(2) Possess or use byproduct material for purposes of radiography pursuant to Parts 30 and 34 of this chapter.

(3) Possess or use at any one time, for purposes of fuel processing, fabricating, or reprocessing, special nuclear material in a quantity exceeding 5,000 grams of contained uranium-235, uranium-233, or plutonium or any combination thereof pursuant to Part 70 of this chapter;

(4) Possess high-level radioactive waste at a geologic repository operations area pursuant to Part 60 of this chapter; or

(5) Possess spent fuel in an independent spent fuel storage installation (ISFSI) or possess spent fuel or high level radioactive waste in a monitored retrievable storage installation (MRS) pursuant to Part 71 of this chapter; or

(6) Possess or use at any one time, for processing or manufacturing for distribution pursuant to Parts 30, 32, or 33 of this Chapter, byproduct material in quantities exceeding any one of the following quantities:

Radionuclide	Quantity in curies
Cesium-137	1
Cobalt-60	1
Gold-198	100
Iodine-131	1
Indium-113	10
Krypton-85	1,000
Protactinium-231	10
Technetium-99m	1,000

The Commission may require, as a license condition, or by rule, regulation or order, pursuant to § 20.502, reports from licensees who are licensed to use radionuclides not on the list in quantities sufficient to cause comparable radiation levels.

(7) Receive radioactive waste from other persons for disposal under Part 61 of this chapter.

(b) When an individual terminates employment with a licensee described in paragraph (a) of this section, or an individual assigned to work in such a licensee's facility, but not employed by the licensee, completes the work assignment in the licensee's facility, the licensee shall furnish to the REIRS Project Manager, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555, a report of the individual's exposures to radiation and radioactive material, incurred during the period of employment or work assignment in the licensee's facility, containing information recorded by the licensee pursuant to §§ 20.401(a) and 20.108. Such report shall be furnished within 30 days after the exposure of the individual has been determined by the licensee or 90 days after the date of termination of employment or work assignment, whichever is earlier.

§ 20.409 Notifications and reports to individuals.

(a) Requirements for notifications and reports to individuals of exposure to radiation or radioactive material are specified in § 19.13 of this chapter.

(b) When a licensee is required pursuant to §§ 20.405 or 20.408 to report to the Commission any exposure of an individual to radiation or radioactive material, the licensee shall also notify the individual. Such notice shall be transmitted at a time not later than the transmittal to the Commission, and shall comply with the provisions of § 19.13(a) of this chapter.

EXCEPTIONS AND ADDITIONAL REQUIREMENTS

§ 20.501 Applications for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

§ 20.502 Additional requirements.

The Commission may, by rule, regulation, or order, impose upon any licensee such requirements, in addition to those established in the regulations in this part, as it deems appropriate or necessary to protect health or to minimize danger to life or property.

ENFORCEMENT

§ 20.601 Violations.

(a) The Commission may obtain an injunction or other court order to prevent a violation of the provisions of—

(1) The Atomic Energy Act of 1954, as amended;

(2) Title II of the Energy Reorganization Act of 1974, as amended;

or

(3) A regulation or order issued pursuant to those Acts.

(b) The Commission may obtain a court order for the payment of a civil penalty imposed under section 234 of the Atomic Energy Act:

(i) For violations of—

(i) Sections 53, 57, 62, 63, 61, 82, 101, 103, 104, 107, or 109 of the Atomic Energy Act of 1954, as amended;

(ii) Section 206 of the Energy Reorganization Act;

(iii) Any rule, regulation, or order issued pursuant to the sections specified in paragraph (b)(1)(i) of this section;

(iv) Any term, condition, or limitation of any license issued under the sections specified in paragraph (b)(1)(i) of this section.

(2) For any violation for which a license may be revoked under section 186 of the Atomic Energy Act of 1954, as amended.

§ 20.602 Criminal penalties.

(a) Section 223 of the Atomic Energy Act of 1954, as amended, provides for criminal sanctions for willful violation of, attempted violation of, or conspiracy to violate, any regulation issued under sections 161b, 161i, or 161o of the Act. For purposes of section 223, all the regulations in §§ 20.1 through 20.602 are issued under one or more of sections 161b, 161i, or 161o, except for the sections listed in paragraph (b) of this section.

(b) The regulations in §§ 20.1 through 20.602 that are not issued under sections 161b, 161i, or 161o for the purposes of section 223 are as follows: §§ 20.1, 20.2, 20.3, 20.4, 20.5, 20.6, 20.7, 20.8, 20.107, 20.108, 20.204, 20.206, 20.302, 20.306, 20.501, 20.502, 20.601, and 20.602.

PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

Appendix A to 49CFR 20.101—Protection Factors for Respirators

Description ¹	Model ²	Protection factor ³		Types of airborne contaminants—radiation outside of Occupational Safety and Health's safety and health administration tests for permeability
		Particulate only	Particulate, gases and vapors ⁴	
I Air-purifying respirators⁵				
Respirator half-mask ⁶	AP	50		50 CFR Part 11, Subpart C
Respirator full	AP	50		
Respirator half-mask, full or hood	AP	1,000		
II Air-cannister-respirating respirators				
1 Air-line respirator				
Respirator half-mask	CP		1,000	
Respirator full	D		5	
Respirator full	CP		5,000	50 CFR Part 11, Subpart J
Respirator full	D		5	
Respirator full	PC		5,000	
Respirator full	CP		(F)	
Respirator full	CP		(F)	
2 Self-contained breathing apparatus (SCBA)				
Respirator full	D		50	
Respirator full	PC		5,000	50 CFR Part 11, Subpart K
Respirator full	PC		50	
Respirator full	CP		1,000	
III Compressor-respirator air supply system of air-purifying and compressor-supplying respirators				50 CFR Part 11, § 11.2004

56 FR 23360

47 FR 1111

¹ For use of the protector of respiratory protective devices to be used only when the concentrations have been identified and the concentrations or possible concentrations are known.

² Only for those models and when having respirators for the use of igniting substances against the skin, fumes and oils are excluded.

³ The model number are defined as follows: CP = canister type; D = demand flow; PC = pressure demand; S.C. = self-contained breathing apparatus; AP = air-purifying; RD = demand respirating device; RP = positive pressure; RRP = positive pressure, respirating device; and SCBA = self-contained breathing apparatus.

⁴ The protection factor is a measure of the degree of protection afforded by a respirator. It is based on the concentration of airborne radioactive material outside the respiratory protective equipment in the room the equipment usually finds the background under conditions of use. It is equal to the airborne activity concentration to be protected against divided by the concentration of the airborne activity concentration.

⁵ The protection factors are:

(a) Only for those models having proper head-to-respirator seal and maintained under supervision in a well-stored respiratory protective program.

(b) For air-purifying respirators and when high efficiency particulate filter above 99.97% removal efficiency by normal penetration 0.3 µm dust (N95) test are used in concentrations not subject to error and not containing radioactive gas or vapor respiratory hazards.

(c) For air-purifying respirators to be used in areas where the quality and quantity of the air is not subject to control.

(d) For air-purifying respirators and when supplied with suitable respirator air, respirator air shall be provided of the quality and quantity required in accordance with 49CFR 20.101.

⁶ Excepting radioactive contaminants that present a hazard of absorption of substance hazard. For these cases, appropriate use of the model number by description through the use of the model number.

⁷ Excepting radioactive contaminants that present a hazard of absorption of substance hazard. For these cases, appropriate use of the model number by description through the use of the model number.

⁸ The protection factor is a measure of the degree of protection afforded by a respirator. It is based on the concentration of airborne radioactive material outside the respiratory protective equipment in the room the equipment usually finds the background under conditions of use. It is equal to the airborne activity concentration to be protected against divided by the concentration of the airborne activity concentration.

⁹ The protection factor is a measure of the degree of protection afforded by a respirator. It is based on the concentration of airborne radioactive material outside the respiratory protective equipment in the room the equipment usually finds the background under conditions of use. It is equal to the airborne activity concentration to be protected against divided by the concentration of the airborne activity concentration.

¹⁰ The protection factor is a measure of the degree of protection afforded by a respirator. It is based on the concentration of airborne radioactive material outside the respiratory protective equipment in the room the equipment usually finds the background under conditions of use. It is equal to the airborne activity concentration to be protected against divided by the concentration of the airborne activity concentration.

¹¹ The protection factor is a measure of the degree of protection afforded by a respirator. It is based on the concentration of airborne radioactive material outside the respiratory protective equipment in the room the equipment usually finds the background under conditions of use. It is equal to the airborne activity concentration to be protected against divided by the concentration of the airborne activity concentration.

¹² The protection factor is a measure of the degree of protection afforded by a respirator. It is based on the concentration of airborne radioactive material outside the respiratory protective equipment in the room the equipment usually finds the background under conditions of use. It is equal to the airborne activity concentration to be protected against divided by the concentration of the airborne activity concentration.

¹³ The protection factor is a measure of the degree of protection afforded by a respirator. It is based on the concentration of airborne radioactive material outside the respiratory protective equipment in the room the equipment usually finds the background under conditions of use. It is equal to the airborne activity concentration to be protected against divided by the concentration of the airborne activity concentration.

¹⁴ The protection factor is a measure of the degree of protection afforded by a respirator. It is based on the concentration of airborne radioactive material outside the respiratory protective equipment in the room the equipment usually finds the background under conditions of use. It is equal to the airborne activity concentration to be protected against divided by the concentration of the airborne activity concentration.

¹⁵ The protection factor is a measure of the degree of protection afforded by a respirator. It is based on the concentration of airborne radioactive material outside the respiratory protective equipment in the room the equipment usually finds the background under conditions of use. It is equal to the airborne activity concentration to be protected against divided by the concentration of the airborne activity concentration.

¹⁶ The protection factor is a measure of the degree of protection afforded by a respirator. It is based on the concentration of airborne radioactive material outside the respiratory protective equipment in the room the equipment usually finds the background under conditions of use. It is equal to the airborne activity concentration to be protected against divided by the concentration of the airborne activity concentration.

¹⁷ The protection factor is a measure of the degree of protection afforded by a respirator. It is based on the concentration of airborne radioactive material outside the respiratory protective equipment in the room the equipment usually finds the background under conditions of use. It is equal to the airborne activity concentration to be protected against divided by the concentration of the airborne activity concentration.

¹⁸ The protection factor is a measure of the degree of protection afforded by a respirator. It is based on the concentration of airborne radioactive material outside the respiratory protective equipment in the room the equipment usually finds the background under conditions of use. It is equal to the airborne activity concentration to be protected against divided by the concentration of the airborne activity concentration.

¹⁹ The protection factor is a measure of the degree of protection afforded by a respirator. It is based on the concentration of airborne radioactive material outside the respiratory protective equipment in the room the equipment usually finds the background under conditions of use. It is equal to the airborne activity concentration to be protected against divided by the concentration of the airborne activity concentration.

²⁰ The protection factor is a measure of the degree of protection afforded by a respirator. It is based on the concentration of airborne radioactive material outside the respiratory protective equipment in the room the equipment usually finds the background under conditions of use. It is equal to the airborne activity concentration to be protected against divided by the concentration of the airborne activity concentration.

Note 1.—Protection factors for respirators, as may be approved by the U.S. Bureau of Mines/National Institute for Occupational Safety and Health (NIOSH) according to applicable approvals for respirators for type and mode of use to protect against airborne radionuclides, may be used to the extent that they do not exceed the protection factors listed in this table. The protection factors listed in this table may not be appropriate to circumstances where chemical or other respiratory hazards exist in addition to radiological hazards. The selection and use of respirators for these circumstances should take into account applicable approvals of the U.S. Bureau of Mines/NIOSH.

Note 2.—Reductive contaminants for which the concentration value in Table 1, column 1, Appendix B of this part are based on internal dose due to inhalation may, in addition, present external exposure hazards at higher concentrations. Under these circumstances, limitations on occupancy may have to be governed by external dose limits.

50 FR 23360

20 FR 10364

Appendix B to 49CFR 171.20.601—
Concentrations in Air and Water Above Natural Background

(See notes at end of appendix.)

Element (isotope number)	Isotope ¹	Table 1		Table 2	
		Column 1	Column 2	Column 1	Column 2
		Air † (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Actinium (89)	Ac 227	5 × 10 ⁻¹⁰	6 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰
	Ac 228	5 × 10 ⁻¹¹	9 × 10 ⁻¹¹	9 × 10 ⁻¹¹	9 × 10 ⁻¹¹
Americium (95)	Am 241	5 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰
	Am 243a	1 × 10 ⁻¹⁰	6 × 10 ⁻¹¹	4 × 10 ⁻¹¹	5 × 10 ⁻¹¹
	Am 243b	5 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰
	Am 243c	4 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰
	Am 243d	3 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰
	Am 243e	6 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰
	Am 243f	1 × 10 ⁻¹⁰	6 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰
	Am 244	4 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰
Bismuth (83)	Bi 212	5 × 10 ⁻¹¹	6 × 10 ⁻¹¹	6 × 10 ⁻¹¹	6 × 10 ⁻¹¹
	Bi 214	1 × 10 ⁻¹¹	6 × 10 ⁻¹¹	6 × 10 ⁻¹¹	6 × 10 ⁻¹¹
	Bi 214a	2 × 10 ⁻¹¹	7 × 10 ⁻¹¹	5 × 10 ⁻¹¹	5 × 10 ⁻¹¹
	Bi 214b	2 × 10 ⁻¹¹	7 × 10 ⁻¹¹	7 × 10 ⁻¹¹	5 × 10 ⁻¹¹
Boron (10)	B 10	5 × 10 ⁻¹¹	5 × 10 ⁻¹¹	5 × 10 ⁻¹¹	1 × 10 ⁻¹¹
	B 11	5 × 10 ⁻¹¹	5 × 10 ⁻¹¹	9 × 10 ⁻¹¹	1 × 10 ⁻¹¹
Cesium (55)	Cs 137	5 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰
	Cs 134	5 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰	7 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰
Cobalt (27)	Co 60	4 × 10 ⁻¹¹	1 × 10 ⁻¹¹	1 × 10 ⁻¹¹	6 × 10 ⁻¹¹
	Co 57	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹	1 × 10 ⁻¹¹	6 × 10 ⁻¹¹
	Co 58	1 × 10 ⁻¹¹	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹	6 × 10 ⁻¹¹
	Co 59	1 × 10 ⁻¹¹	2 × 10 ⁻¹¹	4 × 10 ⁻¹¹	6 × 10 ⁻¹¹
	Co 60a	1 × 10 ⁻¹¹	6 × 10 ⁻¹¹	6 × 10 ⁻¹¹	6 × 10 ⁻¹¹
	Co 60b	5 × 10 ⁻¹¹	5 × 10 ⁻¹¹	6 × 10 ⁻¹¹	6 × 10 ⁻¹¹
Copper (29)	Cu 64	4 × 10 ⁻¹¹	2 × 10 ⁻¹¹	1 × 10 ⁻¹¹	6 × 10 ⁻¹¹
	Cu 65	1 × 10 ⁻¹¹	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹	7 × 10 ⁻¹¹
Curium (96)	Cm 244	1 × 10 ⁻¹⁰	6 × 10 ⁻¹¹	4 × 10 ⁻¹¹	5 × 10 ⁻¹¹
	Cm 246	5 × 10 ⁻¹¹	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹	5 × 10 ⁻¹¹
Dysprosium (63)	Dy 165	7 × 10 ⁻¹¹	5 × 10 ⁻¹¹	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹
	Dy 167	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹	1 × 10 ⁻¹¹	7 × 10 ⁻¹¹
Einsteinium (85)	Es 253	1 × 10 ⁻¹⁰	6 × 10 ⁻¹¹	4 × 10 ⁻¹¹	5 × 10 ⁻¹¹
	Es 254	4 × 10 ⁻¹¹	6 × 10 ⁻¹¹	1 × 10 ⁻¹¹	5 × 10 ⁻¹¹
Europium (63)	Eu 152	1 × 10 ⁻¹¹	6 × 10 ⁻¹¹	4 × 10 ⁻¹¹	5 × 10 ⁻¹¹
	Eu 154	4 × 10 ⁻¹¹	7 × 10 ⁻¹¹	1 × 10 ⁻¹¹	5 × 10 ⁻¹¹
Gadolinium (64)	Gd 153	9 × 10 ⁻¹¹	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹	6 × 10 ⁻¹¹
	Gd 157	1 × 10 ⁻¹¹	2 × 10 ⁻¹¹	4 × 10 ⁻¹¹	6 × 10 ⁻¹¹
Gallium (31)	Ga 70	1 × 10 ⁻¹¹	6 × 10 ⁻¹¹	6 × 10 ⁻¹¹	5 × 10 ⁻¹¹
	Ga 71	1 × 10 ⁻¹¹	6 × 10 ⁻¹¹	4 × 10 ⁻¹¹	5 × 10 ⁻¹¹
Germium (32)	Ge 72	6 × 10 ⁻¹¹	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹	5 × 10 ⁻¹¹
	Ge 73	1 × 10 ⁻¹¹	2 × 10 ⁻¹¹	4 × 10 ⁻¹¹	5 × 10 ⁻¹¹
Gold (79)	Au 196	2 × 10 ⁻¹¹	1 × 10 ⁻¹¹	6 × 10 ⁻¹¹	4 × 10 ⁻¹¹
	Au 197	1 × 10 ⁻¹¹	1 × 10 ⁻¹¹	2 × 10 ⁻¹¹	4 × 10 ⁻¹¹
	Au 198	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹	6 × 10 ⁻¹¹	4 × 10 ⁻¹¹
	Au 199	1 × 10 ⁻¹¹	2 × 10 ⁻¹¹	6 × 10 ⁻¹¹	4 × 10 ⁻¹¹
Hassium (108)	Hs 264	2 × 10 ⁻¹¹	1 × 10 ⁻¹¹	6 × 10 ⁻¹¹	4 × 10 ⁻¹¹
	Hs 265	1 × 10 ⁻¹¹	1 × 10 ⁻¹¹	2 × 10 ⁻¹¹	4 × 10 ⁻¹¹
	Hs 266	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹	6 × 10 ⁻¹¹	4 × 10 ⁻¹¹
	Hs 267	1 × 10 ⁻¹¹	2 × 10 ⁻¹¹	6 × 10 ⁻¹¹	4 × 10 ⁻¹¹
Holmium (67)	Hm 163	6 × 10 ⁻¹¹	1 × 10 ⁻¹¹	2 × 10 ⁻¹¹	4 × 10 ⁻¹¹
	Hm 164	1 × 10 ⁻¹¹	1 × 10 ⁻¹¹	2 × 10 ⁻¹¹	4 × 10 ⁻¹¹
	Hm 165	6 × 10 ⁻¹¹	1 × 10 ⁻¹¹	2 × 10 ⁻¹¹	4 × 10 ⁻¹¹
	Hm 166	1 × 10 ⁻¹¹	1 × 10 ⁻¹¹	6 × 10 ⁻¹¹	4 × 10 ⁻¹¹

APPENDIX B
 Concentrations in Air and Water Above Natural Background--Continued
 (See notes at end of appendix)

Element (atomic number)	Isotope ¹	Table I		Table II		
		Column 1	Column 2	Column 1	Column 2	
		Air † (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	
Bromine (35)	Br 81	5	1 × 10 ⁻⁷	5	5 × 10 ⁻⁷	
		1	2 × 10 ⁻⁷	1	4 × 10 ⁻⁷	
Cadmium (48)	Cd 109	5	2 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
		1	7 × 10 ⁻⁷	1	2 × 10 ⁻⁷	
	Cd 113m	5	4 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
	Cd 113	5	4 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
Cesium (55)	Cs 137	5	2 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
		1	2 × 10 ⁻⁷	1	2 × 10 ⁻⁷	
	Cs 134	5	2 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
Calcium (20)	Ca 45	5	2 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
		1	1 × 10 ⁻⁷	1	2 × 10 ⁻⁷	
	Ca 47	5	2 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
		1	2 × 10 ⁻⁷	1	2 × 10 ⁻⁷	
Californium (98)	Cf 249	5	2 × 10 ⁻¹⁰	5	2 × 10 ⁻¹⁰	
		1	1 × 10 ⁻¹⁰	1	2 × 10 ⁻¹⁰	
	Cf 250	5	2 × 10 ⁻¹⁰	5	2 × 10 ⁻¹⁰	
		1	1 × 10 ⁻¹⁰	1	2 × 10 ⁻¹⁰	
	Cf 251	5	2 × 10 ⁻¹⁰	5	2 × 10 ⁻¹⁰	
		1	1 × 10 ⁻¹⁰	1	2 × 10 ⁻¹⁰	
	Cf 252	5	2 × 10 ⁻¹¹	5	2 × 10 ⁻¹¹	
	Cf 253	5	2 × 10 ⁻¹⁰	5	2 × 10 ⁻¹⁰	
Carbon (6)	C 14	5	4 × 10 ⁻¹⁰	5	2 × 10 ⁻¹⁰	
	(CO ₂)	Sub	2 × 10 ⁻¹²		1 × 10 ⁻¹⁰	
	Cesium (55)	Cs 137	5	4 × 10 ⁻⁷	5	2 × 10 ⁻⁷
			1	2 × 10 ⁻⁷	1	2 × 10 ⁻⁷
Cs 134		5	2 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
		1	2 × 10 ⁻⁷	1	2 × 10 ⁻⁷	
Cesium (55)	Cs 137	5	1 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
		1	6 × 10 ⁻⁷	1	2 × 10 ⁻⁷	
	Cs 134m	5	2 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
		1	4 × 10 ⁻⁷	1	2 × 10 ⁻⁷	
	Cs 134	5	4 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
		1	1 × 10 ⁻⁷	1	2 × 10 ⁻⁷	
	Cs 135	5	2 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
		1	4 × 10 ⁻⁷	1	2 × 10 ⁻⁷	
Cesium (55)	Cs 136	5	2 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
		1	2 × 10 ⁻⁷	1	2 × 10 ⁻⁷	
	Cs 137	5	6 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
		1	1 × 10 ⁻⁷	1	2 × 10 ⁻⁷	
Chlorine (17)	Cl 36	5	4 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
		1	2 × 10 ⁻⁷	1	2 × 10 ⁻⁷	
Chlorine (17)	Cl 36	5	2 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
		1	2 × 10 ⁻⁷	1	2 × 10 ⁻⁷	
Chromium (24)	Cr 51	5	1 × 10 ⁻⁷	5	2 × 10 ⁻⁷	
		1	2 × 10 ⁻⁷	1	2 × 10 ⁻⁷	

APPENDIX B
 Concentrations in Air and Water Above Natural Background—Continued
 [See notes at end of appendix.]

Element (atomic number)	Isotope ¹	Table 1		Table 2	
		Column 1	Column 2	Column 1	Column 2
		Air † (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Cobalt (27)	Co 57	5 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁷	5 × 10 ⁻⁸
		2 × 10 ⁻⁷	1 × 10 ⁻⁷	6 × 10 ⁻⁸	4 × 10 ⁻⁸
	Co 58m	2 × 10 ⁻⁷	5 × 10 ⁻⁸	6 × 10 ⁻⁸	2 × 10 ⁻⁸
		9 × 10 ⁻⁸	6 × 10 ⁻⁸	3 × 10 ⁻⁸	2 × 10 ⁻⁸
	Co 59	5 × 10 ⁻⁷	4 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁷
Copper (29)	Co 64	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	9 × 10 ⁻⁸
		9 × 10 ⁻⁸	1 × 10 ⁻⁷	3 × 10 ⁻⁸	2 × 10 ⁻⁸
Carbon (96)	Co 143	2 × 10 ⁻¹⁰	7 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
		2 × 10 ⁻¹⁰	7 × 10 ⁻¹⁰	6 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Co 143	6 × 10 ⁻¹⁰	1 × 10 ⁻⁹	2 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰
		1 × 10 ⁻¹⁰	7 × 10 ⁻¹⁰	3 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Co 144	9 × 10 ⁻¹⁰	2 × 10 ⁻⁹	3 × 10 ⁻¹⁰	7 × 10 ⁻¹⁰
		1 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	9 × 10 ⁻¹⁰
	Co 145	2 × 10 ⁻¹⁰	1 × 10 ⁻⁹	2 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰
		1 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Co 146	2 × 10 ⁻¹⁰	1 × 10 ⁻⁹	2 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰
		1 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Co 147	2 × 10 ⁻¹⁰	1 × 10 ⁻⁹	2 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰
		1 × 10 ⁻¹⁰	6 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Co 148	6 × 10 ⁻¹⁰	1 × 10 ⁻⁹	2 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰
		1 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰
Dysprosium (66)	Dy 163	2 × 10 ⁻⁷	1 × 10 ⁻⁷	9 × 10 ⁻⁸	4 × 10 ⁻⁸
		2 × 10 ⁻⁷	1 × 10 ⁻⁷	7 × 10 ⁻⁸	4 × 10 ⁻⁸
	Dy 166	2 × 10 ⁻⁷	1 × 10 ⁻⁷	5 × 10 ⁻⁸	4 × 10 ⁻⁸
Bismuthium (99)	Bi 205	2 × 10 ⁻¹⁰	7 × 10 ⁻¹⁰	5 × 10 ⁻¹¹	2 × 10 ⁻¹¹
		6 × 10 ⁻¹⁰	7 × 10 ⁻¹⁰	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹
	Bi 204m	5 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
		6 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Bi 204	2 × 10 ⁻¹¹	4 × 10 ⁻¹⁰	6 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰
		1 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰
	Bi 205	2 × 10 ⁻¹⁰	5 × 10 ⁻¹⁰	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹
Bismium (83)	Bi 199	6 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	9 × 10 ⁻⁸
		4 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁷	9 × 10 ⁻⁸
	Bi 197	7 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁷
Bismium (83)	Bi 182	4 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁷	6 × 10 ⁻⁸
	(T/2 = 9.3 hrs)	2 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁷	6 × 10 ⁻⁸
	Bi 182	1 × 10 ⁻⁷	2 × 10 ⁻⁷	4 × 10 ⁻⁸	2 × 10 ⁻⁸
	(T/2 = 15 yrs)	2 × 10 ⁻⁷	2 × 10 ⁻⁷	6 × 10 ⁻⁸	2 × 10 ⁻⁸
	Bi 184	4 × 10 ⁻⁷	6 × 10 ⁻⁷	1 × 10 ⁻⁷	2 × 10 ⁻⁷
	7 × 10 ⁻⁷	6 × 10 ⁻⁷	5 × 10 ⁻⁷	2 × 10 ⁻⁷	
	9 × 10 ⁻⁷	4 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	
	7 × 10 ⁻⁷	6 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	

PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

APPENDIX B
Concentrations in Air and Water Above Natural Background—Continued
(See notes at end of appendix)

Element (atomic number)	Isotope	Table 1		Table 2	
		Column 1	Column 2	Column 1	Column 2
		Air † (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Potassium (19)	K 40	5 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰
	K 41	7 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰
	K 42	2 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰	6 × 10 ⁻¹¹	3 × 10 ⁻¹¹
Radium (88)	Ra 226	1 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰	4 × 10 ⁻¹¹	2 × 10 ⁻¹¹
	Ra 228	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰	5 × 10 ⁻¹¹
	Ra 228m	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰	5 × 10 ⁻¹¹
Thorium (90)	Th 232	2 × 10 ⁻¹⁰	4 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Th 230	9 × 10 ⁻¹¹	6 × 10 ⁻¹¹	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹
	Th 231	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
Uranium (92)	U 238	4 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰	6 × 10 ⁻¹¹
	U 235	2 × 10 ⁻¹⁰	1 × 10 ⁻¹⁰	6 × 10 ⁻¹¹	4 × 10 ⁻¹¹
	U 234	1 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	4 × 10 ⁻¹¹	2 × 10 ⁻¹¹
Bismuth (83)	Bi 210	6 × 10 ⁻¹¹	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹	2 × 10 ⁻¹¹
	Bi 212	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Bi 214	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
Polonium (84)	Po 210	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Po 212	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Po 214	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
Actinium (89)	Ac 227	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Ac 228	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Ac 228m	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
Protactinium (91)	Pa 231	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Pa 233	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Pa 233m	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
Neptunium (93)	Np 237	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Np 239	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Np 241	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
Plutonium (94)	Pu 239	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Pu 240	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Pu 241	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
Americium (95)	Am 241	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Am 242	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Am 243	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
Curium (96)	Cm 246	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Cm 247	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Cm 248	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
Berkelium (97)	Bk 247	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Bk 249	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Bk 250	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
Californium (98)	Cf 251	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Cf 252	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Cf 253	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
Einsteinium (99)	Es 252	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Es 253	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Es 254	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
Fermium (100)	Fm 257	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Fm 258	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Fm 259	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰

APPENDIX B
 Concentrations in Air and Water Above Natural Background—Continued
 [See note at end of appendix]

Element (atomic number)	Isotope ¹	Table 1		Table 2		
		Column 1	Column 2	Column 1	Column 2	
		† Air ($\mu\text{Ci/ml}$)	Water ($\mu\text{Ci/ml}$)	† Air ($\mu\text{Ci/ml}$)	Water ($\mu\text{Ci/ml}$)	
Iodine (53)	I 134	I	3×10^{-7}	2×10^{-7}	1×10^{-7}	6×10^{-8}
	I 135	S	1×10^{-7}	7×10^{-8}	1×10^{-8}	4×10^{-8}
Bromine (77)	B 190	S	4×10^{-7}	2×10^{-7}	1×10^{-8}	7×10^{-8}
	B 192	S	1×10^{-7}	4×10^{-7}	4×10^{-8}	2×10^{-8}
	B 194	S	4×10^{-7}	1×10^{-7}	1×10^{-8}	2×10^{-8}
Cesium (55)	Cs 134	S	1×10^{-7}	1×10^{-7}	4×10^{-8}	4×10^{-8}
	Cs 137	S	2×10^{-7}	1×10^{-7}	9×10^{-8}	4×10^{-8}
Radium (88)	Ra 226	S	2×10^{-7}	1×10^{-7}	2×10^{-8}	2×10^{-8}
	Ra 228	S	2×10^{-7}	2×10^{-7}	2×10^{-8}	2×10^{-8}
Krypton (36)	Kr 81m	Sub	6×10^{-7}		1×10^{-7}	
	Kr 82	Sub	1×10^{-7}		2×10^{-7}	
	Kr 83	Sub	1×10^{-7}		2×10^{-7}	
	Kr 85	Sub	1×10^{-7}		2×10^{-7}	
Lanthanum (57)	La 140	S	2×10^{-7}	7×10^{-8}	2×10^{-8}	2×10^{-8}
	La 139	S	1×10^{-7}	7×10^{-8}	4×10^{-8}	2×10^{-8}
Lead (82)	Pb 202	S	2×10^{-7}	1×10^{-7}	9×10^{-8}	4×10^{-8}
	Pb 210	S	2×10^{-7}	1×10^{-7}	6×10^{-8}	1×10^{-7}
	Pb 212	S	1×10^{-7}	4×10^{-7}	4×10^{-8}	2×10^{-8}
Lithium (7)	Li 7	S	2×10^{-7}	2×10^{-7}	2×10^{-8}	2×10^{-8}
	Li 6	S	2×10^{-7}	2×10^{-7}	7×10^{-8}	2×10^{-8}
Lutetium (71)	Lu 177	S	4×10^{-7}	2×10^{-7}	2×10^{-8}	1×10^{-8}
	Lu 175	S	2×10^{-7}	2×10^{-7}	2×10^{-8}	1×10^{-8}
Manganese (25)	Mn 53	S	2×10^{-7}	1×10^{-7}	7×10^{-8}	2×10^{-8}
	Mn 54	S	1×10^{-7}	9×10^{-8}	2×10^{-8}	2×10^{-8}
	Mn 55	S	4×10^{-7}	4×10^{-7}	1×10^{-8}	1×10^{-8}
Mercury (80)	Hg 197m	S	4×10^{-7}	2×10^{-7}	2×10^{-8}	1×10^{-8}
	Hg 197	S	2×10^{-7}	2×10^{-7}	2×10^{-8}	2×10^{-8}
	Hg 203	S	7×10^{-7}	6×10^{-7}	2×10^{-8}	2×10^{-8}
Molybdenum (42)	Mo 99	S	2×10^{-7}	2×10^{-7}	2×10^{-8}	2×10^{-8}
	Mo 93	S	1×10^{-7}	2×10^{-7}	4×10^{-8}	1×10^{-8}
	Mo 95	S	7×10^{-7}	2×10^{-7}	2×10^{-8}	2×10^{-8}
Neodymium (60)	Nd 144	S	2×10^{-7}	2×10^{-7}	2×10^{-8}	7×10^{-8}
	Nd 147	S	2×10^{-7}	2×10^{-7}	1×10^{-8}	6×10^{-8}
	Nd 149	S	4×10^{-7}	2×10^{-7}	2×10^{-8}	6×10^{-8}
Plutonium (94)	Pu 238	S	2×10^{-7}	2×10^{-7}	6×10^{-8}	2×10^{-8}
	Pu 239	S	2×10^{-7}	2×10^{-7}	2×10^{-8}	2×10^{-8}
	Pu 240	S	1×10^{-7}	2×10^{-7}	2×10^{-8}	2×10^{-8}

APPENDIX B
 Concentrations in Air and Water Above Natural Background—Continued
 (See notes at end of appendix)

Element (atomic number)	Isotope	Table 1		Table 2	
		Column 1	Column 2	Column 1	Column 2
		Air † (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Neptunium (93)	Np 237	4 × 10 ⁻¹⁰	9 × 10 ⁻¹¹	1 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
	Np 239	1 × 10 ⁻¹⁰	9 × 10 ⁻¹¹	4 × 10 ⁻¹⁰	2 × 10 ⁻¹⁰
Niobium (41)	Ni 93	2 × 10 ⁻⁷	4 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁷
	Ni 94	7 × 10 ⁻⁷	4 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁷
	Ni 95	2 × 10 ⁻⁷	6 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
	Ni 96	2 × 10 ⁻⁷	6 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
Niobium (Columbium) (41)	Nb 93m	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
	Nb 94	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
	Nb 95	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
	Nb 97	4 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	9 × 10 ⁻⁸
Osmium (76)	Os 182	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	7 × 10 ⁻⁸
	Os 184	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	7 × 10 ⁻⁸
	Os 187m	2 × 10 ⁻⁷	7 × 10 ⁻⁷	6 × 10 ⁻⁷	2 × 10 ⁻⁷
	Os 191	2 × 10 ⁻⁷	7 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
Osmium (76)	Os 192	4 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁷	6 × 10 ⁻⁸
	Os 194	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
	Os 196	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
	Os 198	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
Palladium (46)	Pd 102	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
	Pd 106	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
Phosphorus (15)	P 32	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
	P 33	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
Platinum (78)	Pt 191	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
	Pt 193m	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
	Pt 195	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
	Pt 197	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
Plutonium (94)	Pu 238	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
	Pu 239	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
	Pu 240	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷
	Pu 241	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁷

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APPENDIX B
 Concentrations in Air and Water Above Natural Background—Continued
 (See notes at end of appendix)

Element (atomic number)	Isotope	Table 1		Table 2		
		Column 1	Column 2	Column 1	Column 2	
		† Air ($\mu\text{Ci/ml}$)	Water ($\mu\text{Ci/ml}$)	† Air ($\mu\text{Ci/ml}$)	Water ($\mu\text{Ci/ml}$)	
Plutonium (94)	Pu 242	5	5×10^{-12}	1×10^{-12}	6×10^{-12}	2×10^{-12}
		1	4×10^{-11}	9×10^{-12}	1×10^{-10}	3×10^{-10}
	Pu 243	5	2×10^{-10}	1×10^{-10}	6×10^{-10}	2×10^{-10}
		1	2×10^{-9}	1×10^{-9}	2×10^{-9}	2×10^{-9}
	Pu 244	5	2×10^{-10}	1×10^{-10}	6×10^{-10}	4×10^{-10}
		1	2×10^{-11}	2×10^{-11}	1×10^{-10}	1×10^{-10}
Protactinium (91)	Pa 231	5	2×10^{-10}	2×10^{-10}	7×10^{-10}	2×10^{-10}
		1	2×10^{-9}	2×10^{-9}	7×10^{-9}	2×10^{-9}
Promethium (61)	Pm 147	5	6×10^{-10}	6×10^{-10}	2×10^{-10}	2×10^{-10}
		1	1×10^{-9}	6×10^{-9}	2×10^{-9}	2×10^{-9}
	Pm 149	5	2×10^{-9}	1×10^{-9}	1×10^{-9}	4×10^{-9}
		1	2×10^{-7}	1×10^{-7}	6×10^{-7}	4×10^{-7}
Protactinium (91)	Pa 230	5	2×10^{-10}	7×10^{-10}	6×10^{-11}	2×10^{-11}
		1	6×10^{-10}	7×10^{-10}	2×10^{-11}	2×10^{-11}
	Pa 231	5	1×10^{-10}	2×10^{-10}	4×10^{-10}	9×10^{-10}
		1	1×10^{-9}	2×10^{-9}	4×10^{-9}	2×10^{-9}
	Pa 232	5	6×10^{-9}	4×10^{-9}	2×10^{-9}	1×10^{-9}
		1	2×10^{-7}	2×10^{-7}	6×10^{-7}	1×10^{-6}
Radium (88)	Ra 222	5	2×10^{-10}	2×10^{-10}	6×10^{-11}	7×10^{-11}
		1	2×10^{-9}	1×10^{-9}	2×10^{-9}	4×10^{-9}
	Ra 224	5	2×10^{-10}	7×10^{-10}	2×10^{-10}	2×10^{-10}
		1	7×10^{-10}	2×10^{-9}	2×10^{-11}	2×10^{-10}
	Ra 226	5	2×10^{-11}	4×10^{-11}	2×10^{-10}	2×10^{-10}
		1	2×10^{-11}	9×10^{-11}	2×10^{-10}	2×10^{-10}
	Ra 228	5	7×10^{-11}	2×10^{-11}	2×10^{-10}	2×10^{-10}
		1	4×10^{-11}	7×10^{-11}	1×10^{-10}	2×10^{-10}
Radium (86)	Ra 220	5	2×10^{-11}		1×10^{-10}	
	Ra 223	5	2×10^{-10}		2×10^{-10}	
Rhenium (75)	Re 187	5	2×10^{-10}	2×10^{-10}	9×10^{-10}	6×10^{-10}
		1	2×10^{-9}	2×10^{-9}	2×10^{-9}	2×10^{-9}
	Re 186	5	6×10^{-10}	2×10^{-10}	2×10^{-10}	9×10^{-10}
		1	2×10^{-9}	1×10^{-9}	6×10^{-9}	2×10^{-9}
	Re 187	5	9×10^{-10}	7×10^{-10}	2×10^{-10}	2×10^{-10}
		1	2×10^{-9}	4×10^{-9}	2×10^{-9}	2×10^{-9}
	Ra 188	5	4×10^{-10}	2×10^{-10}	1×10^{-10}	6×10^{-10}
		1	2×10^{-9}	9×10^{-9}	6×10^{-9}	2×10^{-9}
Rhenium (85)	Rh 105m	5	2×10^{-10}	4×10^{-11}	2×10^{-11}	1×10^{-11}
		1	6×10^{-10}	2×10^{-10}	2×10^{-10}	1×10^{-10}
	Rh 106	5	2×10^{-10}	4×10^{-10}	2×10^{-10}	1×10^{-10}
		1	2×10^{-9}	2×10^{-9}	2×10^{-9}	1×10^{-9}
Ruthenium (44)	Ru 86	5	2×10^{-10}	2×10^{-10}	1×10^{-10}	7×10^{-10}
		1	7×10^{-10}	7×10^{-10}	2×10^{-10}	2×10^{-10}
	Ru 87	5	2×10^{-10}	9×10^{-10}	2×10^{-10}	1×10^{-10}
		1	7×10^{-9}	2×10^{-9}	2×10^{-9}	2×10^{-9}

APPENDIX B
 Concentrations in Air and Water Above Natural Background—Continued
 (See notes at end of appendix.)

Element (atomic number)	Isotope	Table 1		Table 2	
		Column 1	Column 2	Column 1	Column 2
		Air † (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Radium (88)	Ra 226	2 × 10 ⁻⁷	1 × 10 ⁻⁷	5 × 10 ⁻⁸	4 × 10 ⁻⁸
	Ra 228	2 × 10 ⁻⁷	1 × 10 ⁻⁷	4 × 10 ⁻⁸	2 × 10 ⁻⁸
	Ac 227	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	5 × 10 ⁻⁸
	Ac 228	7 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	1 × 10 ⁻⁸
	Ac 228m	5 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	1 × 10 ⁻⁸
Actinium (89)	Ac 227	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	6 × 10 ⁻⁸
	Ac 228	2 × 10 ⁻⁷	1 × 10 ⁻⁷	2 × 10 ⁻⁸	4 × 10 ⁻⁸
	Ac 228m	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Americium (95)	Am 241	4 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁸	2 × 10 ⁻⁸
	Am 243	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	4 × 10 ⁻⁸
	Am 243m	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Berkelium (97)	Bk 247	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Bk 249	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Bk 250	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Californium (98)	Cf 251	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Cf 252	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Cf 253	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Einsteinium (99)	Es 252	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Es 254	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Es 255	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Fermium (100)	Fm 257	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Fm 258	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Fm 259	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Mendelevium (101)	Md 258	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Md 260	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Md 261	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Nobelium (102)	No 259	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	No 261	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	No 262	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Lawrencium (103)	Lr 260	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Lr 262	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Lr 263	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Rutherfordium (104)	Rf 261	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Rf 263	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Rf 265	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Dubnium (105)	Db 261	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Db 263	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Db 265	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Seaborgium (106)	Sg 266	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Sg 268	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Sg 270	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Bohrium (107)	Bh 269	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Bh 271	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Bh 273	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Hassium (108)	Hs 277	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Hs 279	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Hs 281	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Meitnerium (109)	Mt 288	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Mt 290	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Mt 292	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Darmstadtium (110)	Ds 288	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Ds 290	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Ds 292	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Roentgenium (111)	Rg 289	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Rg 291	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Rg 293	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Copernicium (112)	Cn 289	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Cn 291	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Cn 293	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Nihonium (113)	Nh 291	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Nh 293	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Nh 295	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Flerovium (114)	Fl 293	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Fl 295	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Fl 297	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Livermorium (116)	Lv 293	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Lv 295	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Lv 297	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Tennessine (117)	Ts 294	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Ts 296	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Ts 298	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
Oganesson (118)	Og 294	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Og 296	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸
	Og 298	2 × 10 ⁻⁷	2 × 10 ⁻⁷	2 × 10 ⁻⁸	2 × 10 ⁻⁸

APPENDIX B
 Concentrations in Air and Water Above Natural Background—Continued
 (See notes at end of appendix.)

Element (atomic number)	Isotope ¹	Table 1		Table 2	
		Column 1	Column 2	Column 1	Column 2
		† (μCi/ml) Air	(μCi/ml) Water	(μCi/ml) Air	(μCi/ml) Water
Technetium (43)	Tc 96m	5 × 10 ⁻⁷	4 × 10 ⁻⁷	5 × 10 ⁻⁷	1 × 10 ⁻⁷
	Tc 96	5 × 10 ⁻⁷	5 × 10 ⁻⁷	1 × 10 ⁻⁷	1 × 10 ⁻⁷
	Tc 96	5 × 10 ⁻⁷	1 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Tc 97m	5 × 10 ⁻⁷	1 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Tc 97	1 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Tc 97	5 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁷	5 × 10 ⁻⁷
	Tc 99m	4 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁷	5 × 10 ⁻⁷
	Tc 99	1 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Tc 99	5 × 10 ⁻⁷	1 × 10 ⁻⁷	7 × 10 ⁻⁷	5 × 10 ⁻⁷
Tellurium (52)	Te 126m	4 × 10 ⁻⁷	5 × 10 ⁻⁷	1 × 10 ⁻⁷	5 × 10 ⁻⁷
	Te 126	1 × 10 ⁻⁷	5 × 10 ⁻⁷	4 × 10 ⁻⁷	1 × 10 ⁻⁷
	Te 127m	1 × 10 ⁻⁷	2 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Te 127	4 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁷	5 × 10 ⁻⁷
	Te 127	2 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Te 129m	5 × 10 ⁻⁷	1 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Te 129	5 × 10 ⁻⁷	5 × 10 ⁻⁷	1 × 10 ⁻⁷	5 × 10 ⁻⁷
	Te 129	5 × 10 ⁻⁷	5 × 10 ⁻⁷	2 × 10 ⁻⁷	5 × 10 ⁻⁷
	Te 129	4 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁷	5 × 10 ⁻⁷
	Te 131m	4 × 10 ⁻⁷	2 × 10 ⁻⁷	1 × 10 ⁻⁷	5 × 10 ⁻⁷
Vanadium (51)	Vb 50	5 × 10 ⁻⁷	1 × 10 ⁻⁷	1 × 10 ⁻⁷	4 × 10 ⁻⁷
	Vb 50	5 × 10 ⁻⁷	1 × 10 ⁻⁷	1 × 10 ⁻⁷	4 × 10 ⁻⁷
	Vb 50	5 × 10 ⁻⁷	1 × 10 ⁻⁷	1 × 10 ⁻⁷	4 × 10 ⁻⁷
Thallium (81)	Tl 206	1 × 10 ⁻⁷	7 × 10 ⁻⁷	4 × 10 ⁻⁷	2 × 10 ⁻⁷
	Tl 207	5 × 10 ⁻⁷	9 × 10 ⁻⁷	7 × 10 ⁻⁷	5 × 10 ⁻⁷
	Tl 207	9 × 10 ⁻⁷	2 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Tl 208	5 × 10 ⁻⁷	4 × 10 ⁻⁷	5 × 10 ⁻⁷	1 × 10 ⁻⁷
	Tl 208	5 × 10 ⁻⁷	2 × 10 ⁻⁷	5 × 10 ⁻⁷	7 × 10 ⁻⁷
Thoron (90)	Th 227	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Th 227	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Th 228	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Th 228	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Th 228	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Th 228	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Th 228	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
	Th 228	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷
Th natural	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷	5 × 10 ⁻⁷	

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued
 (See notes at end of appendix)

Element (atomic number)	Isotope	S	Table 1		Table 2	
			Column 1	Column 2	Column 1	Column 2
			† Air ($\mu\text{Ci/ml}$)	Water ($\mu\text{Ci/ml}$)	Air ($\mu\text{Ci/ml}$)	Water ($\mu\text{Ci/ml}$)
Thorium (90)	Th 234	S	6×10^{-6}	2×10^{-4}	2×10^{-6}	2×10^{-6}
	Th 230	I	2×10^{-4}	2×10^{-4}	1×10^{-6}	2×10^{-6}
Thorium (90)	Th 232	I	4×10^{-4}	1×10^{-4}	1×10^{-6}	2×10^{-6}
	Th 231	S	2×10^{-6}	1×10^{-6}	1×10^{-6}	2×10^{-6}
Th (90)	Th 230	S	1×10^{-7}	1×10^{-7}	4×10^{-6}	2×10^{-6}
	Th 231	I	2×10^{-7}	1×10^{-7}	2×10^{-6}	2×10^{-6}
Uranium (92)	U 238	S	4×10^{-7}	2×10^{-7}	1×10^{-6}	2×10^{-6}
	U 235	I	2×10^{-9}	2×10^{-9}	2×10^{-6}	2×10^{-6}
	U 234	I	1×10^{-7}	2×10^{-7}	2×10^{-6}	2×10^{-6}
	U 233	S	1×10^{-7}	2×10^{-7}	2×10^{-6}	2×10^{-6}
	U 232	S	2×10^{-7}	2×10^{-7}	2×10^{-6}	2×10^{-6}
Uranium (92)	U 234m	S	2×10^{-11}	2×10^{-11}	2×10^{-11}	2×10^{-11}
	U 234	S	1×10^{-10}	2×10^{-10}	2×10^{-11}	2×10^{-11}
	U 234	S	1×10^{-10}	2×10^{-10}	4×10^{-11}	2×10^{-11}
	U 234	S	2×10^{-10}	2×10^{-10}	2×10^{-11}	2×10^{-11}
	U 234	S	6×10^{-11}	1×10^{-10}	2×10^{-11}	2×10^{-11}
	U 234	S	1×10^{-10}	1×10^{-10}	4×10^{-11}	2×10^{-11}
	U 234	S	7×10^{-11}	1×10^{-10}	2×10^{-11}	2×10^{-11}
	U 234	S	1×10^{-10}	1×10^{-10}	2×10^{-11}	2×10^{-11}
	U 234	S	1×10^{-10}	1×10^{-10}	2×10^{-11}	2×10^{-11}
	U 234	S	2×10^{-11}	1×10^{-10}	2×10^{-11}	2×10^{-11}
Vanadium (23)	V 48	S	2×10^{-7}	1×10^{-6}	2×10^{-6}	2×10^{-6}
	V 47	I	2×10^{-7}	1×10^{-6}	2×10^{-6}	2×10^{-6}
Xenon (54)	Xe 135m	Sub	2×10^{-6}	...	2×10^{-6}	...
	Xe 135	Sub	1×10^{-6}	...	2×10^{-6}	...
	Xe 135m	Sub	1×10^{-6}	...	2×10^{-6}	...
Zirconium (78)	Zr 95	S	4×10^{-6}	2×10^{-6}	2×10^{-6}	2×10^{-6}
	Zr 91	I	2×10^{-7}	2×10^{-7}	2×10^{-6}	2×10^{-6}
Yttrium (39)	Y 90	S	1×10^{-7}	2×10^{-7}	2×10^{-6}	2×10^{-6}
	Y 91m	S	2×10^{-7}	1×10^{-7}	2×10^{-6}	2×10^{-6}
	Y 91	S	2×10^{-7}	1×10^{-7}	2×10^{-6}	2×10^{-6}
	Y 91	S	2×10^{-7}	1×10^{-7}	2×10^{-6}	2×10^{-6}
	Y 92	S	4×10^{-7}	2×10^{-7}	2×10^{-6}	2×10^{-6}
Y 90	S	2×10^{-7}	2×10^{-7}	2×10^{-6}	2×10^{-6}	
Y 90	S	2×10^{-7}	2×10^{-7}	2×10^{-6}	2×10^{-6}	
Y 90	S	1×10^{-7}	2×10^{-7}	2×10^{-6}	2×10^{-6}	

APPENDIX B
Concentrations in Air and Water Above Natural Background—Continued

Element (atomic number)	Isotope ¹	Table I		Table II		
		Column 1	Column 2	Column 1	Column 2	
		Air ($\mu\text{Ci/ml}$)	Water ($\mu\text{Ci/ml}$)	Air ($\mu\text{Ci/ml}$)	Water ($\mu\text{Ci/ml}$)	
Zinc (80)	Zn 65	1 x 10 ⁻⁷	2 x 10 ⁻⁷	4 x 10 ⁻⁷	1 x 10 ⁻⁶	
		6 x 10 ⁻⁷	2 x 10 ⁻⁷	2 x 10 ⁻⁷	2 x 10 ⁻⁷	
	Zn 69m	4 x 10 ⁻⁷	2 x 10 ⁻⁷	1 x 10 ⁻⁶	7 x 10 ⁻⁷	
		2 x 10 ⁻⁷	2 x 10 ⁻⁷	1 x 10 ⁻⁶	6 x 10 ⁻⁷	
Zinc (80)	Zn 69	7 x 10 ⁻⁷	2 x 10 ⁻⁷	2 x 10 ⁻⁷	2 x 10 ⁻⁷	
		9 x 10 ⁻⁷	2 x 10 ⁻⁷	2 x 10 ⁻⁷	2 x 10 ⁻⁷	
	Erbiumium (80)	Er 93	1 x 10 ⁻⁷	2 x 10 ⁻⁷	4 x 10 ⁻⁷	2 x 10 ⁻⁷
			2 x 10 ⁻⁷	2 x 10 ⁻⁷	1 x 10 ⁻⁶	2 x 10 ⁻⁷
Erbiumium (80)	Er 93	1 x 10 ⁻⁷	2 x 10 ⁻⁷	4 x 10 ⁻⁷	2 x 10 ⁻⁷	
	Er 93	1 x 10 ⁻⁷	2 x 10 ⁻⁷	4 x 10 ⁻⁷	2 x 10 ⁻⁷	
	Er 97	1 x 10 ⁻⁷	2 x 10 ⁻⁷	4 x 10 ⁻⁷	2 x 10 ⁻⁷	
Erbiumium (80)		7 x 10 ⁻⁷	2 x 10 ⁻⁷	2 x 10 ⁻⁷	2 x 10 ⁻⁷	
	Sub	1 x 10 ⁻⁷		2 x 10 ⁻⁷		
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.						
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.		2 x 10 ⁻⁷	9 x 10 ⁻⁷	1 x 10 ⁻⁶	2 x 10 ⁻⁶	
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission.		6 x 10 ⁻⁸	4 x 10 ⁻⁷	2 x 10 ⁻⁶	2 x 10 ⁻⁶	

¹Specific (E), available (E)
²"Ac" means that values given are for substances in a concentration of one curie of activity per gram of substance.

* These radon concentrations are appropriate for protection from radon-222 combined with its short-lived daughters. Alternatively, the value in Table I may be replaced by one-third (1/3) "working level." (A "working level" is defined as any combination of short-lived radon-222 daughters, polonium-218, lead-214, bismuth-214 and polonium-214, in one liter of air, without regard to the degree of equilibrium, that will result in the ultimate emission of 1.3 x 10⁵ MeV of alpha particle energy.) The Table II value may be replaced by one-thirtieth (1/30) of a "working level." The limit on radon-222 concentrations in restricted areas may be based on an annual average.

† 4. For soluble mixtures of U-235, U-238 and U-233 in air chemical activity may be the limiting factor. If the percent by weight (enrichment) of U-235 is less than 5, the concentration value for a 60-hour workweek, Table I, is 0.5 milligram uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 60-hour workweek shall not exceed 2 x 10⁻⁴ SA $\mu\text{Ci-hr/ml}$, where SA is the specific activity of the uranium isotope. The concentration value for Table II is 0.007 milligram uranium per cubic meter of air. The specific activity for natural uranium is 0.71 x 10⁻⁶ curies per gram U. The specific activity for other mixtures of U-235, U-238 and U-233, if not known, shall be:
SA = 0.8 x 10⁻⁶ curies/gram U U-depleted
SA = (0.4 + 0.28 E + 0.006 E²) 10⁻⁶ E 2.7
where E is the percentage by weight of U-235, expressed as percent.

* Amended 27 FR 22319.
** Amended 29 FR 22990; footnote redesignated 40 FR 20704.
*** Amended 40 FR 20704.
† Amended 28 FR 24314.
‡ Amended 29 FR 25642; redesignated 40 FR 20704.

PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

NOTE TO APPENDIX B

NOTE: In any case where there is a mixture in air or water of more than one radionuclide, the limiting value for purposes of this Appendix should be determined as follows:

1. If the identity and concentration of each radionuclide in the mixture are known, the limiting values should be derived as follows: Determine, for each radionuclide in the mixture, the ratio between the quantity present in the mixture and the limit otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all the radionuclides in the mixture shall 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 MPCs are MPC_A, MPC_B, and MPC_C respectively, then the concentrations shall be limited so that the following relationship exists:

C_A / MPC_A + C_B / MPC_B + C_C / MPC_C ≤ 1

2. If either the identity or the concentration of any radionuclide in the mixture is not known, the limiting value for purposes of Appendix B shall be:

- a. For purposes of Table I, Col. 1--6 x 10⁻⁶
b. For purposes of Table I, Col. 2--4 x 10⁻⁶
c. For purposes of Table II, Col. 1--2 x 10⁻⁶
d. For purposes of Table II, Col. 2--4 x 10⁻⁶

3. If any of the conditions specified below are met, the corresponding values specified below may be used in lieu of those specified in paragraph 2 above.

a. If the identity of each radionuclide in the mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the concentration limit for the mixture is the limit specified in Appendix "B" for the radionuclide in the mixture having the lowest concentration limit; or

b. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in Appendix "B" are not present in the mixture, the concentration limit for the mixture is the lowest concentration limit specified in Appendix "B" for any radionuclide which is not known to be absent from the mixture; or

Table with 4 columns: a. Element (atomic number) and isotopes, Column 1 Air (pCi/ml), Column 2 Water (pCi/ml), Column 3 Air (pCi/ml), Column 4 Water (pCi/ml). Rows list various elements and isotopes with corresponding activity limits.

4. If a mixture of radionuclides consists of uranium and its daughters in one that prior to chemical separation of the uranium from the ore, the value specified below may be used for uranium and its daughters through radium-226, instead of those from paragraph 1, 2, or 3 above.

a. For purposes of Table I, Col. 1--2x10⁻⁶ pCi/ml gross alpha activity; or 5x10⁻⁶ pCi/ml natural uranium; or 7.5 micrograms per cubic meter of air natural uranium.

b. For purposes of Table II, Col. 1--6 x 10⁻⁶ pCi/ml gross alpha activity; or 2x10⁻⁶ pCi/ml natural uranium; or 3 micrograms per cubic meter of air natural uranium.

5. For purposes of this note, a radionuclide may be considered as not present in a mixture if (a) the ratio of the concentration of that radionuclide in the mixture (C_i) to the concentration limit for that radionuclide specified in Table II of Appendix B (MPC_i) does not exceed the

(a) C_i / MPC_i ≤ 1/10 and (b) the sum of such ratios for all the radionuclides considered as not present in the mixture does not exceed 1/10.

(b) C₁ / MPC₁ + C₂ / MPC₂ + ... ≤ 1/10

PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

Appendix C to §§20.1-20.601

Material	Microcuries
Americium-241	.01
Antimony-122	100
Antimony-124	10
Antimony-126	10
Arsenic-73	100
Arsenic-76	10
Arsenic-78	10
Arsenic-77	100
Barium-131	10
Bismuth-213	10
Bismuth-210	1
Bromine-82	10
Cadmium-109	10
Cadmium-115m	10
Cadmium-115	100
Calcium-45	10
Calcium-47	10
Carbon-14	100
Cerium-141	100
Cerium-143	100
Cerium-144	1
Cesium-137	1,000
Cesium-134m	100
Cesium-134	1
Cesium-135	10
Cesium-136	10
Cesium-137	10
Chlorine-36	10
Chlorine-38	10
Chromium-51	1,000
Cobalt-58m	10
Cobalt-58	10
Cobalt-60	1
Copper-64	100
Dysprosium-165	10
Dysprosium-166	100
Erbium-168	100
Erbium-171	100
Europium-152 0.2 h	100
Europium-152 12.7 h	1
Europium-154	1
Europium-155	10
Fluorine-18	1,000
Gadolinium-153	10
Gadolinium-156	100
Gallium-72	10
Germanium-71	100
Gold-198	100
Gold-199	100
Helium-3	10
Holmium-166	100
Hydrogen-3	1,000
Indium-113m	100
Indium-114m	10
Indium-115m	100
Indium-115	10
Iodine-125	1
Iodine-126	1
Iodine-129	0.1
Iodine-131	1
Iodine-132	10
Iodine-133	1
Iodine-134	10
Iodine-135	10
Iridium-192	100
Iridium-194	100
Iron-55	10
Iron-59	100
Krypton-85	10
Krypton-87	10
Lanthanum-140	10
Lithium-7	100
Manganese-52	10
Manganese-54	10
Manganese-56	10
Mercury-187m	100
Mercury-187	100
Mercury-203	10
Neodymium-147	100
Neodymium-150	100
Nickel-60	100
Nickel-63	10
Nickel-65	100
Niobium-93m	10
Niobium-95	10
Niobium-97	10
Osmium-186	10

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Material	Microcuries
Osmium-191m	100
Osmium-191	100
Osmium-196	100
Palladium-106	100
Palladium-109	100
Phosphorus-32	10
Platinum-191	100
Platinum-193m	100
Platinum-193	100
Platinum-197m	100
Platinum-197	100
Plutonium-239	100
Potassium-40	0.1
Potassium-42	10
Praseodymium-143	100
Praseodymium-145	100
Promethium-147	10
Promethium-148	10
Radium-226	0.1
Rhenium-186	100
Rhenium-187	100
Rhodium-105m	100
Rhodium-106	100
Rubidium-86	10
Rubidium-87	10
Ruthenium-97	100
Ruthenium-100	10
Ruthenium-104	10
Ruthenium-106	1
Samarium-151	10
Samarium-153	100
Scandium-44	10
Scandium-47	100
Scandium-48	10
Selenium-75	10
Silicon-31	100
Silver-106	10
Silver-110m	1
Silver-111	100
Sodium-24	10
Strontium-88	10
Strontium-89	0.1
Strontium-90	10
Strontium-91	10
Strontium-93	10
Sulphur-35	100
Tantalum-182	10
Technetium-96	10
Technetium-97m	100
Technetium-97	100
Technetium-99m	100
Technetium-99	10
Tellurium-125m	10
Tellurium-127m	10
Tellurium-127	100
Tellurium-129m	10
Tellurium-130	100
Tellurium-131m	10
Tellurium-132	10
Terbium-160	10
Thallium-200	100
Thallium-201	100
Thallium-202	100
Thallium-204	10
Thorium (natural) ¹	100
Thulium-170	10
Thulium-171	10
Tin-113	10
Tin-125	10
Tungsten-187	10
Tungsten-188	100
Tungsten-187	100
Uranium (natural) ²	0.1
Uranium-233	0.1
Uranium-235-Uranium-235	0.1
Vanadium-50	10
Xenon-133m	1,000
Xenon-135	100
Xenon-136	100
Ytterbium-175	10
Yttrium-90	10
Yttrium-91	10
Yttrium-92	100
Yttrium-93	100
Zinc-65	10
Zinc-69m	100
Zinc-69	1,000
Zirconium-93	10
Zirconium-95	10
Zirconium-97	10

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Any alpha emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition .01

Any radionuclide other than alpha emitting radionuclides, not listed above or mixtures of beta emitters of unknown composition... 1

Note.—For purposes of § 20.203, where there is involved a combination of isotopes in known amounts, the limit for the combination should be derived as follows. Determine, for each isotope in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific isotope when not in combination. The sum of such ratios for all the isotopes in the combination may not exceed "1" (i.e., "unity").

¹Based on alpha disintegration rate of Th-232, Th-230 and their daughter products.

²Based on alpha disintegration rate of U-238, U-235, and U-235.

³Amended 24 FR 16848.

⁴Amended 24 FR 13490.

PART 20 • STANDARDS FOR PROTECTION AGAINST RADIATION

Appendix D to §§20.1-20.601—
United States Nuclear Regulatory Commission Regional Offices

	Address	Telephone (24 hours)
Region I Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont	USNRC, 475 Alrendale Road, King of Prussia, PA 19406	(215) 937-8000 (FTS) 346-5000
Region II Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, Puerto Rico, South Carolina, Tennessee, Virginia, Virgin Islands, and West Virginia	USNRC, 101 Marietta Street, NW, Suite 2900, Atlanta, GA 30323	(404) 331-4503 (FTS) 342-4500
Region III Arizona, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin	USNRC, 799 Roosevelt Road, Glen Ellyn, IL 60137	(708) 790-5500 (FTS) 366-5500
Region IV Arkansas, Colorado, Idaho, Kansas, Louisiana, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming	USNRC, 611 Ryan Plaza Drive, Suite 1000, Arlington, TX 76011	(817) 963-6100 (FTS) 729-6100
Region V Field Office	USNRC, Region V Uranium Recovery Field Office, 730 Birme Street, P.O. Box 25325, Denver, CO 80225	(303) 236-2805 (FTS) 776-2805
Region VI Alaska, Arizona, California, Hawaii, Nevada, Oregon, Pacific Trust Territories, and Washington	USNRC, 1450 Marin Lane, Suite 210, Walnut Creek, CA 94596	(510) 975-0200

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Regulations Mandatory as of January 1, 1994, With Earlier Compliance Encouraged

Subpart A—General Provisions

§ 20.1001 Purpose.

(a) The regulations in this part establish standards for protection against ionizing radiation resulting from activities conducted under licenses issued by the Nuclear Regulatory Commission. These regulations are issued under the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974, as amended.

(b) It is the purpose of the regulations in this part to control the receipt, possession, use, transfer, and disposal of licensed material by any licensee in such a manner that the total dose to an individual (including doses resulting from licensed and unlicensed radioactive material and from radiation sources other than background radiation) does not exceed the standards for protection against radiation prescribed in the regulations in this part. However, nothing in this part shall be construed as limiting actions that may be necessary to protect health and safety.

§ 20.1002 Scope.

The regulations in this part apply to persons licensed by the Commission to receive, possess, use, transfer, or dispose of byproduct, source, or special nuclear material or to operate a production or utilization facility under parts 30 through 35, 39, 40, 50, 60, 61, 70, or 72 of this chapter. The limits in this part do not apply to doses due to background radiation, to exposure of patients to radiation for the purpose of

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medical diagnosis or therapy, or to voluntary participation in medical research programs.

§ 20.1003 Definitions.

As used in this part:

Absorbed dose means the energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the gray (Gy).

Act means the Atomic Energy Act of 1954 (42 U.S.C. 2011 et seq.), as amended.

Activity is the rate of disintegration (transformation) or decay of radioactive material. The units of activity are the curie (Ci) and the becquerel (Bq).

Adult means an individual 18 or more years of age.

Airborne radioactive material means radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases.

Airborne radioactivity area means a room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations—

- (1) in excess of the derived air concentrations (DACs) specified in appendix B, to §§ 20.1001-20.2401, or
- (2) to such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

ALARA (acronym for "as low as is reasonably achievable") means making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of

improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

Annual limit on intake (ALI) means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 5 rems (0.05 Sv) or a committed dose equivalent of 50 rems (0.5 Sv) to any individual organ or tissue. (ALI values for intake by ingestion and by inhalation of selected

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radionuclides are given in Table 1. Columns 1 and 2, of appendix B to §§ 20.1001-20.2401).

Background radiation means radiation from cosmic sources: naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material) and global fallout as it exists in the environment from the testing of nuclear explosive devices. "Background radiation" does not include radiation from source, byproduct, or special nuclear materials regulated by the Commission.

Bioassay (radiobioassay) means the determination of kinds, quantities or concentrations, and, in some cases, the locations of radioactive material in the human body, whether by direct measurement (in vivo counting) or by analysis and evaluation of materials excreted or removed from the human body.

Byproduct material means—

- (1) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material; and
- (2) The tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by these solution extraction operations do not constitute "byproduct material" within this definition.

Class (or *lung class* or *inhalation class*) means a classification scheme for inhaled material according to its rate of clearance from the pulmonary region of the lung. Materials are classified as D, W, or Y, which applies to a range of clearance half-times: for Class D (Days) of less than 10 days, for Class W (Weeks) from 10 to 100 days, and for Class Y (Years) of greater than 100 days.

Collective dose is the sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation.

Commission means the Nuclear Regulatory Commission or its duly authorized representatives.

Committed dose equivalent ($H_{T,50}$) means the dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Committed effective dose equivalent ($H_{E,50}$) is the sum of the products of the weighting factors applicable to each of

the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues ($H_{E,50} = \sum w_T H_{T,50}$).

Controlled area means an area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason.

Declared pregnant woman means a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

Deep-dose equivalent (H_d), which applies to external whole-body exposure, is the dose equivalent at a tissue depth of 1 cm (1000 mg/cm²).

Department means the Department of Energy established by the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565, 42 U.S.C. 7101 et seq.) to the extent that the Department, or its duly authorized representatives, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers, and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to sections 104 (b), (c), and (d) of the Energy Reorganization Act of 1974 (Pub. L. 93-438, 88 Stat. 1233 at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to section 301(a) of the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565 at 577-578, 42 U.S.C. 7151).

Derived air concentration (DAC) means the concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI. DAC values are given in Table 1, Column 3, of appendix B to §§ 20.1001-20.2401.

Derived air concentration-hour (DAC-hour) is the product of the concentration of radioactive material in air (expressed as a fraction or multiple of the derived air concentration for each radionuclide) and the time of exposure to that radionuclide, in hours. A licensee may take 2,000 DAC-hours to represent one ALI, equivalent to a committed effective dose equivalent of 5 rems (0.05 Sv).

Dose or radiation dose is a generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined in other paragraphs of this section.

Dose equivalent (H_T) means the product of the absorbed dose in tissue,

quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

Dosimetry processor means an individual or organization that processes and evaluates individual monitoring equipment in order to determine the radiation dose delivered to the equipment.

Effective dose equivalent (H_E) is the sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (w_T) applicable to each of the body organs or tissues that are irradiated ($H_E = \sum w_T H_T$).

Embryo/fetus means the developing human organism from conception until the time of birth.

Entrance or access point means any location through which an individual could gain access to radiation areas or to radioactive materials. This includes entry or exit portals of sufficient size to permit human entry, irrespective of their intended use.

Exposure means being exposed to ionizing radiation or to radioactive material.

External dose means that portion of the dose equivalent received from radiation sources outside the body.

Extremity means hand, elbow, arm below the elbow, foot, knee, or leg below the knee.

Eye dose equivalent applies to the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeter (300 mg/cm²).

Generally applicable environmental radiation standards means standards issued by the Environmental Protection Agency (EPA) under the authority of the Atomic Energy Act of 1954, as amended, that impose limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material.

Government agency means any executive department, commission, independent establishment, corporation wholly or partly owned by the United States of America, which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government.

Gray (See § 20.1004).

High radiation area means an area, accessible to individuals, in which radiation levels 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 from any surface that the radiation penetrates.

Individual means any human being.

Individual monitoring means—

(1) The assessment of dose equivalent by the use of devices designed to be worn by an individual;

(2) The assessment of committed effective dose equivalent by bioassay (see *Bioassay*) or by determination of the time-weighted air concentrations to which an individual has been exposed, i.e., DAC-hours; or

(3) The assessment of dose equivalent by the use of survey data.

Individual Monitoring Devices (individual monitoring equipment) means devices designed to be worn by a single individual for the assessment of dose equivalent such as film badges, thermoluminescent dosimeters (TLDs), pocket ionization chambers, and personal ("lapel") air sampling devices.

Internal dose means that portion of the dose equivalent received from radioactive material taken into the body.

License means a license issued under the regulations in parts 30 through 35, 39, 40, 50, 60, 61, 70, or 72 of this chapter.

Licensed material means source material, special nuclear material, or byproduct material received, possessed, used, transferred or disposed of under a general or specific license issued by the Commission.

Licensee means the holder of a license.

Limits (dose limits) means the permissible upper bounds of radiation doses.

Lost or missing licensed material means licensed material whose location is unknown. It includes material that has been shipped but has not reached its destination and whose location cannot be readily traced in the transportation system.

Member of the public means an individual in a controlled or unrestricted area. However, an individual is not a member of the public during any period in which the individual receives an occupational dose.

Minor means an individual less than 18 years of age.

Monitoring (radiation monitoring, radiation protection monitoring) means the measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses.

Nonstochastic effect means health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced

cataract formation is an example of a nonstochastic effect (also called a deterministic effect).

NRC means the Nuclear Regulatory Commission or its duly authorized representatives.

Occupational dose means the dose received by an individual in a restricted area or in the course of employment in which the individual's assigned duties involve exposure to radiation and to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include dose received from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the general public.

Person means—

(1) Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission or the Department of Energy (except that the Department shall be considered a person within the meaning of the regulations in 10 CFR chapter I to the extent that its facilities and activities are subject to the licensing and related regulatory authority of the Commission under section 202 of the Energy Reorganization Act of 1974 (88 Stat. 1244), the Uranium Mill Tailings Radiation Control Act of 1978 (92 Stat. 3021), the Nuclear Waste Policy Act of 1982 (96 Stat. 2201), and section 3(b)(2) of the Low-Level Radioactive Waste Policy Amendments Act of 1985 (99 Stat. 1842)), any State or any political subdivision of or any political entity within a State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and

(2) Any legal successor, representative, agent, or agency of the foregoing.

Planned special exposure means an infrequent exposure to radiation, separate from and in addition to the annual dose limits.

Public dose means the dose received by a member of the public from exposure to radiation and to radioactive material released by a licensee, or to another source of radiation either within a licensee's controlled area or in unrestricted areas. It does not include occupational dose or doses received from background radiation, as a patient from medical practices, or from voluntary participation in medical research programs.

Quality Factor (Q) means the modifying factor (listed in tables

1004(b).1 and 1004(b).2 of § 20.1004) that is used to derive dose equivalent from absorbed dose.

Quarter means a period of time equal to one-fourth of the year observed by the licensee (approximately 13 consecutive weeks), providing that the beginning of the first quarter in a year coincides with the starting date of the year and that no day is omitted or duplicated in consecutive quarters.

Rad (See § 20.1004).

Radiation (ionizing radiation) means alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in this part, does not include non-ionizing radiation, such as radio- or microwaves, or visible, infrared, or ultraviolet light.

Radiation area means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Reference man means a hypothetical aggregation of human physical and physiological characteristics arrived at by international consensus. These characteristics may be used by researchers and public health workers to standardize results of experiments and to relate biological insult to a common base.

Rem (See § 20.1004).

Respiratory protective device means an apparatus, such as a respirator, used to reduce the individual's intake of airborne radioactive materials.

Restricted area means an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

Sanitary sewerage means a system of public sewers for carrying off waste water and refuse, but excluding sewage treatment facilities, septic tanks, and leach fields owned or operated by the licensee.

Shallow-dose equivalent (H_s), which applies to the external exposure of the skin or an extremity, is taken as the dose equivalent at a tissue depth of 0.007 centimeter (7 mg/cm²) averaged over an area of 1 square centimeter.

Sievert (See § 20.1004).

Site boundary means that line beyond which the land or property is not owned, leased, or otherwise controlled by the licensee.

Source material means—

(1) Uranium or thorium or any combination of uranium and thorium in any physical or chemical form; or

(2) Ores that contain, by weight, one-twentieth of 1 percent (0.05 percent), or more, of uranium, thorium, or any combination of uranium and thorium. Source material does not include special nuclear material.

Special nuclear material means—

(1) Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material that the Commission, pursuant to the provisions of section 51 of the Act, determines to be special nuclear material, but does not include source material; or

(2) Any material artificially enriched by any of the foregoing but does not include source material.

Stochastic effects means health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

Survey means an evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

Total Effective Dose Equivalent (TEDE) means the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Unrestricted area means an area, access to which is neither limited nor controlled by the licensee.

Uranium fuel cycle means the operations of milling of uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using uranium fuel, and reprocessing of spent uranium fuel to the extent that these activities directly support the production of electrical power for public use. Uranium fuel cycle does not include mining operations, operations at waste disposal sites, transportation of radioactive material in support of these operations, and the reuse of recovered non-uranium special nuclear and byproduct materials from the cycle.

Very high radiation area means an area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in 1 hour at 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)).

Week means 7 consecutive days starting on Sunday.

Weighting factor w_T , for an organ or tissue (T) is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective dose equivalent, the values of w_T are:

ORGAN DOSE WEIGHTING FACTORS

Organ or tissue	w_T
Gonads.....	0.25
Breast.....	0.15
Red bone marrow.....	0.12
Lung.....	0.12
Thyroid.....	0.03
Bone surfaces.....	0.03
Remainder.....	¹ 0.30
Whole Body.....	* 1.00

¹ 0.30 results from 0.06 for each of 5 "remainder" organs (excluding the skin and the lens of the eye) that receive the highest doses.

* For the purpose of weighting the external whole body dose (for adding it to the internal dose), a single weighting factor, $w_T = 1.0$, has been specified. The use of other weighting factors for external exposure will be approved on a case-by-case basis until such time as specific guidance is issued.

Whole body means, for purposes of external exposure, head, trunk (including male gonads), arms above the elbow, or legs above the knee.

Working level (WL) is any combination of short-lived radon daughters (for radon-222: polonium-218, lead-214, bismuth-214, and polonium-214; and for radon-220: polonium-218, lead-212, bismuth-212, and polonium-212) in 1 liter of air that will result in the ultimate emission of 1.3×10^8 MeV of potential alpha particle energy.

Working level month (WLM) means an exposure to 1 working level for 170 hours (2,000 working hours per year/12 months per year = approximately 170 hours per month).

Year means the period of time beginning in January used to determine compliance with the provisions of this part. The licensee may change the starting date of the year used to determine compliance by the licensee provided that the change is made at the beginning of the year and that no day is

omitted or duplicated in consecutive years.

§ 20.1004 Units of radiation dose.

(a) Definitions. As used in this part, the units of radiation dose are:

Gray (Gy) is the SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 joule/kilogram (100 rads).

Rad is the special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram or 0.01 joule/kilogram (0.01 gray).

Rem is the special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem = 0.01 sievert).

Sievert is 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 rems).

(b) As used in this part, the quality factors for converting absorbed dose to dose equivalent are shown in table 1004(b).1.

TABLE 1004(b).1.—QUALITY FACTORS AND ABSORBED DOSE EQUIVALENCIES

Type of radiation	Quality factor	Absorbed dose equal to a unit dose equivalent *
	(Q)	
X-, gamma, or beta radiation.....	1	1
Alpha particles, multiple-charged particles, fission fragments and heavy particles of unknown charge.....	20	0.05
Neutrons of unknown energy.....	10	0.1
High-energy protons.....	10	0.1

* Absorbed dose in rad equal to 1 rem or the absorbed dose in gray equal to 1 sievert.

(c) If it is more convenient to measure the neutron fluence rate than to determine the neutron dose equivalent rate in rems per hour or sieverts per hour, as provided in paragraph (b) of this section, 1 rem (0.01 Sv) of neutron radiation of unknown energies may, for purposes of the regulations in this part, be assumed to result from a total fluence of 25 million neutrons per square centimeter incident upon the body. If sufficient information exists to estimate the approximate energy distribution of the neutrons, the licensee may use the fluence rate per unit dose equivalent or the appropriate Q value from table 1004(b).2 to convert a measured tissue dose in rads to dose equivalent in rems.

TABLE 1004(b).2.—MEAN QUALITY FACTORS, Q, AND FLUENCE PER UNIT DOSE EQUIVALENT FOR MONOENERGETIC NEUTRONS

	Neutron energy (MeV)	Quality factor ^a (Q)	Fluence per unit dose equivalent ^b (neutrons cm ⁻² rem ⁻¹)
(thermal)	2.5×10^{-4}	2	960×10^4
	1×10^{-3}	2	960×10^4
	1×10^{-2}	2	810×10^4
	1×10^{-1}	2	810×10^4
	1×10^0	2	840×10^4
	1×10^1	2	960×10^4
	1×10^2	2.5	1010×10^4
	1×10^3	7.5	170×10^4
	5×10^3	11	39×10^4
	1	11	27×10^4
	2.5	9	29×10^4
	5	8	23×10^4
	7	7	24×10^4
	10	6.5	24×10^4
	14	7.5	17×10^4
	20	8	16×10^4
	40	7	14×10^4
	60	5.5	16×10^4
	1×10^7	4	20×10^4
2×10^7	3.5	19×10^4	
3×10^7	3.5	16×10^4	
4×10^7	3.5	14×10^4	

^a Value of quality factor (Q) at the point where the dose equivalent is maximum in a 30-cm diameter cylinder tissue-equivalent phantom.

^b Monoenergetic neutrons incident normally on a 30-cm diameter cylinder tissue-equivalent phantom.

§ 20.1005 Units of radioactivity.

For the purposes of this part, activity is expressed in the special unit of curies (Ci) or in the SI unit of becquerels (Bq), or their multiples, or disintegrations (transformations) per unit of time.

(a) One becquerel = 1 disintegration per second (s⁻¹).

(b) One curie = 3.7×10^{10} disintegrations per second = 3.7×10^{10} becquerels = 2.22×10^{12} disintegrations per minute.

§ 20.1006 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by an officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

§ 20.1007 Communications.

Unless otherwise specified, communications or reports concerning the regulations in this part should be addressed to the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, DC 20555. A communication, report, or application may be delivered in person to the Office of the Executive Director for Operations, 11555 Rockville Pike, Rockville, MD 20852.

§ 20.1008 Implementation.

(a) Licensees shall implement the provisions of §§ 20.1001-20.2401 on or before January 1, 1994. If a licensee chooses to implement the provisions of §§ 20.1001-20.2401 prior to January 1, 1994, the licensee shall implement all provision of these sections not otherwise exempted by paragraph (d) of this section, and shall provide written notification to either the Director of the Office of Nuclear Materials Safety and Safeguards or the Director of the Office of Nuclear Reactor Regulation, as appropriate, that the licensee is adopting early implementation of §§ 20.1001-20.2401 and associated appendices. Until January 1, 1994, or until the licensee notifies the Commission of early implementation, compliance will be required with §§ 20.1-20.601 of this part.

(b) After the time the licensee implements §§ 20.1001-20.2401, the applicable section of §§ 20.1001-20.2401 shall be used in lieu of any section in §§ 20.1-20.601 of this part that is cited in license conditions or technical specifications, except as specified in paragraphs (c), (d) and (e) of this section. If the requirements of this part are more restrictive than the existing license condition, then the licensee shall comply with this part unless exempted by paragraph (d) of this section.

(c) Any existing license condition or technical specification that is more restrictive than a requirement in §§ 20.1001-20.2401 remains in force until there is a technical specification change, license amendment, or license renewal.

(d) If a license condition or technical specification exempted a licensee from a provision of Part 20 in §§ 20.1-20.601, it exempts a licensee from the corresponding provision of §§ 20.1001-20.2401.

(e) If a license condition cites provisions in §§ 20.1-20.601 and there are no corresponding provisions in §§ 20.1001-20.2401, then the license condition remains in force until there is a technical specification change, license amendment, or license renewal that modifies or removes this condition.

§ 20.1009 Reporting, recording, and application requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control number 3150-0014.

(b) The approved information collection requirements contained in this part appear in §§ 20.1101, 20.1202, 20.1204, 20.1206, 20.1301, 20.1501, 20.1601, 20.1703, 20.1901, 20.1902, 20.1904, 20.1906, 20.2002, 20.2004, 20.2006, 20.2102, 20.2103, 20.2104, 20.2105, 20.2106, 20.2107, 20.2108, 20.2110, 20.2201, 20.2202, 20.2203, 20.2204, 20.2206, and appendix F to 20.1001-20.2401.

(c) This part contains information collection requirements in addition to those approved under the control number specified in paragraph (a) of this section. These information collection requirements and the control numbers under which they are approved are as follows:

(1) In § 20.2104, NRC Form 4 is approved under control number 3150-0005.

(2) In §§ 20.2108 and 20.2206, NRC Form 5 is approved under control number 3150-0006.

Subpart B—Radiation Protection Programs

§ 20.1101 Radiation protection programs.

(a) Each licensee shall develop, document, and implement a radiation protection program commensurate with the scope and extent of licensed activities and sufficient to ensure compliance with the provisions of this part. (See § 20.2102 for recordkeeping requirements relating to these programs.)

(b) The licensee shall use, to the extent practicable, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA).

(c) The licensee shall periodically (at least annually) review the radiation protection program content and implementation.

Subpart C—Occupational Dose Limits

§ 20.1201 Occupational dose limits for adults.

(a) The licensee shall control the occupational dose to individual adults, except for planned special exposures under § 20.1206, to the following dose limits.

(1) An annual limit, which is the more limiting of—

(i) The total effective dose equivalent being equal to 5 rems (0.05 Sv); or

(ii) The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems (0.5 Sv).

(2) The annual limits to the lens of the eye, to the skin, and to the extremities, which are:

(i) An eye dose equivalent of 15 rems (0.15 Sv), and

(ii) A shallow-dose equivalent of 50 rems (0.50 Sv) to the skin or to any extremity.

(b) Doses received in excess of the annual limits, including doses received during accidents, emergencies, and planned special exposures, must be subtracted from the limits for planned special exposures that the individual may receive during the current year (see

§ 20.1206(e)(1)) and during the individual's lifetime (see § 20.1206(e)(2)).

(c) The assigned deep-dose equivalent and shallow-dose equivalent must be for the part of the body receiving the highest exposure. The deep-dose equivalent, eye dose equivalent and shallow-dose equivalent may be assessed from surveys or other radiation measurements for the purpose of demonstrating compliance with the occupational dose limits, if the individual monitoring device was not in the region of highest potential exposure, or the results of individual monitoring are unavailable.

(d) Derived air concentration (DAC) and annual limit on intake (ALI) values are presented in table 1 of appendix B to §§ 20.1001–20.2401 and may be used to determine the individual's dose (see § 20.2106) and to demonstrate compliance with the occupational dose limits.

(e) In addition to the annual dose limits, the licensee shall limit the soluble uranium intake by an individual to 10 milligrams in a week in consideration of chemical toxicity (see footnote 3 of appendix B to §§ 20.1001–20.2401).

(f) The licensee shall reduce the dose that an individual may be allowed to receive in the current year by the amount of occupational dose received while employed by any other person (see § 20.2104(e)).

§ 20.1202 Compliance with requirements for summation of external and internal doses.

(a) If the licensee is required to monitor under both §§ 20.1502(a) and (b), the licensee shall demonstrate compliance with the dose limits by summing external and internal doses. If the licensee is required to monitor only under § 20.1502(a) or only under § 20.1502(b), then summation is not required to demonstrate compliance with the dose limits. The licensee may demonstrate compliance with the requirements for summation of external and internal doses by meeting one of the conditions specified in paragraph (b) of this section and the conditions in paragraphs (c) and (d) of this section.

(Note: The dose equivalents for the lens of the eye, the skin, and the extremities are not included in the summation, but are subject to separate limits.)

(b) *Intake by inhalation.* If the only intake of radionuclides is by inhalation, the total effective dose equivalent limit is not exceeded if the sum of the deep-dose equivalent divided by the total effective dose equivalent limit, and one of the following, does not exceed unity:

- (1) The sum of the fractions of the inhalation ALI for each radionuclide, or
- (2) The total number of derived air concentration-hours (DAC-hours) for all radionuclides divided by 2,000, or

(3) The sum of the calculated committed effective dose equivalents to all significantly irradiated¹ organs or tissues (T) calculated from bioassay data using appropriate biological models and expressed as a fraction of the annual limit.

(c) *Intake by oral ingestion.* If the occupationally exposed individual also receives an intake of radionuclides by oral ingestion greater than 10 percent of the applicable oral ALI, the licensee shall account for this intake and include it in demonstrating compliance with the limits.

(d) *Intake through wounds or absorption through skin.* The licensee shall evaluate and, to the extent practical, account for intakes through wounds or skin absorption.

Note: The intake through intact skin has been included in the calculation of DAC for hydrogen-3 and does not need to be further evaluated.

§ 20.1203 Determination of external dose from airborne radioactive material.

Licensees shall, when determining the dose from airborne radioactive material, include the contribution to the deep-dose equivalent, eye dose equivalent, and shallow-dose equivalent from external exposure to the radioactive cloud (see appendix B to §§ 20.1001–20.2401, footnotes 1 and 2).

Note: Airborne radioactivity measurements and DAC values should not be used as the primary means to assess the deep-dose equivalent when the airborne radioactive material includes radionuclides other than noble gases or if the cloud of airborne radioactive material is not relatively uniform. The determination of the deep-dose equivalent to an individual should be based upon measurements using instruments or individual monitoring devices.

§ 20.1204 Determination of internal exposures.

(a) For purposes of assessing dose used to determine compliance with occupational dose equivalent limits, the licensee shall, when required under § 20.1502, take suitable and timely measurements of—

- (1) Concentrations of radioactive materials in air in work areas; or
- (2) Quantities of radionuclides in the body; or

¹An organ or tissue is deemed to be significantly irradiated if for that organ or tissue, the product of the weighting factor, w_T , and the committed dose equivalent, $H_{T,50}$, per unit intake is greater than 10 percent of the maximum weighted value of $H_{T,50}$ (i.e., $w_T H_{T,50}$) per unit intake for any organ or tissue.

(3) Quantities of radionuclides excreted from the body; or

(4) Combinations of these measurements.

(b) Unless respiratory protective equipment is used, as provided in § 20.1703, or the assessment of intake is based on bioassays, the licensee shall assume that an individual inhales radioactive material at the airborne concentration in which the individual is present.

(c) When specific information on the physical and biochemical properties of the radionuclides taken into the body or the behavior of the material in an individual is known, the licensee may—

(1) Use that information to calculate the committed effective dose equivalent, and, if used, the licensee shall document that information in the individual's record; and

(2) Upon prior approval of the Commission, adjust the DAC or ALI values to reflect the actual physical and chemical characteristics of airborne radioactive material (e.g., aerosol size distribution or density); and

(3) Separately assess the contribution of fractional intakes of Class D, W, or Y compounds of a given radionuclide (see appendix B to §§ 20.1001–20.2401) to the committed effective dose equivalent.

(d) If the licensee chooses to assess intakes of Class Y material using the measurements given in § 20.1204(a)(2) or (3), the licensee may delay the recording and reporting of the assessments for periods up to 7 months, unless otherwise required by §§ 20.2202 or 20.2203, in order to permit the licensee to make additional measurements basic to the assessments.

(e) If the identity and concentration of each radionuclide in a mixture are known, the fraction of the DAC applicable to the mixture for use in calculating DAC-hours must be either—

(1) The sum of the ratios of the concentration to the appropriate DAC value (e.g., D, W, Y) from appendix B to §§ 20.1001–20.2401 for each radionuclide in the mixture; or

(2) The ratio of the total concentration for all radionuclides in the mixture to the most restrictive DAC value for any radionuclide in the mixture.

(f) 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 must be the most restrictive DAC of any radionuclide in the mixture.

(g) When a mixture of radionuclides in air exists, licensees may disregard certain radionuclides in the mixture if—

(1) The licensee uses the total activity of the mixture in demonstrating

compliance with the dose limits in § 20.1201 and in complying with the monitoring requirements in § 20.1502(b), and

(2) The concentration of any radionuclide disregarded is less than 10 percent of its DAC, and

(3) The sum of these percentages for all of the radionuclides disregarded in the mixture does not exceed 30 percent.

(h)(1) In order to calculate the committed effective dose equivalent, the licensee may assume that the inhalation of one ALI, or an exposure of 2,000 DAC-hours, results in a committed effective dose equivalent of 5 rems (0.05 Sv) for radionuclides that have their ALIs or DACs based on the committed effective dose equivalent.

(2) When the ALI (and the associated DAC) is determined by the nonstochastic organ dose limit of 50 rems (0.5 Sv), the intake of radionuclides that would result in a committed effective dose equivalent of 5 rems (0.05 Sv) [the stochastic ALI] is listed in parentheses in table 1 of appendix B to §§ 20.1001–20.2401. In this case, the licensee may, as a simplifying assumption, use the stochastic ALIs to determine committed effective dose equivalent. However, if the licensee uses the stochastic ALIs, the licensee must also demonstrate that the limit in § 20.1201(a)(1)(ii) is met.

§ 20.1205 (Reserved)

§ 20.1206 Planned special exposures.

A licensee may authorize an adult worker to receive doses in addition to and accounted for separately from the doses received under the limits specified in § 20.1201 provided that each of the following conditions is satisfied—

(a) The licensee authorizes a planned special exposure only in an exceptional situation when alternatives that might avoid the higher exposure are unavailable or impractical.

(b) The licensee (and employer if the employer is not the licensee) specifically authorizes the planned special exposure, in writing, before the exposure occurs.

(c) Before a planned special exposure, the licensee ensures that the individuals involved are—

(1) Informed of the purpose of the planned operation;

(2) Informed of the estimated doses and associated potential risks and specific radiation levels or other conditions that might be involved in performing the task; and

(3) Instructed in the measures to be taken to keep the dose ALARA considering other risks that may be present.

(d) Prior to permitting an individual to participate in a planned special exposure, the licensee ascertains prior doses as required by § 20.2104(b) during the lifetime of the individual for each individual involved.

(e) Subject to § 20.1201(b), the licensee does not authorize a planned special exposure that would cause an individual to receive a dose from all planned special exposures and all doses in excess of the limits to exceed—

(1) The numerical values of any of the dose limits in § 20.1201(a) in any year; and

(2) Five times the annual dose limits in § 20.1201(a) during the individual's lifetime.

(f) The licensee maintains records of the conduct of a planned special exposure in accordance with § 20.2105 and submits a written report in accordance with § 20.2204.

(g) The licensee records the best estimate of the dose resulting from the planned special exposure in the individual's record and informs the individual, in writing, of the dose within 30 days from the date of the planned special exposure. The dose from planned special exposures is not to be considered in controlling future occupational dose of the individual under § 20.1201(a) but is to be included in evaluations required by § 20.1206 (d) and (e).

§ 20.1207 Occupational dose limits for minors.

The annual occupational dose limits for minors are 10 percent of the annual dose limits specified for adult workers in § 20.1201.

§ 20.1208 Dose to an embryo/fetus.

(a) The licensee shall ensure that the dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 0.5 rem (5 mSv). (For recordkeeping requirements, see § 20.2106.)

(b) The licensee shall make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit in paragraph (a) of this section.

(c) The dose to an embryo/fetus shall be taken as the sum of—

(1) The deep-dose equivalent to the declared pregnant woman; and

(2) The dose to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman.

(d) If the dose to the embryo/fetus is found to have exceeded 0.5 rem (5 mSv),

or is within 0.05 rem (0.5 mSv) of this dose, by the time the woman declares the pregnancy to the licensee, the licensee shall be deemed to be in compliance with paragraph (a) of this section if the additional dose to the embryo/fetus does not exceed 0.05 rem (0.5 mSv) during the remainder of the pregnancy.

Subpart D—Radiation Dose Limits for Individual Members of the Public

§ 20.1301 Dose limits for individual members of the public.

(a) Each licensee shall conduct operations so that—

(1) The total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv) in a year, exclusive of the dose contribution from the licensee's disposal of radioactive material into sanitary sewerage in accordance with § 20.2003, and

(2) The dose in any unrestricted area from external sources does not exceed 0.002 rem (0.02 mSv) in any one hour.

(b) If the licensee permits members of the public to have access to controlled areas, the limits for members of the public continue to apply to those individuals.

(c) A licensee or license applicant may apply for prior NRC authorization to operate up to an annual dose limit for an individual member of the public of 0.5 rem (5 mSv). The licensee or license applicant shall include the following information in this application:

(1) Demonstration of the need for and the expected duration of operations in excess of the limit in paragraph (a) of this section;

(2) The licensee's program to assess and control dose within the 0.5 rem (5 mSv) annual limit; and

(3) The procedures to be followed to maintain the dose as low as is reasonably achievable.

(d) In addition to the requirements of this part, a licensee subject to the provisions of EPA's generally applicable environmental radiation standards in 40 CFR Part 190 shall comply with those standards.

(e) The Commission may impose additional restrictions on radiation levels in unrestricted areas and on the total quantity of radionuclides that a licensee may release in effluents in order to restrict the collective dose.

§ 20.1302 Compliance with dose limits for individual members of the public.

(a) The licensee shall make or cause to be made, as appropriate, surveys of radiation levels in unrestricted and controlled areas and radioactive

materials in effluents released to unrestricted and controlled areas to demonstrate compliance with the dose limits for individual members of the public in § 20.1301.

(b) A licensee shall show compliance with the annual dose limit in § 20.1301 by—

(1) Demonstrating by measurement or calculation that the total effective dose equivalent to the individual likely to receive the highest dose from the licensed operation does not exceed the annual dose limit; or

(2) Demonstrating that—

(i) The annual average concentrations of radioactive material released in gaseous and liquid effluents at the boundary of the unrestricted area do not exceed the values specified in table 2 of appendix B to §§ 20.1001–20.2401; and

(ii) If an individual were continuously present in an unrestricted area, the dose from external sources would not exceed 0.002 rem (0.02 mSv) in an hour and 0.05 rem (0.5 mSv) in a year.

(c) Upon approval from the Commission, the licensee may adjust the effluent concentration values in appendix B to §§ 20.1001–20.2401, table 2, for members of the public, to take into account the actual physical and chemical characteristics of the effluents (e.g., aerosol size distribution, solubility, density, radioactive decay equilibrium, chemical form).

Subpart E—[Reserved]

Subpart F—Surveys and Monitoring

§ 20.1501 General.

(a) Each licensee shall make or cause to be made, surveys that—

(1) May be necessary for the licensee to comply with the regulations in this part; and

(2) Are reasonable under the circumstances to evaluate—

(i) The extent of radiation levels; and
(ii) Concentrations or quantities of radioactive material; and
(iii) The potential radiological hazards that could be present.

(b) The licensee shall ensure that instruments and equipment used for quantitative radiation measurements (e.g., dose rate and effluent monitoring) are calibrated periodically for the radiation measured.

(c) All personnel dosimeters (except for direct and indirect reading pocket ionization chambers and those dosimeters used to measure the dose to the extremities) that require processing to determine the radiation dose and that are used by licensees to comply with § 20.1201, with other applicable provisions of this chapter, or with

conditions specified in a license must be processed and evaluated by a dosimetry processor—

(1) Holding current personnel dosimetry accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology; and

(2) Approved in this accreditation process for the type of radiation or radiations included in the NVLAP program that most closely approximates the type of radiation or radiations for which the individual wearing the dosimeter is monitored.

§ 20.1502 Conditions requiring individual monitoring of external and internal occupational dose.

Each licensee shall monitor exposures to radiation and radioactive material at levels sufficient to demonstrate compliance with the occupational dose limits of this part. As a minimum—

(a) Each licensee shall monitor occupational exposure to radiation and shall supply and require the use of individual monitoring devices by—

(1) Adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of the limits in § 20.1201(a).

(2) Minors and declared pregnant women likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of any of the applicable limits in § 20.1207 or § 20.1208, and

(3) Individuals entering a high or very high radiation area.

(b) Each licensee shall monitor (see § 20.1204) the occupational intake of radioactive material by and assess the committed effective dose equivalent to—

(1) Adults likely to receive, in 1 year, an intake in excess of 10 percent of the applicable ALI(s) in table 1, Columns 1 and 2, of appendix B to §§ 20.1001–20.2401; and

(2) Minors and declared pregnant women likely to receive, in 1 year, a committed effective dose equivalent in excess of 0.05 rem (0.5 mSv).

Subpart G—Control of Exposure From External Sources in Restricted Areas

§ 20.1601 Control of access to high radiation areas.

(a) The licensee shall ensure that each entrance or access point to a high radiation area has one or more of the following features—

(1) A control device that, upon entry into the area, causes the level of radiation to be reduced below that level at which an individual might receive a

deep-dose equivalent of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates;

(2) A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the high radiation area and the supervisor of the activity are made aware of the entry; or

(3) Entryways that are locked, except during periods when access to the areas is required, with positive control over each individual entry.

(b) In place of the controls required by paragraph (a) of this section for a high radiation area, the licensee may substitute continuous direct or electronic surveillance that is capable of preventing unauthorized entry.

(c) A licensee may apply to the Commission for approval of alternative methods for controlling access to high radiation areas.

(d) The licensee shall establish the controls required by paragraphs (a) and (c) of this section in a way that does not prevent individuals from leaving a high radiation area.

(e) Control is not required for each entrance or access point to a room or other area that is a high radiation area solely because of the presence of radioactive materials prepared for transport and packaged and labeled in accordance with the regulations of the Department of Transportation provided that—

(1) The packages do not remain in the area longer than 3 days; and

(2) The dose rate at 1 meter from the external surface of any package does not exceed 0.01 rem (0.1 mSv) per hour.

(f) Control of entrance or access to rooms or other areas in hospitals is not required solely because of the presence of patients containing radioactive material, provided that there are personnel in attendance who will take the necessary precautions to prevent the exposure of individuals to radiation or radioactive material in excess of the limits established in this part and to operate within the ALARA provisions of the licensee's radiation protection program.

§ 20.1602 Control of access to very high radiation areas.

In addition to the requirements in § 20.1601, the licensee shall institute additional measures to ensure that an individual is not able to gain unauthorized or inadvertent access to areas in which radiation levels could be encountered at 500 rads (5 grays) or more in 1 hour at 1 meter from a radiation source or any surface through which the radiation penetrates.

§ 20.1603 Control of access to very high radiation areas—irradiators.

(a) Each area in which there may exist radiation levels in excess of 500 rads (5 grays) in 1 hour at 1 meter from a sealed radioactive source² that is used to irradiate materials must meet the following requirements.

(1) Each entrance or access point must be equipped with entry control devices which—

(i) Function automatically to prevent any individual from inadvertently entering the area when very high radiation levels exist;

(ii) Permit deliberate entry into the area only after a control device is actuated that causes the radiation level within the area, from the sealed source, to be reduced below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and

(iii) Prevent operation of the source if the source would produce radiation levels in the area that could result in a deep-dose equivalent to an individual in excess of 0.1 rem (1 mSv) in 1 hour.

(2) Additional control devices must be provided so that, upon failure of the entry control devices to function as required by paragraph (a)(1) of this section—

(i) The radiation level within the area, from the sealed source, is reduced below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and

(ii) Conspicuous visible and audible alarm signals are generated to make an individual attempting to enter the area aware of the hazard and at least one other authorized individual, who is physically present, familiar with the activity, and prepared to render or summon assistance, aware of the failure of the entry control devices.

(3) The licensee shall provide control devices so that, upon failure or removal of physical radiation barriers other than the source's shielded storage container—

(i) The radiation level from the source is reduced below that at which it would

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 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, is always physically inaccessible to any individual and 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.

be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and

(ii) Conspicuous visible and audible alarm signals are generated to make potentially affected individuals aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of the failure or removal of the physical barrier.

(4) When the shield for the stored source is a liquid, the licensee shall provide means to monitor the integrity of the shield and to signal, automatically, loss of adequate shielding.

(5) Physical radiation barriers that comprise permanent structural components, such as walls, that have no credible probability of failure or removal in ordinary circumstances need not meet the requirements of paragraphs (a) (3) and (4) of this section.

(6) Each area must be equipped with devices that will automatically generate conspicuous visible and audible alarm signals to alert personnel in the area before the source can be put into operation and in sufficient time for any individual in the area to operate a clearly identified control device, which must be installed in the area and which can prevent the source from being put into operation.

(7) Each area must be controlled by use of such administrative procedures and such devices as are necessary to ensure that the area is cleared of personnel prior to each use of the source.

(8) Each area must be checked by a radiation measurement to ensure that, prior to the first individual's entry into the area after any use of the source, the radiation level from the source in the area is below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour.

(9) The entry control devices required in paragraph (a)(1) of this section must have been tested for proper functioning (see § 20.2109 for recordkeeping requirements).

(i) Testing must be conducted prior to initial operation with the source of radiation on any day (unless operations were continued uninterrupted from the previous day); and

(ii) Testing must be conducted prior to resumption of operation of the source of radiation after any unintended interruption; and

(iii) The licensee shall submit and adhere to a schedule for periodic tests of the entry control and warning systems.

(10) The licensee may not conduct operations, other than those necessary to place the source in safe condition or to effect repairs on controls, unless control devices are functioning properly.

(11) Entry and exit portals that are used in transporting materials to and from the irradiation area, and that are not intended for use by individuals, must be controlled by such devices and administrative procedures as are necessary to physically protect and warn against inadvertent entry by any individual through these portals. Exit portals for processed materials must be equipped to detect and signal the presence of any loose radiation sources that are carried toward such an exit and to automatically prevent loose radiation sources from being carried out of the area.

(b) Persons holding licenses or applicants for licenses for radiation sources that are within the purview of paragraph (a) of this section and that will be used in a variety of positions or in locations, such as open fields or forests, that make it impracticable to comply with certain requirements of paragraph (a) of this section, such as those for the automatic control of radiation levels, may apply to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555, for approval of the use of alternative safety measures. Any alternative safety measures must provide a degree of personnel protection at least equivalent to those specified in paragraph (a) of this section. At least one of the alternative measures must include an entry-preventing interlock control based on a measurement of the radiation that ensures the absence of high radiation levels before an individual can gain access to the area where such radiation sources are used.

(c) The entry control devices required by paragraphs (a) and (b) of this section must be established in such a way that no individual will be prevented from leaving the area.

Subpart H—Respiratory Protection and Controls to Restrict Internal Exposure in Restricted Areas

§ 20.1701 Use of process or other engineering controls.

The licensee shall use, to the extent practicable, process or other engineering controls (e.g., containment or ventilation) to control the concentrations of radioactive material in air.

§ 20.1702 Use of other controls.

When it is not practicable to apply process or other engineering controls to control the concentrations of radioactive material in air to values below those that define an airborne radioactivity area, the licensee shall, consistent with maintaining the total effective dose equivalent ALARA, increase monitoring and limit intakes by one or more of the following means:

- (a) Control of access;
- (b) Limitation of exposure times;
- (c) Use of respiratory protection equipment; or
- (d) Other controls.

§ 20.1703 Use of individual respiratory protection equipment.

(a) If the licensee uses respiratory protection equipment to limit intakes pursuant to § 20.1702—

(1) The licensee shall use only respiratory protection equipment that is tested and certified or had certification extended by the National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA).

(2) If the licensee wishes to use equipment that has not been tested or certified by NIOSH/MSHA, has not had certification extended by NIOSH/MSHA, or for which there is no schedule for testing or certification, the licensee shall submit an application for authorized use of that equipment, including a demonstration by testing, or a demonstration on the basis of reliable test information, that the material and performance characteristics of the equipment are capable of providing the proposed degree of protection under anticipated conditions of use.

(3) The licensee shall implement and maintain a respiratory protection program that includes—

(i) Air sampling sufficient to identify the potential hazard, permit proper equipment selection, and estimate exposures;

(ii) Surveys and bioassays, as appropriate, to evaluate actual intakes;

(iii) Testing of respirators for operability immediately prior to each use;

(iv) Written procedures regarding selection, fitting, issuance, maintenance, and testing of respirators, including testing for operability immediately prior to each use; supervision and training of personnel; monitoring, including air sampling and bioassays; and recordkeeping; and

(v) Determination by a physician prior to initial fitting of respirators, and at least every 12 months thereafter, that the individual user is physically able to

use the respiratory protection equipment.

(4) The licensee shall issue a written policy statement on respirator usage covering—

(i) The use of process or other engineering controls, instead of respirators;

(ii) The routine, nonroutine, and emergency use of respirators; and

(iii) The periods of respirator use and relief from respirator use.

(5) The licensee shall advise each respirator user that the user may leave the area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other conditions that might require such relief.

(6) The licensee shall use equipment within limitations for type and mode of use and shall provide proper visual, communication, and other special capabilities (such as adequate skin protection) when needed.

(b) In estimating exposure of individuals to airborne radioactive materials, the licensee may make allowance for respiratory protection equipment used to limit intakes pursuant to § 20.1702, provided that the following conditions, in addition to those in § 20.1703(a), are satisfied:

(1) The licensee selects respiratory protection equipment that provides a protection factor (see appendix A to §§ 20.1001–20.2401) greater than the multiple by which peak concentrations of airborne radioactive materials in the working area are expected to exceed the values specified in appendix B to §§ 20.1001–20.2401, table 1, column 3. If the selection of a respiratory protection device with a protection factor greater than the peak concentration is inconsistent with the goal specified in § 20.1702 of keeping the total effective dose equivalent ALARA, the licensee may select respiratory protection equipment with a lower protection factor only if such a selection would result in keeping the total effective dose equivalent ALARA. The concentration of radioactive material in the air that is inhaled when respirators are worn may be initially estimated by dividing the average concentration in air, during each period of uninterrupted use, by the protection factor. If the exposure is later found to be greater than estimated, the corrected value must be used; if the exposure is later found to be less than estimated, the corrected value may be used.

deep-dose equivalent of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

(2) A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the high radiation area and the supervisor of the activity are made aware of the entry; or

(3) Entryways that are locked, except during periods when access to the areas is required, with positive control over each individual entry.

(b) In place of the controls required by paragraph (a) of this section for a high radiation area, the licensee may substitute continuous direct or electronic surveillance that is capable of preventing unauthorized entry.

(c) A licensee may apply to the Commission for approval of alternative methods for controlling access to high radiation areas.

(d) The licensee shall establish the controls required by paragraphs (a) and (c) of this section in a way that does not prevent individuals from leaving a high radiation area.

(e) Control is not required for each entrance or access point to a room or other area that is a high radiation area solely because of the presence of radioactive materials prepared for transport and packaged and labeled in accordance with the regulations of the Department of Transportation provided that—

(1) The packages do not remain in the area longer than 3 days; and

(2) The dose rate at 1 meter from the external surface of any package does not exceed 0.01 rem (0.1 mSv) per hour.

(f) Control of entrance or access to rooms or other areas in hospitals is not required solely because of the presence of patients containing radioactive material, provided that there are personnel in attendance who will take the necessary precautions to prevent the exposure of individuals to radiation or radioactive material in excess of the limits established in this part and to operate within the ALARA provisions of the licensee's radiation protection program.

§ 20.1602 Control of access to very high radiation areas.

In addition to the requirements in § 20.1601, the licensee shall institute additional measures to ensure that an individual is not able to gain unauthorized or inadvertent access to areas in which radiation levels could be encountered at 500 rads (5 grays) or more in 1 hour at 1 meter from a radiation source or any surface through which the radiation penetrates.

§ 20.1603 Control of access to very high radiation areas—irradiators.

(a) Each area in which there may exist radiation levels in excess of 500 rads (5 grays) in 1 hour at 1 meter from a sealed radioactive source² that is used to irradiate materials must meet the following requirements.

(1) Each entrance or access point must be equipped with entry control devices which—

(i) Function automatically to prevent any individual from inadvertently entering the area when very high radiation levels exist;

(ii) Permit deliberate entry into the area only after a control device is actuated that causes the radiation level within the area, from the sealed source, to be reduced below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and

(iii) Prevent operation of the source if the source would produce radiation levels in the area that could result in a deep-dose equivalent to an individual in excess of 0.1 rem (1 mSv) in 1 hour.

(2) Additional control devices must be provided so that, upon failure of the entry control devices to function as required by paragraph (a)(1) of this section—

(i) The radiation level within the area, from the sealed source, is reduced below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and

(ii) Conspicuous visible and audible alarm signals are generated to make an individual attempting to enter the area aware of the hazard and at least one other authorized individual, who is physically present, familiar with the activity, and prepared to render or summon assistance, aware of the failure of the entry control devices.

(3) The licensee shall provide control devices so that, upon failure or removal of physical radiation barriers other than the source's shielded storage container—

(i) The radiation level from the source is reduced below that at which it would

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 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, is always physically inaccessible to any individual and 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.

be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour; and

(ii) Conspicuous visible and audible alarm signals are generated to make potentially affected individuals aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of the failure or removal of the physical barrier.

(4) When the shield for the stored source is a liquid, the licensee shall provide means to monitor the integrity of the shield and to signal, automatically, loss of adequate shielding.

(5) Physical radiation barriers that comprise permanent structural components, such as walls, that have no credible probability of failure or removal in ordinary circumstances need not meet the requirements of paragraphs (a) (3) and (4) of this section.

(6) Each area must be equipped with devices that will automatically generate conspicuous visible and audible alarm signals to alert personnel in the area before the source can be put into operation and in sufficient time for any individual in the area to operate a clearly identified control device, which must be installed in the area and which can prevent the source from being put into operation.

(7) Each area must be controlled by use of such administrative procedures and such devices as are necessary to ensure that the area is cleared of personnel prior to each use of the source.

(8) Each area must be checked by a radiation measurement to ensure that, prior to the first individual's entry into the area after any use of the source, the radiation level from the source in the area is below that at which it would be possible for an individual to receive a deep-dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour.

(9) The entry control devices required in paragraph (a)(1) of this section must have been tested for proper functioning (see § 20.2109 for recordkeeping requirements).

(i) Testing must be conducted prior to initial operation with the source of radiation on any day (unless operations were continued uninterrupted from the previous day); and

(ii) Testing must be conducted prior to resumption of operation of the source of radiation after any unintended interruption; and

(iii) The licensee shall submit and adhere to a schedule for periodic tests of the entry control and warning systems.

(10) The licensee may not conduct operations, other than those necessary to place the source in safe condition or to effect repairs on controls, unless control devices are functioning properly.

(11) Entry and exit portals that are used in transporting materials to and from the irradiation area, and that are not intended for use by individuals, must be controlled by such devices and administrative procedures as are necessary to physically protect and warn against inadvertent entry by any individual through these portals. Exit portals for processed materials must be equipped to detect and signal the presence of any loose radiation sources that are carried toward such an exit and to automatically prevent loose radiation sources from being carried out of the area.

(b) Persons holding licenses or applicants for licenses for radiation sources that are within the purview of paragraph (a) of this section and that will be used in a variety of positions or in locations, such as open fields or forests, that make it impracticable to comply with certain requirements of paragraph (a) of this section, such as those for the automatic control of radiation levels, may apply to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555, for approval of the use of alternative safety measures. Any alternative safety measures must provide a degree of personnel protection at least equivalent to those specified in paragraph (a) of this section. At least one of the alternative measures must include an entry-preventing interlock control based on a measurement of the radiation that ensures the absence of high radiation levels before an individual can gain access to the area where such radiation sources are used.

(c) The entry control devices required by paragraphs (a) and (b) of this section must be established in such a way that no individual will be prevented from leaving the area.

Subpart H—Respiratory Protection and Controls to Restrict Internal Exposure in Restricted Areas

§ 20.1701 Use of process or other engineering controls.

The licensee shall use, to the extent practicable, process or other engineering controls (e.g., containment or ventilation) to control the concentrations of radioactive material in air.

§ 20.1702 Use of other controls.

When it is not practicable to apply process or other engineering controls to control the concentrations of radioactive material in air to values below those that define an airborne radioactivity area, the licensee shall, consistent with maintaining the total effective dose equivalent ALARA, increase monitoring and limit intakes by one or more of the following means:

- (a) Control of access;
- (b) Limitation of exposure times;
- (c) Use of respiratory protection equipment; or
- (d) Other controls.

§ 20.1703 Use of individual respiratory protection equipment.

(a) If the licensee uses respiratory protection equipment to limit intakes pursuant to § 20.1702—

(1) The licensee shall use only respiratory protection equipment that is tested and certified or had certification extended by the National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA).

(2) If the licensee wishes to use equipment that has not been tested or certified by NIOSH/MSHA, has not had certification extended by NIOSH/MSHA, or for which there is no schedule for testing or certification, the licensee shall submit an application for authorized use of that equipment, including a demonstration by testing, or a demonstration on the basis of reliable test information, that the material and performance characteristics of the equipment are capable of providing the proposed degree of protection under anticipated conditions of use.

(3) The licensee shall implement and maintain a respiratory protection program that includes—

- (i) Air sampling sufficient to identify the potential hazard, permit proper equipment selection, and estimate exposures;
- (ii) Surveys and bioassays, as appropriate, to evaluate actual intakes;
- (iii) Testing of respirators for operability immediately prior to each use;
- (iv) Written procedures regarding selection, fitting, issuance, maintenance, and testing of respirators, including testing for operability immediately prior to each use; supervision and training of personnel; monitoring, including air sampling and bioassays; and recordkeeping; and
- (v) Determination by a physician prior to initial fitting of respirators, and at least every 12 months thereafter, that the individual user is physically able to

use the respiratory protection equipment.

(4) The licensee shall issue a written policy statement on respirator usage covering—

- (i) The use of process or other engineering controls, instead of respirators;
- (ii) The routine, nonroutine, and emergency use of respirators; and
- (iii) The periods of respirator use and relief from respirator use.

(5) The licensee shall advise each respirator user that the user may leave the area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other conditions that might require such relief.

(6) The licensee shall use equipment within limitations for type and mode of use and shall provide proper visual, communication, and other special capabilities (such as adequate skin protection) when needed.

(b) In estimating exposure of individuals to airborne radioactive materials, the licensee may make allowance for respiratory protection equipment used to limit intakes pursuant to § 20.1702, provided that the following conditions, in addition to those in § 20.1703(a), are satisfied:

- (1) The licensee selects respiratory protection equipment that provides a protection factor (see appendix A to §§ 20.1001–20.2401) greater than the multiple by which peak concentrations of airborne radioactive materials in the working area are expected to exceed the values specified in appendix B to §§ 20.1001–20.2401, table 1, column 3. If the selection of a respiratory protection device with a protection factor greater than the peak concentration is inconsistent with the goal specified in § 20.1702 of keeping the total effective dose equivalent ALARA, the licensee may select respiratory protection equipment with a lower protection factor only if such a selection would result in keeping the total effective dose equivalent ALARA. The concentration of radioactive material in the air that is inhaled when respirators are worn may be initially estimated by dividing the average concentration in air, during each period of uninterrupted use, by the protection factor. If the exposure is later found to be greater than estimated, the corrected value must be used; if the exposure is later found to be less than estimated, the corrected value may be used.

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(2) The licensee shall obtain authorization from the Commission before assigning respiratory protection factors in excess of those specified in appendix A to §§ 20.1001-20.2401. The Commission may authorize a licensee to use higher protection factors on receipt of an application that—

- (i) Describes the situation for which a need exists for higher protection factors, and
- (ii) Demonstrates that the respiratory protection equipment provides these higher protection factors under the proposed conditions of use.

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(c) The licensee shall use as emergency devices only respiratory protection equipment that has been specifically certified or had certification extended for emergency use by NIOSH/MSHA.

(d) The licensee shall notify, in writing, the Regional Administrator of the appropriate NRC Regional Office listed in appendix D to §§ 20.1001-20.2401 at least 30 days before the date that respiratory protection equipment is first used under the provisions of either § 20.1703 (a) or (b).

§ 20.1704 Further restrictions on the use of respiratory protection equipment.

The Commission may impose restrictions in addition to those in §§ 20.1702, 20.1703, and appendix A to §§ 20.1001-20.2401 to—

- (a) Ensure that the respiratory protection program of the licensee is adequate to limit exposures of individuals to airborne radioactive materials; and
- (b) Limit the extent to which a licensee may use respiratory protection equipment instead of process or other engineering controls.

Subpart I—Storage and Control of Licensed Material

§ 20.1801 Security of stored material.

The licensee shall secure from

unauthorized removal or access licensed materials that are stored in controlled or unrestricted areas.

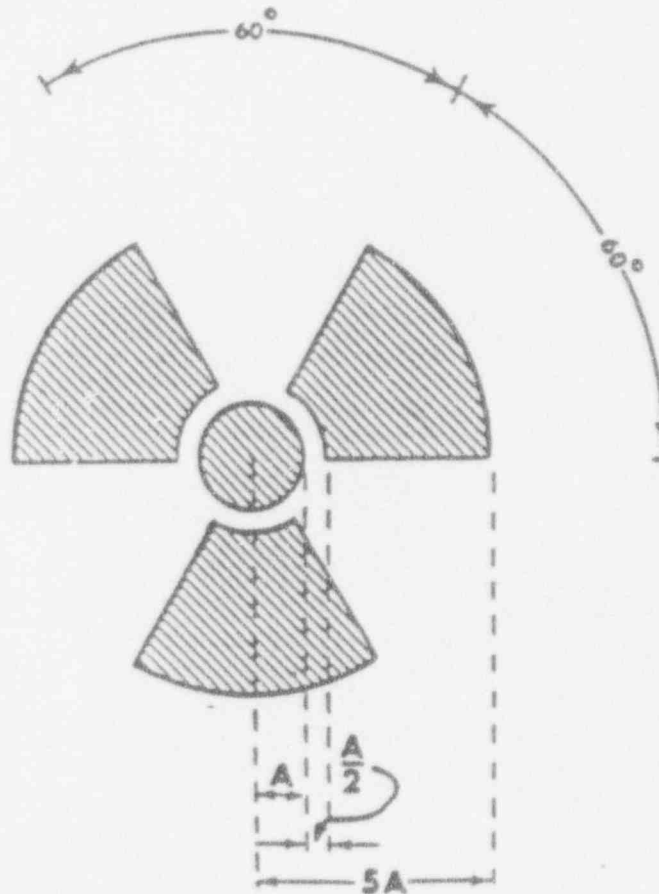
§ 20.1802 Control of material not in storage.

The licensee shall control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and that is not in storage.

Subpart J—Precautionary Procedures

§ 20.1901 Caution signs.

(a) *Standard radiation symbol.* Unless otherwise authorized by the Commission, the symbol prescribed by this part shall use the colors magenta, or purple, or black on yellow background. The symbol prescribed by this part is the three-bladed design:



RADIATION SYMBOL

(1) Cross-hatched area is to be magenta, or purple, or black, and

(2) The background is to be yellow.

(b) *Exception to color requirements for standard radiation symbol.*

Notwithstanding the requirements of paragraph (a) of this section, licensees are authorized to label sources, source holders, or device components containing sources of licensed materials that are subjected to high temperatures, with conspicuously etched or stamped radiation caution symbols and without a color requirement.

(c) *Additional information on signs and labels.* In addition to the contents of signs and labels prescribed in this part, the licensee may provide, on or near the required signs and labels, additional information, as appropriate, to make individuals aware of potential radiation exposures and to minimize the exposures.

§ 20.1902 Posting requirements.

(a) *Posting of radiation areas.* The licensee shall post each radiation area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIATION AREA."

(b) *Posting of high radiation areas.* The licensee shall post each high radiation area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, HIGH RADIATION AREA" or "DANGER, HIGH RADIATION AREA."

(c) *Posting of very high radiation areas.* The licensee shall post each very high radiation area with a conspicuous sign or signs bearing the radiation symbol and words "GRAVE DANGER, VERY HIGH RADIATION AREA."

(d) *Posting of airborne radioactivity areas.* The licensee shall post each airborne radioactivity area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, AIRBORNE RADIOACTIVITY AREA" or "DANGER, AIRBORNE RADIOACTIVITY AREA."

(e) *Posting of areas or rooms in which licensed material is used or stored.* The licensee shall post each area or room in which there is used or stored an amount of licensed material exceeding 10 times the quantity of such material specified in appendix C to §§ 20.1001-20.2401 with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL(S)" or "DANGER, RADIOACTIVE MATERIAL(S)."

§ 20.1903 Exceptions to posting requirements.

(a) A licensee is not required to post caution signs in areas or rooms containing radioactive materials for

periods of less than 8 hours, if each of the following conditions is met:

(1) The materials are constantly attended during these periods by an individual who takes the precautions necessary to prevent the exposure of individuals to radiation or radioactive materials in excess of the limits established in this part; and

(2) The area or room is subject to the licensee's control.

(b) Rooms or other areas in hospitals that are occupied by patients are not required to be posted with caution signs pursuant to § 20.1902 provided that the patient could be released from confinement pursuant to § 35.75 of this chapter.

(c) A room or area is not required to be posted with a caution sign because of the presence of a sealed source provided the radiation level at 30 centimeters from the surface of the source container or housing does not exceed 0.005 rem (0.05 mSv) per hour.

§ 20.1904 Labeling containers.

(a) The licensee shall ensure that each container of licensed material bears a durable, clearly visible label bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL." The label must also provide sufficient information (such as the radionuclide(s) present, an estimate of the quantity of radioactivity, the date for which the activity is estimated, radiation levels, kinds of materials, and mass enrichment) to permit individuals handling or using the containers, or working in the vicinity of the containers, to take precautions to avoid or minimize exposures.

(b) Each licensee shall, prior to removal or disposal of empty uncontaminated containers to unrestricted areas, remove or deface the radioactive material label or otherwise clearly indicate that the container no longer contains radioactive materials.

§ 20.1905 Exemptions to labeling requirements.

A licensee is not required to label—
(a) Containers holding licensed material in quantities less than the

quantities listed in appendix C to §§ 20.1001-20.2401; or

(b) Containers holding licensed material in concentrations less than those specified in table 3 of appendix B to §§ 20.1001-20.2401; or

(c) Containers attended by an individual who takes the precautions necessary to prevent the exposure of individuals in excess of the limits established by this part; or

(d) Containers when they are in transport and packaged and labeled in accordance with the regulations of the Department of Transportation,² or

(e) Containers that are accessible only to individuals authorized to handle or use them, or to work in the vicinity of the containers, if the contents are identified to these individuals by a readily available written record

(examples of containers of this type are containers in locations such as water-filled canals, storage vaults, or hot cells). The record must be retained as long as the containers are in use for the purpose indicated on the record; or

(f) Installed manufacturing or process equipment, such as reactor components, piping, and tanks.

§ 20.1906 Procedures for receiving and opening packages.

(a) Each licensee who expects to receive a package containing quantities of radioactive material in excess of a Type A quantity, as defined in § 71.4 and appendix A to part 71 of this chapter, shall make arrangements to receive—

(1) The package when the carrier offers it for delivery; or

(2) Notification of the arrival of the package at the carrier's terminal and to take possession of the package expeditiously.

² 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 (m) and (w) and 173.421-424.

(b) Each licensee shall—

(1) Monitor the external surfaces of a labeled ⁶⁰ package for radioactive contamination unless the package contains only radioactive material in the form of a gas or in special form as defined in 10 CFR 71.4;

(2) Monitor the external surfaces of a labeled ⁶⁰ package for radiation levels unless the package contains quantities of radioactive material that are less than or equal to the Type A quantity, as defined in § 71.4 and appendix A to part 71 of this chapter; and

(3) Monitor all packages known to contain radioactive material for radioactive contamination and radiation levels if there is evidence of degradation of package integrity, such as packages that are crushed, wet, or damaged.

(c) The licensee shall perform the monitoring required by paragraph (b) of this section as soon as practicable after receipt of the package, but not later than 3 hours after the package is received at the licensee's facility if it is received during the licensee's normal working hours, or not later than 3 hours from the beginning of the next working day if it is received after working hours.

(d) The licensee shall immediately notify the final delivery carrier and, by telephone and telegram, mailgram, or facsimile, the Administrator of the appropriate NRC Regional Office listed in appendix D to §§ 20.1001-20.2401 when—

(1) Removable radioactive surface contamination exceeds the limits of § 71.87(i) of this chapter; or

(2) External radiation levels exceed the limits of § 71.47 of this chapter.

(e) Each licensee shall—

(1) Establish, maintain, and retain written procedures for safely opening packages in which radioactive material is received; and

(2) Ensure that the procedures are followed and that due consideration is given to special instructions for the type of package being opened.

(f) Licensees transferring special form sources in licensee-owned or licensee-operated vehicles to and from a work site are exempt from the contamination monitoring requirements of paragraph (b) of this section, but are not exempt from the survey requirement in paragraph (b) of this section for measuring radiation levels that is required to ensure that the source is still properly lodged in its shield.

Subpart K—Waste Disposal

§ 20.2001 General requirements.

(a) A licensee shall dispose of licensed material only—

(1) By transfer to an authorized recipient as provided in § 20.2006 or in the regulations in parts 30, 40, 60, 81, 70, or 72 of this chapter; or

(2) By decay in storage; or

(3) By release in effluents within the limits in § 20.1301; or

(4) As authorized under §§ 20.2002, 20.2003, 20.2004, or § 20.2005.

(b) A person must be specifically licensed to receive waste containing licensed material from other persons for:

(1) Treatment prior to disposal; or

(2) Treatment or disposal by incineration; or

(3) Decay in storage; or

(4) Disposal at a land disposal facility licensed under part 61 of this chapter; or

(5) Disposal at a geologic repository under part 60 of this chapter.

§ 20.2002 Method for obtaining approval of proposed disposal procedures.

A licensee or applicant for a license may apply to the Commission for approval of proposed procedures, not otherwise authorized in the regulations in this chapter, to dispose of licensed material generated in the licensee's activities. Each application shall include:

(a) A description of the waste containing licensed material to be disposed of, including the physical and chemical properties important to risk evaluation, and the proposed manner and conditions of waste disposal; and

(b) An analysis and evaluation of pertinent information on the nature of the environment; and

(c) The nature and location of other potentially affected licensed and unlicensed facilities; and

(d) Analyses and procedures to ensure that doses are maintained ALARA and within the dose limits in this part.

§ 20.2003 Disposal by release into sanitary sewerage.

(a) A licensee may discharge licensed material into sanitary sewerage if each of the following conditions is satisfied:

(1) The material is readily soluble (or is readily dispersible biological material) in water; and

(2) The quantity of licensed or other radioactive material that the licensee releases into the sewer in 1 month divided by the average monthly volume of water released into the sewer by the licensee does not exceed the concentration listed in table 3 of appendix B to §§ 20.1001-20.2401; and

(3) If more than one radionuclide is released, the following conditions must also be satisfied:

(i) The licensee shall determine the fraction of the limit in table 3 of appendix B to §§ 20.1001-20.2401 represented by discharges into sanitary sewerage by dividing the actual monthly average concentration of each radionuclide released by the licensee into the sewer by the concentration of that radionuclide listed in table 3 of appendix B to §§ 20.1001-20.2401; and

(ii) The sum of the fractions for each radionuclide required by paragraph (a)(3)(i) of this section does not exceed unity; and

(4) The total quantity of licensed and other radioactive material that the licensee releases into the sanitary sewerage system in a year does not exceed 5 curies (185 GBq) of hydrogen-3, 1 curie (37 GBq) of carbon-14, and 1 curie (37 GBq) of all other radioactive materials combined.

(b) Excreta from individuals undergoing medical diagnosis or therapy with radioactive material are not subject to the limitations contained in paragraph (a) of this section.

§ 20.2004 Treatment or disposal by incineration.

(a) A licensee may treat or dispose of licensed material by incineration only:

(1) As authorized by paragraph (b) of this section; or

(2) If the material is in a form and concentration specified in § 20.2005; or

(3) As specifically approved by the Commission pursuant to § 20.2002.

(b) (1) Waste oils (petroleum derived or synthetic oils used principally as lubricants, coolants, hydraulic or insulating fluids, or metalworking oils) that have been radioactively contaminated in the course of the operation or maintenance of a nuclear power reactor licensed under part 50 of this chapter may be incinerated on the site where generated provided that the total radioactive effluents from the facility, including the effluents from such incineration, conform to the requirements of Appendix I to Part 50 of this chapter and the effluent release limits contained in applicable license conditions other than effluent limits specifically related to incineration of waste oil. The licensee shall report any changes or additions to the information supplied under §§ 50.34 and 50.34e of this chapter associated with this incineration pursuant to § 50.71 of this

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* 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.

chapter, as appropriate. The licensee shall also follow the procedures of § 20.59 of this chapter with respect to such changes to the facility or procedures.

(2) Solid residues produced in the process of incinerating waste oils must be disposed of as provided by § 20.2001.

(3) The provisions of this section authorize onsite waste oil incineration under the terms of this section and supersede any provision in an individual plant license or technical specification that may be inconsistent.

§ 20.2005 Disposal of specific wastes.

(a) A licensee may dispose of the following licensed material as if it were not radioactive:

(1) 0.05 microcurie (1.85 kBq), or less, of hydrogen-3 or carbon-14 per gram of medium used for liquid scintillation counting; and

(2) 0.05 microcurie (1.85 kBq), or less, of hydrogen-3 or carbon-14 per gram of animal tissue, averaged over the weight of the entire animal.

(b) A licensee may not dispose of tissue under paragraph (a)(2) of this section in a manner that would permit its use either as food for humans or as animal feed.

(c) The licensee shall maintain records in accordance with § 20.2108.

§ 20.2006 Transfer for disposal and manifests.

(a) The requirements of this section and appendix F to §§ 20.1001-20.2401 are designed to control transfers of low-level radioactive waste intended for disposal at a land disposal facility (as defined in part 61 of this chapter), establish a manifest tracking system, and supplement existing requirements concerning transfers and recordkeeping for those wastes.

(b) Each shipment of radioactive waste intended for disposal at a licensed land disposal facility must be accompanied by a shipment manifest as specified in section I of appendix F to §§ 20.1001-20.2401.

(c) Each shipment manifest must include a certification by the waste generator as specified in section II of appendix F to §§ 20.1001-20.2401.

(d) Each person involved in the transfer for disposal and disposal of waste, including the waste generator, waste collector, waste processor, and disposal facility operator, shall comply with the requirements specified in section III of appendix F to §§ 20.1001-20.2401.

§ 20.2007 Compliance with environmental and health protection regulations.

Nothing in this subpart relieves the licensee from complying with other applicable Federal, State, and local regulations governing any other toxic or hazardous properties of materials that may be disposed of under this subpart.

Subpart L—Records

§ 20.2101 General provisions.

(a) Each licensee shall use the units: curie, rad, rem, including multiples and subdivisions, and shall clearly indicate the units of all quantities on records required by this part.

(b) The licensee shall make a clear distinction among the quantities entered on the records required by this part (e.g., total effective dose equivalent, shallow-dose equivalent, eye dose equivalent, deep-dose equivalent, committed effective dose equivalent).

§ 20.2102 Records of radiation protection programs.

(a) Each licensee shall maintain records of the radiation protection program, including:

(1) The provisions of the program; and
(2) Audits and other reviews of program content and implementation.

(b) The licensee shall retain the records required by paragraph (a)(1) of this section until the Commission terminates each pertinent license requiring the record. The licensee shall retain the records required by paragraph (a)(2) of this section for 3 years after the record is made.

§ 20.2103 Records of surveys.

(a) Each licensee shall maintain records showing the results of surveys and calibrations required by §§ 20.1501 and 20.1906(b). The licensee shall retain these records for 3 years after the record is made.

(b) The licensee shall retain each of the following records until the Commission terminates each pertinent license requiring the record:

(1) Records of the results of surveys to determine the dose from external sources and used, in the absence of or in combination with individual monitoring data, in the assessment of individual dose equivalents; and

(2) Records of the results of measurements and calculations used to determine individual intakes of radioactive material and used in the assessment of internal dose; and

(3) Records showing the results of air sampling, surveys, and bioassays required pursuant to § 20.1703(a)(3)(i) and (ii); and

(4) Records of the results of measurements and calculations used to evaluate the release of radioactive effluents to the environment.

§ 20.2104 Determination of prior occupational dose.

(a) For each individual who may enter the licensee's restricted or controlled area and is likely to receive, in a year, an occupational dose requiring monitoring pursuant to § 20.1502, the licensee shall—

(1) Determine the occupational radiation dose received during the current year; and

(2) Attempt to obtain the records of cumulative occupational radiation dose.

(b) Prior to permitting an individual to participate in a planned special exposure, the licensee shall determine—

(1) The internal and external doses from all previous planned special exposures; and

(2) All doses in excess of the limits (including doses received during accidents and emergencies) received during the lifetime of the individual.

(c) In complying with the requirements of paragraph (a) of this section, a licensee may—

(1) Accept, as a record of the occupational dose that the individual received during the current year, a written signed statement from the individual, or from the individual's most recent employer for work involving radiation exposure, that discloses the nature and the amount of any occupational dose that the individual may have received during the current year;

(2) Accept, as the record of cumulative radiation dose, an up-to-date NRC Form 4, or equivalent, signed by the individual and countersigned by an appropriate official of the most recent employer for work involving radiation exposure, or the individual's current employer (if the individual is not employed by the licensee); and

(3) Obtain reports of the individual's dose equivalent(s) from the most recent employer for work involving radiation exposure, or the individual's current employer (if the individual is not employed by the licensee) by telephone, telegram, electronic media, or letter. The licensee shall request a written verification of the dose data if the authenticity of the transmitted report cannot be established.

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(d) The licensee shall record the exposure history of each individual, as required by paragraph (a) of this section, on NRC Form 4, or other clear and legible record, including all of the information required by NRC Form 4⁴. The form or record must show each period in which the individual received occupational exposure to radiation or radioactive material and must be signed by the individual who received the exposure. For each period for which the licensee obtains reports, the licensee shall use the dose shown in the report in preparing the NRC Form 4. For any period in which the licensee does not obtain a report, the licensee shall place a notation on the NRC Form 4 indicating the periods of time for which data are not available.

(e) If the licensee is unable to obtain a complete record of an individual's current and previously accumulated occupational dose, the licensee shall assume—

(1) In establishing administrative controls under § 20.1201(f) for the current year, that the allowable dose limit for the individual is reduced by 1.25 rems (12.5 mSv) for each quarter for which records were unavailable and the individual was engaged in activities that could have resulted in occupational radiation exposure; and

(2) That the individual is not available for planned special exposures.

(f) The licensee shall retain the records on NRC Form 4 or equivalent until the Commission terminates each pertinent license requiring this record. The licensee shall retain records used in preparing NRC Form 4 for 3 years after the record is made.

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§ 20.2105 Records of planned special exposures.

(a) For each use of the provisions of § 20.1206 for planned special exposures, the licensee shall maintain records that describe—

(1) The exceptional circumstances requiring the use of a planned special exposure; and

(2) The name of the management official who authorized the planned special exposure and a copy of the signed authorization; and

(3) What actions were necessary; and

(4) Why the actions were necessary; and

(5) How doses were maintained ALARA; and

(6) What individual and collective doses were expected to result, and the doses actually received in the planned special exposure.

(b) The licensee shall retain the records until the Commission terminates each pertinent license requiring these records.

§ 20.2106 Records of individual monitoring results.

(a) *Recordkeeping requirement.* Each licensee shall maintain records of doses received by all individuals for whom

monitoring was required pursuant to § 20.1502, and records of doses received during planned special exposures, accidents, and emergency conditions. These records⁴ must include, when applicable—

(1) The deep-dose equivalent to the whole body, eye dose equivalent, shallow-dose equivalent to the skin, and shallow-dose equivalent to the extremities; and

(2) The estimated intake or body burden of radionuclides (see § 20.1202); and

(3) The committed effective dose equivalent assigned to the intake or body burden of radionuclides; and

(4) The specific information used to calculate the committed effective dose equivalent pursuant to § 20.1204(c); and

(5) The total effective dose equivalent when required by § 20.1202; and

(6) The total of the deep-dose equivalent and the committed dose to the organ receiving the highest total dose.

(b) *Recordkeeping frequency.* The licensee shall make entries of the records specified in paragraph (a) of this section at least annually.

(c) *Recordkeeping format.* The licensee shall maintain the records specified in paragraph (a) of this section on NRC Form 5, in accordance with the instructions for NRC Form 5, or in clear and legible records containing all the information required by NRC Form 5.

(d) *Privacy protection.* The records required under this section should be protected from public disclosure because of their personal privacy nature. These records are protected by most State privacy laws and, when transferred to the NRC, are protected by the Privacy Act of 1974, Public Law 93-579, 5 U.S.C. 552a, and the Commission's regulations in 10 CFR part 9.

(e) The licensee shall maintain the records of dose to an embryo/fetus with the records of dose to the declared pregnant woman. The declaration of pregnancy shall also be kept on file, but may be maintained separately from the dose records.

(f) The licensee shall retain each required form or record until the Commission terminates each pertinent license requiring the record.

§ 20.2107 Records of dose to individual members of the public.

(a) Each licensee shall maintain records sufficient to demonstrate compliance with the dose limit for

⁴ 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 NRC Form 4 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.

⁴ Assessments of dose equivalent and records made using units in effect before the licensee's adoption of this part need not be changed.

individual members of the public (see § 20.1301).

(b) The licensee shall retain the records required by paragraph (a) of this section until the Commission terminates each pertinent license requiring the record.

§ 20.2108 Records of waste disposal.

(a) Each licensee shall maintain records of the disposal of licensed materials made under §§ 20.2002, 20.2003, 20.2004, 20.2005, 10 CFR part 81 and disposal by burial in soil, including burials authorized before January 28, 1981.*

(b) The licensee shall retain the records required by paragraph (a) of this section until the Commission terminates each pertinent license requiring the record.

§ 20.2109 Records of testing entry control devices for very high radiation areas.

(a) Each licensee shall maintain records of tests made under § 20.1603(a)(9) on entry control devices for very high radiation areas. These records must include the date, time, and results of each such test of function.

(b) The licensee shall retain the records required by paragraph (a) of this section for 3 years after the record is made.

§ 20.2110 Form of records.

Each record required by this part 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 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.

Subpart M—Reports

§ 20.2201 Reports of theft or loss of licensed material.

(a) Telephone reports. (1) Each licensee shall report by telephone as follows:

(i) Immediately after its occurrence becomes known to the licensee, any lost, stolen, or missing licensed material in an aggregate quantity equal to or greater than 1,000 times the quantity specified in appendix C to §§ 20.1001–20.2401 under such circumstances that it appears to the licensee that an exposure could result to persons in unrestricted areas; or

(ii) Within 30 days after the occurrence of any lost, stolen, or missing licensed material becomes known to the licensee, all licensed material in a quantity greater than 10 times the quantity specified in appendix C to §§ 20.1001–20.2401 that is still missing at this time.

(2) Reports must be made as follows:

(i) Licensees having an installed Emergency Notification System shall make the reports to the NRC Operations Center in accordance with § 50.72 of this chapter, and

(ii) All other licensees shall make reports to the NRC Operations Center.

(b) *Written reports.* (1) Each licensee required to make a report under paragraph (a) of this section shall, within 30 days after making the telephone report, make a written report setting forth the following information:

(i) A description of the licensed material involved, including kind, quantity, and chemical and physical form; and

(ii) A description of the circumstances under which the loss or theft occurred; and

(iii) A statement of disposition, or probable disposition, of the licensed material involved; and

(iv) Exposures of individuals to radiation, circumstances under which the exposures occurred, and the possible total effective dose equivalent to persons in unrestricted areas; and

(v) Actions that have been taken, or will be taken, to recover the material; and

(vi) Procedures or measures that have been, or will be, adopted to ensure against a recurrence of the loss or theft of licensed material.

(2) Reports must be made as follows:

(i) For holders of an operating license for a nuclear power plant, the events included in paragraph (b) of this section must be reported in accordance with the procedures described in § 50.73(b), (c), (d), (e), and (g) of this chapter and must include the information required in paragraph (b)(1) of this section, and

(ii) All other licensees shall make reports to the Administrator of the appropriate NRC Regional Office listed in appendix D to §§ 20.1001–20.2401.

(c) A duplicate report is not required under paragraph (b) of this section if the

licensee is also required to submit a report pursuant to §§ 30.55(c), 40.64(c), 50.72, 50.73, 70.52, 73.27(b), 73.67(e)(3)(vi), 73.67(g)(3)(iii), 73.71, or § 150.19(c) of this chapter.

(d) Subsequent to filing the written report, the licensee shall also report any additional substantive information on the loss or theft within 30 days after the licensee learns of such information.

(e) The licensee shall prepare any report filed with the Commission pursuant to this section so that names of individuals who may have received exposure to radiation are stated in a separate and detachable part of the report.

§ 20.2202 Notification of incidents.

(a) Immediate notification. Notwithstanding any other requirements for notification, each licensee shall immediately report any event involving byproduct, source, or special nuclear material possessed by the licensee that may have caused or threatens to cause any of the following conditions—

- (1) An individual to receive—
 - (i) A total effective dose equivalent of 25 rems (0.25 Sv) or more; or
 - (ii) An eye dose equivalent of 75 rems (0.75 Sv) or more; or
 - (iii) A shallow-dose equivalent to the skin or extremities of 250 rads (2.5 Gy) or more; or

(2) The release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake five times the annual limit on intake (the provisions of this paragraph do not apply to locations where personnel are not normally stationed during routine operations, such as hot-cells or process enclosures).

(3) [Removed 56 FR 40757.]

(4) [Removed 56 FR 40757.]

(b) Twenty-four hour notification. Each licensee shall, within 24 hours of discovery of the event, report any event involving loss of control of licensed material possessed by the licensee that may have caused, or threatens to cause, any of the following conditions:

- (1) An individual to receive, in a period of 24 hours—
 - (i) A total effective dose equivalent exceeding 5 rems (0.05 Sv); or
 - (ii) An eye dose equivalent exceeding 15 rems (0.15 Sv); or
 - (iii) A shallow-dose equivalent to the skin or extremities exceeding 50 rems (0.5 Sv); or

* A previous § 20.304 permitted burial of small quantities of licensed materials in soil before January 28, 1981, without specific Commission authorization.

(2) The release of radioactive material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake in excess of one occupational annual limit on intake (the provisions of this paragraph do not apply to locations where personnel are not normally stationed during routine operations, such as hot-cells or process enclosures.

(3) [Removed 56 FR 40757.]

(4) [Removed 56 FR 40757.]

(c) The licensee shall prepare any report filed with the Commission pursuant to this section so that names of individuals who have received exposure to radiation or radioactive material are stated in a separate and detachable part of the report.

(d) Reports made by licensees in response to the requirements of this section must be made as follows:

(1) Licensees having an installed Emergency Notification System shall make the reports required by paragraphs (a) and (b) of this section to the NRC Operations Center in accordance with 30 CFR 50.72; and

(2) All other licensees shall make the reports required by paragraphs (a) and (b) of this section by telephone to the NRC Operations Center and by telegram, mailgram, or facsimile to the Administrator of the appropriate NRC Regional Office listed in appendix D to §§ 20.1001-20.2401.

(e) The provisions of this section do not include doses that result from planned special exposures, that are within the limits for planned special exposures, and that are reported under § 20.2204.

§ 20.2203 Reports of exposures, radiation levels, and concentrations of radioactive material exceeding the limits.

(a) Reportable events. In addition to the notification required by § 20.2202, each licensee shall submit a written report within 30 days after learning of any of the following occurrences:

(1) Any incident for which notification is required by § 20.2202; or
(2) Doses in excess of any of the following:

- (i) The occupational dose limits for adults in § 20.1201; or
- (ii) The occupational dose limits for a minor in § 20.1207; or
- (iii) The limits for an embryo/fetus of a declared pregnant woman in § 20.1208; or
- (iv) The limits for an individual member of the public in § 20.1301; or
- (v) Any applicable limit in the license; or

(3) Levels of radiation or

concentrations of radioactive material in—

- (i) A restricted area in excess of any applicable limit in the license; or
- (ii) An unrestricted area in excess of 10 times any applicable limit set forth in this part or in the license (whether or not involving exposure of any individual in excess of the limits in § 20.1301); or
- (4) For licensees subject to the provisions of EPA's generally applicable environmental radiation standards in 40 CFR part 190, levels of radiation or releases of radioactive material in excess of those standards, or of license conditions related to those standards.

(b) Contents of reports. (1) Each report required by paragraph (a) of this section must describe the extent of exposure of individuals to radiation and radioactive material, including, as appropriate:

- (i) Estimates of each individual's dose; and
- (ii) The levels of radiation and concentrations of radioactive material involved; and
- (iii) The cause of the elevated exposures, dose rates, or concentrations; and
- (iv) Corrective steps taken or planned to ensure against a recurrence, including the schedule for achieving conformance with applicable limits, generally applicable environmental standards, and associated license conditions.

(2) Each report filed pursuant to paragraph (a) of this section must include for each individual¹ exposed: the name, Social Security account number, and date of birth. The report must be prepared so that this information is stated in a separate and detachable part of the report.

(c) For holders of an operating license for a nuclear power plant, the occurrences included in paragraph (a) of this section must be reported in accordance with the procedures described in § 50.73(b), (c), (d), (e), and (g) of this chapter and must also include the information required by paragraph (b) of this section. Occurrences reported in accordance with § 50.73 of this chapter need not be reported by a duplicate report under paragraph (a) of this section.

(d) All licensees, other than those holding an operating license for a nuclear power plant, who make reports under paragraph (a) of this section shall submit the report in writing to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington, DC 20555, with a copy to the appropriate NRC Regional Office listed in appendix D to §§ 20.1001-20.2401.

¹ With respect to the limit for the embryo-fetus (§ 20.1208), the identifiers should be those of the declared pregnant woman.

§ 20.2204 Reports of planned special exposures.

The licensee shall submit a written report to the Administrator of the appropriate NRC Regional Office listed in appendix D to §§ 20.1001-20.2401 within 30 days following any planned special exposure conducted in accordance with § 20.1206, informing the Commission that a planned special exposure was conducted and indicating the date the planned special exposure occurred and the information required by § 20.2105.

§ 20.2205 [Reserved]

§ 20.2206 Reports of individual monitoring.

(a) This section applies to each person licensed by the Commission to—

(1) Operate a nuclear reactor designed to produce electrical or heat energy pursuant to § 50.21(b) or § 50.22 of this chapter or a testing facility as defined in § 50.2 of this chapter; or

(2) Possess or use byproduct material for purposes of radiography pursuant to Parts 30 and 34 of this chapter; or

(3) Possess or use at any one time, for purposes of fuel processing, fabricating, or reprocessing, special nuclear material in a quantity exceeding 5,000 grams of contained uranium-235, uranium-233, or plutonium, or any combination thereof pursuant to part 70 of this chapter; or

(4) Possess high-level radioactive waste at a geologic repository operations area pursuant to part 60 of this chapter; or

(5) Possess spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to part 72 of this chapter; or

(6) Receive radioactive waste from other persons for disposal under part 61 of this chapter; or

(7) Possess or use at any time, for processing or manufacturing for distribution pursuant to parts 30, 32, 23 or 35 of this chapter, byproduct material in quantities exceeding any one of the following quantities:

Radionuclide	Quantity of radionuclide ¹ in curies
Cesium-137	1
Cobalt-60	1
Gold-198	100
Iodine-131	1
Iridium-192	10
Krypton-85	1,000
Promethium-147	10
Technetium-99m	1,000

¹ The Commission may require as a license condition, or by rule, regulation, or order pursuant to § 20.2302, reports from licensees who are licensed to use radionuclides not on this list, in quantities sufficient to cause comparable radiation levels.

(b) Each licensee in a category listed in paragraph (a) of this section shall submit an annual report of the results of individual monitoring carried out by the licensee for each individual for whom monitoring was required by § 20.1502 during that year. The licensee may include additional data for individuals for whom monitoring was provided but not required. The licensee shall use Form NRC 5 or electronic media containing all the information required by Form NRC 5.

(c) The licensee shall file the report required by § 20.2206(b), covering the preceding year, on or before April 30 of each year. The licensee shall submit the report to the REIRS Project Manager, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

Subpart N—Exemptions and Additional Requirements

§ 20.2301 Applications for exemptions.

The Commission may, upon application by a licensee or upon its own initiative, grant an exemption from the requirements of the regulations in this part if it determines the exemption is authorized by law and would not result in undue hazard to life or property.

§ 20.2302 Additional requirements.

The Commission may, by rule, regulation, or order, impose requirements on a licensee, in addition to those established in the regulations in this part, as it deems appropriate or necessary to protect health or to minimize danger to life or property.

Subpart O—Enforcement

§ 20.2401 Violations.

(a) The Commission may obtain an injunction or other court order to prevent a violation of the provisions of—

- (1) The Atomic Energy Act of 1954, as amended;
- (2) Title II of the Energy Reorganization Act of 1974, as amended;
- or
- (3) A regulation or order issued pursuant to those Acts.

(b) The Commission may obtain a court order for the payment of a civil

penalty imposed under section 234 of the Atomic Energy Act:

- (1) For violations of—
 - (i) Sections 53, 57, 62, 63, 81, 82, 101, 103, 104, 107 or 109 of the Atomic Energy Act of 1954, as amended;
 - (ii) Section 206 of the Energy Reorganization Act;
 - (iii) Any rule, regulation, or order issued pursuant to the sections specified in paragraph (b)(1)(i) of this section;
 - (iv) Any term, condition, or limitation of any license issued under the sections specified in paragraph (b)(1)(i) of this section.
- (2) For any violation for which a license may be revoked under Section 186 of the Atomic Energy Act of 1954, as amended.

§ 20.2402 Criminal penalties.

(a) Section 223 of the Atomic Energy Act of 1954, as amended, provides for criminal sanctions for willful violation of, attempted violation of, or conspiracy to violate, any regulation issued under sections 161b, 161i, or 161o of the Act. For purposes of section 223, all the regulations in §§ 20.1001 through 20.2402 are issued under one or more of sections 161b, 161i, or 161o, except for the sections listed in paragraph (b) this section.

(b) The regulations in §§ 20.1001 through 20.2402 that are not issued under Sections 161b, 161i, or 161o for the purposes of Section 223 are as follows: §§ 20.1001, 20.1002, 20.1003, 20.1004, 20.1005, 20.1006, 20.1007, 20.1008, 20.1009, 20.1704, 20.1903, 20.1905, 20.2002, 20.2007, 20.2301, 20.2302, 20.2401, and 20.2402.

APPENDIX A TO §§ 20.1001—20.2401—PROTECTION FACTORS FOR RESPIRATORS *

Description*	Protection Factors *			Tested & Certified Equipment National Institute for Occupational Safety and Health/Mine Safety and Health Administration tests for permeability
	Modes †	Particulates only	Particulates, gases, & vapors ‡	
I. Air-Purifying Respirators †				
Facepiece, half-mask	NP	10		30 CFR Part 11, Subpart K
Facepiece, full	NP	50		
Facepiece, half-mask full or hood	PP	1000		
II. Atmosphere Supplying Respirators				
1. Air-line respirator				
Facepiece, half-mask	CF		1000	30 CFR Part 11, Subpart J
Facepiece, half-mask	D		5	
Facepiece, full	CF		2000	
Facepiece, full	D		5	
Facepiece, full	PD		2000	
Hood	CF		(*)	
Suit	CF		(†) (†)	
2. Self-contained breathing apparatus (SCBA)				
Facepiece, full	D		50	30 CFR Part 11, Subpart H
Facepiece, full	PD		* 10,000	
Facepiece, full	RD		50	
Facepiece, full	RP		* 5,000	
III. Combination Respirators				
Any combination of air-purifying and atmosphere-supplying respirators		Protection factor for type and mode of operation as listed above		30 CFR Part 11, § 11.63(b)

Footnotes

- a. For use in the selection of respiratory protective devices to be used only where the contaminants have been identified and the concentrations (or possible concentrations) are known.
- b. Only for shaven faces and where nothing interferes with the seal of tight-fitting facepieces against the skin (hoods and suits are excepted).
- c. The mode symbols are defined as follows:
 CF - continuous flow
 D - demand
 NP - negative pressure (i.e., negative phase during inhalation)
 PD - pressure demand (i.e., always positive pressure)

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PP = positive pressure
 RD = demand, recirculating (closed circuit)
 RP = pressure demand, recirculating (closed circuit)

d.1 The protection factor is a measure of the degree of protection afforded by a respirator, defined as the ratio of the concentration of airborne radioactive material outside the respiratory protective equipment to that inside the equipment (usually inside the facepiece) under conditions of use. It is applied to the ambient airborne concentration to estimate the concentrations inhaled by the wearer according to the following formula:

$$\frac{\text{Concentration inhaled}}{\text{Ambient airborne concentration}} = \frac{1}{\text{Protection factor}}$$

2. The protection factors apply:

(a) Only for individuals trained in using respirators and wearing properly fitted respirators that are used and maintained under supervision in a well-planned respiratory protective program.

(b) For air-purifying respirators only when high efficiency particulate filters (above 99.97% removal efficiency by thermally generated 0.3 µm dioctyl phthalate (DOP) test or equivalent) are used in atmospheres not deficient in oxygen and not containing radioactive gas or vapor respiratory hazards.

(c) No adjustment is to be made for the use of sorbents against radioactive material in the form of gases or vapors.

(d) For atmosphere-supplying respirators only when supplied with adequate respirable air. Respirable air shall be provided of the quality and quantity required in accordance with NIOSH/MSHA certification (described in 30 CFR part 11). Oxygen and air shall not be used in the same apparatus.

e. Excluding radioactive contaminants that present an absorption or submersion hazard. For tritium oxide, approximately one-third of the intake occurs by absorption through the skin so that an overall protection factor of less than 2 is appropriate when atmosphere-supplying respirators are used to protect against tritium oxide. If the protection factor for a device is 5 the effective protection factor for tritium is about 1.4; for devices with protection factors of 10 the effective factor for tritium oxide is about 1.7, and for devices with protection factors of 100 or more the effective factor for tritium oxide is about 1.9. Air-purifying respirators are not suitable for protection against tritium oxide. See also footnote i concerning supplied-air suits.

f. Canisters and cartridges shall not be used beyond service-life limitations.

g. Under-chin type only. This type of respirator is not satisfactory for use where it might be possible (e.g., in an accident or emergency were to occur) for the ambient airborne concentrations to reach instantaneous values greater than 10 times the pertinent values in table 1, column 3 of appendix B to §§ 20.1001-20.2401 of this part. This type of respirator is not suitable for protection against plutonium or other high-toxicity materials. The mask is to be tested for fit prior to use, each time it is donned.

h.1. Equipment shall be operated in a manner that ensures that proper air flow rates are maintained. A protection factor of no more than 1000 may be utilized for tested-and-certified supplied-air hoods when a minimum air flow of 6 cubic feet (0.17 cubic meters) per minute is maintained and

calibrated air-line pressure gauges or flow measuring devices are used. A protection factor of up to 2000 may be used for tested and certified hoods only when the air flow is maintained at the manufacturer's recommended maximum rate for the equipment, this rate is greater than 6 cubic feet (0.17 cubic meters) per minute, and calibrated air-line pressure gauges or flow measuring devices are used.

2. The design of the supplied-air hood or helmet (with a minimum flow of 6 cfm (0.17 m³ per minute) of air) may determine its overall efficiency and the protection it provides. For example, some hoods aspirate contaminated air into the breathing zone when the wearer works with hands-over-head. This aspiration may be overcome if a short cape-like extension to the hood is worn under a coat or overalls. Other limitations specified by the approval agency shall be considered before using a hood in certain types of atmospheres (see footnote i).

i. Appropriate protection factors shall be determined, taking into account the design of the suit and its permeability to the contaminant under conditions of use. There shall be a standby rescue person equipped with a respirator or other apparatus appropriate for the potential hazards and communications equipment whenever supplied-air suits are used.

j. No approval schedules are currently available for this equipment. Equipment is to be evaluated by testing or on the basis of reliable test information.

k. This type of respirator may provide greater protection and be used as an emergency device in unknown concentrations for protection against inhalation hazards. External radiation hazards and other limitations to permitted exposure, such as skin absorption, must be taken into account in such circumstances.

l. Quantitative fit testing shall be performed on each individual and no more than 0.02% leakage is allowed with this type of apparatus. Perceptible outward leakage of gas from this or any positive pressure self-contained breathing apparatus is unacceptable because service life will be reduced substantially. Special training in the use of this type of apparatus shall be provided to the wearer.

Note 1: Protection factors for respirators as may be approved by the U.S. Bureau of Mines/National Institute for Occupational Safety and Health (NIOSH), according to applicable approvals for respirators for type and mode of use to protect against airborne radionuclides, may be used to the extent that

they do not exceed the protection factors listed in this table. The protection factors listed in this table may not be appropriate to circumstances where chemical or other respiratory hazards exist in addition to radioactive hazards. The selection and use of respirators for such circumstances should take into account applicable approvals of the U.S. Bureau of Mines/NIOSH.

Note 2: Radioactive contaminants for which the concentration values in Table 1, Column 3 of Appendix B to §§ 20.1001-20.2401 of this part are based on internal dose due to inhalation may, in addition, present external exposure hazards at higher concentrations. Under these circumstances, limitations on occupancy may have to be governed by external dose limits.

Appendix B to §§ 20.1001-20.2401—
 Annual Limit 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 1 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 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 of less than 30 days for D, for W from 30 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 1, columns 2 and 3.

Table 2 provides concentration limits for airborne and liquid effluents released to the general environment. Table 3 provides concentration limits for discharges to sanitary sewer systems.

Notation

The values in Tables 1, 2, and 3 are presented in the computer "E" notation. In this notation a value of 6E-02 represents a value of 6 x 10⁻² or 0.06, 6E+2 represents 6 x 10² or 600, and 6E+0 represents 6 x 10⁰ or 6.

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Table 1 "Occupational"

Note that the columns in Table 1, 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 a given radionuclide by "Reference Man" which would result in either (1) a committed effective dose equivalent of 5 rems (stochastic ALI) or (2) a committed dose equivalent of 50 rems 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 5 rems. 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 § 20.1003. 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 five 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 parts of the GI tract—stomach, small intestine, upper large intestine, and lower large intestine—are to be treated as four separate organs.

Note that the dose equivalents for extremities (hands and forearms, feet and lower legs), 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: LL 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 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 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 (i.e., $\sum (intake \text{ (in } \mu\text{Ci)}) / (ALI_{ns}) < 1.0$). If there is an external deep dose equivalent contribution of H_e , then this sum must be less than $1 - (H_e/50)$ instead of being < 1.0 .

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: $DAC = ALI \text{ (in } \mu\text{Ci)} / (2000 \text{ hours per working year} \times 60 \text{ minutes/hour} \times 2 \times 10^4 \text{ ml per minute}) = [ALI / 2.4 \times 10^7] \mu\text{Ci/ml}$, where $2 \times 10^4 \text{ ml}$ is the volume of air breathed per minute at work by "Reference Man" under working conditions of "light work."

The DAC values relate to one of two modes of exposure: either external submersion or the internal committed dose equivalents resulting from inhalation of radioactive materials. Derived air concentrations based upon submersion are for immersion in a semi-infinite cloud of uniform concentration and apply to each radionuclide separately.

The ALI and DAC values relate to exposure to the single radionuclide named, but also include contributions from the ingrowth of any daughter radionuclide produced in the body by the 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 value 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 radiation (see § 20.1202). When an individual is exposed to radioactive materials which fall under several of the translocation classifications (i.e., Class D, Class W, or Class Y) of the same radionuclide, 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 radioisotopes. For this reason, values are given for Class D, W, and Y compounds, even for very short-lived radionuclides.

Table 2

The columns in Table 2 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 § 20.1302. The concentration values given in Columns 1 and 2 of Table 2 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 0.05 rem (50 millirem or 0.5 millisieverts).

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 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 2. For this reason, the DAC and airborne effluent limits are not always proportional as was the case in appendix B to §§ 20.1-20.801.

The air concentration values listed in Table 2, 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 $2.4 \times 10^7 \text{ ml}$, 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 5-rem annual occupational dose limit to the 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 (external dose) is limiting, the occupational DAC in Table 1, Column 3, was divided by 219. The factor of 219 is composed of a factor of 50, as described above, and a factor of 4.36 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 7.3×10^3 . The factor of $7.3 \times 10^3 \text{ (ml)}$ includes the following components: the factors of 50 and 2 described above and a factor of $7.3 \times 10^4 \text{ (ml)}$ 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 sewerage) 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 either from knowledge of the radionuclide composition of the source or from actual measurements.

Table 3 "Sewer Disposal"

The monthly average concentrations for release to sanitary sewers are applicable to the provisions in § 20.2003. The concentration values were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by $7.3 \times 10^3 \text{ (ml)}$. The factor of $7.3 \times 10^3 \text{ (ml)}$ is composed of a factor of $7.3 \times 10^4 \text{ (ml)}$, 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.

LIST OF ELEMENTS

Name	Atomic	
	Symbol	No
Actinium	Ac	89
Aluminum	Al	13
Americium	Am	95
Antimony	Sb	51
Argon	Ar	18
Arsenic	As	33
Astatine	At	85
Barium	Ba	56
Berkelium	Bk	97
Beryllium	Be	4
Bismuth	Bi	83
Bromine	Br	35
Cadmium	Cd	48
Calcium	Ca	20
Californium	Cf	98
Carbon	C	6
Cerium	Ce	58
Cesium	Cs	55
Chlorine	Cl	17
Chromium	Cr	24
Cobalt	Co	27
Copper	Cu	29
Curium	Cm	96
Dysprosium	Dy	66
Einsteinium	Es	99
Erbium	Er	68
Europium	Eu	63
Fermium	Fm	100
Fluorine	F	9
Francium	Fr	87
Gadolinium	Gd	64

LIST OF ELEMENTS—Continued

Name	Atomic	
	Symbol	No
Gallium	Ga	31
Germanium	Ge	32
Gold	Au	79
Hafnium	Hf	72
Hassium	Hs	67
Hydrogen	H	1
Indium	In	49
Iodine	I	53
Iridium	Ir	77
Iron	Fe	26
Krypton	Kr	36
Lanthanum	La	57
Lead	Pb	82
Lutetium	Lu	71
Magnesium	Mg	12
Manganese	Mn	25
Mendelevium	Md	101
Mercury	Hg	80
Molybdenum	Mo	42
Neodymium	Nd	60
Neptunium	Np	93
Nickel	Ni	28
Niobium	Nb	41
Osmium	Os	76
Palladium	Pd	46
Phosphorus	P	15
Platinum	Pt	78
Plutonium	Pu	94
Polonium	Po	84
Potassium	K	19
Praseodymium	Pr	59
Promethium	Pm	61
Protactinium	Pa	91
Radium	Ra	88

LIST OF ELEMENTS—Continued

Name	Atomic	
	Symbol	No
Radon	Rn	86
Rhenium	Re	75
Rhodium	Rh	45
Rubidium	Rb	37
Ruthenium	Ru	44
Samarium	Sm	62
Scandium	Sc	21
Selenium	Se	34
Silicon	Si	14
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	82
Vanadium	V	23
Xenon	Xe	54
Ytterbium	Yb	70
Yttrium	Y	39
Zinc	Zn	30
Zirconium	Zr	40

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration (μCi/ml)
			Oral Ingestion All (μCi)	Inhalation All (μCi)	DAC (μCi/m)	Air (μCi/m ³)	Water (μCi/ml)	
1	Hydrogen-3	Water, DAC includes skin absorption Gas (HT or T ₂) Submersion ² : Use above values as HT and T ₂ oxidize in air and in the body to HTD.	5E+0	5E+0	2E-5	1E-7	1E-3	1E-2
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	9E-6	3E-8	-	-
4	Beryllium-10	W, see ⁷ Be	1E+3 LLL well (1E+3)	2E+2	6E-8	2E-10	-	-
		Y, see ⁷ Be	-	1E+1	6E-9	2E-11	2E-5	2E-6
6	Carbon-11 ²	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
9	Fluorine-18 ²	D, Fluorides of H, Li, Na, K, Rb, Cs, and Fr	5E+4 SI well (5E+4)	7E+4	3E-5	1E-7	-	-
		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, W, 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	6E-5	6E-4
12	Magnesium-26	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	6E-7	2E-9	-	-
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 LLL well (3E+3)	2E+2	1E-7	3E-10	-	-
		W, see ³¹ Si	-	1E+2	6E-8	2E-10	4E-5	4E-4
		Y, see ³¹ Si	-	6E+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	6E-10	-	-
15	Phosphorus-33	D, see ³² P W, see ³² P	6E+3	8E+3	4E-6	1E-8	8E-5	8E-4
			-	3E+3	1E-6	4E-9	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sources
			Col. 1 Dose Ingestion AI (μ Ci)	Inhalation		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/m ³)	Monthly Average Concentration (μ Ci/ml)
				Col. 2 ALI (μ Ci)	Col. 3 DAC (μ Ci/ml)			
36	Sulfur-35	Vapor	-	1E+4	6E-6	2E-8	-	-
		D, sulfides and sulfates except those given for W	1E+4 ILI well (8E+3)	2E+4	7E-6	2E-8	-	-
		W, elemental sulfur, sulfides of Sr, Ba, Ge, Sn, Pb, As, Sb, Bi, Cu, Ag, Au, Zn, Cd, Hg, V, and Mo. Sulfates of Ca, Sr, Ba, Ra, Ac, Sb, and Bi	6E+3	-	-	-	2E-4	1E-3
37	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, Au, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, W, Tc, and Re	-	2E+2	1E-7	3E-10	-	-
37	Chlorine-38 ²	D, see ³⁶ Cl	2E+4 St. well (3E+4)	4E+4	2E-5	6E-8	-	-
		W, see ³⁶ Cl	-	5E+4	2E-5	6E-8	2E-4	2E-3
37	Chlorine-39 ²	D, see ³⁶ Cl	2E+4 St. well (4E+4)	5E+4	2E-5	7E-8	-	-
		W, see ³⁶ Cl	-	6E+4	2E-5	8E-8	5E-4	5E-3
38	Argon-37	Submersion ¹	-	-	1E+0	6E-3	-	-
38	Argon-39	Submersion ¹	-	-	2E+4	8E-7	-	-
38	Argon-41	Submersion ¹	-	-	3E+6	1E-8	-	-
39	Potassium-40	D, all compounds	3E+2	4E+2	2E-7	6E-10	4E-6	4E-5
39	Potassium-42	D, all compounds	5E+3	5E+3	2E-6	7E-9	6E-5	6E-4
39	Potassium-43	D, all compounds	6E+3	9E+3	4E-6	1E-8	9E-5	9E-4
39	Potassium-44 ²	D, all compounds	2E+4 St. well (4E+4)	7E+4	3E-5	9E-8	-	-
		W, see ³⁶ Cl	-	-	-	-	5E-4	5E-3
39	Potassium-r ²	D, all compounds	3E+4 St. well (5E+4)	1E+5	5E-5	2E-7	-	-
		W, see ³⁶ Cl	-	-	-	-	7E-4	7E-3
20	Calcium-41	W, all compounds	3E+3 Bone surf (4E+3)	4E+3 Bone surf (4E+3)	2E-6	-	-	-
		W, all compounds	-	-	-	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-44a	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 ILI well (3E+3)	3E+3	1E-6	4E-9	-	-
		W, all compounds	-	-	-	-	4E-5	4E-4
21	Scandium-48	Y, all compounds	8E+2	1E+3	6E-7	2E-9	1E-5	1E-4
21	Scandium-49 ²	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+3	5E-9	2E-11	4E-6	4E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	-	3E+1	1E-8	4E-11	-	-
		Y, SrTiO ₃	-	6E+0	2E-9	6E-12	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Dose Ingestion (μ R)	Col. 2 Inhalation		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/m ³)	Monthly Average Concentration (μ Ci/m ³)
				ALI	MDI			
22	Titanium-45	D. see 44Ti	5E+3	3E+4	2E-5	5E-8	2E-6	2E-5
		W. see 44Ti	-	4E+4	2E-5	5E-8	-	-
		Y. see 44Ti	-	3E+4	2E-5	4E-8	-	-
23	Vanadium-47 ²	D. all compounds except those given for V	3E+4 SI, well (3E+4)	3E+4	3E-5	2E-7	-	-
		W. oxides, hydroxides, carbides, and halides	-	2E+5	6E-5	2E-7	-	-
23	Vanadium-46	D. see 47V	5E+2	2E+3	3E-7	2E-9	5E-6	5E-5
		W. see 47V	-	5E+2	3E-7	5E-10	-	-
23	Vanadium-49	D. see 47V	7E+4 LI well (5E+4)	3E+4 Bone surf (3E+4)	2E-5	-	-	-
		W. see 47V	-	2E+4	5E-6	2E-8	2E-3	2E-2
24	Cesium-137	D. all compounds except those given for b and Y	5E+3	2E+6	3E-6	2E-8	5E-5	5E-4
		W. halides and nitrates	-	7E+3	3E-6	2E-8	-	-
		Y. oxides and hydroxides	-	7E+3	3E-6	2E-8	-	-
24	Chromium-49 ²	D. see 48Cr	3E+4	5E+4	4E-5	2E-7	4E-4	4E-3
		W. see 48Cr	-	2E+5	4E-5	2E-7	-	-
		Y. see 48Cr	-	5E+4	4E-5	2E-7	-	-
24	Chromium-51	D. see 48Cr	4E+4	5E+4	2E-5	5E-8	5E-4	5E-3
		W. see 48Cr	-	2E+4	2E-5	3E-8	-	-
		Y. see 48Cr	-	2E+4	5E-6	2E-8	-	-
25	Manganese-52 ²	D. all compounds except those given for W	2E+4	5E+4	2E-5	2E-8	3E-4	3E-3
		W. oxides, hydroxides, halides, and nitrates	-	5E+4	3E-5	5E-8	-	-
25	Manganese-52 ²	D. see 51Mn	3E+4 SI, well (4E+4)	5E+4	4E-5	2E-7	-	-
		W. see 51Mn	-	2E+5	4E-5	2E-7	5E-4	5E-3
25	Manganese-52	D. see 51Mn	7E+2	2E+3	5E-7	2E-9	2E-5	2E-4
		W. see 51Mn	-	5E+2	4E-7	2E-9	-	-
25	Manganese-53	D. see 51Mn	5E+4	2E+4	5E-6	-	7E-4	7E-3
		W. see 51Mn	-	2E+4 Bone surf (2E+4)	-	3E-8	-	-
25	Manganese-54	D. see 51Mn	2E+3	5E+2	4E-7	2E-9	3E-5	3E-4
		W. see 51Mn	-	5E+2	3E-7	2E-9	-	-
25	Manganese-56	D. see 51Mn	5E+3	2E+4	5E-6	2E-8	7E-5	7E-4
		W. see 51Mn	-	2E+4	5E-6	3E-8	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 All (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
26	Iron-52	D, all compounds except those given for W	5E+2	3E+3	3E-6	4E-9	3E-8	3E-4
		W, oxides, hydroxides, and halides	-	2E+3	3E-6	3E-9	-	-
26	Iron-55	D, see ^{52}Fe	5E+3	2E+3	5E-7	3E-9	3E-4	3E-3
		W, see ^{52}Fe	-	4E+3	2E-6	6E-9	-	-
26	Iron-59	D, see ^{52}Fe	5E+2	3E+2	3E-7	3E-10	3E-5	3E-4
		W, see ^{52}Fe	-	5E+2	2E-7	7E-10	-	-
26	Iron-60	D, see ^{52}Fe	3E+1	6E+0	3E-9	3E-12	4E-7	4E-6
		W, see ^{52}Fe	-	2E+1	3E-9	3E-11	-	-
27	Cobalt-55	W, all compounds except those given for Y	3E+3	3E+3	3E-6	4E-9	2E-8	2E-4
		Y, oxides, hydroxides, halides, and nitrates	-	3E+3	3E-6	4E-9	-	-
27	Cobalt-56	W, see ^{55}Co	6E+2	3E+2	3E-7	4E-10	6E-6	6E-5
		Y, see ^{55}Co	4E+2	2E+2	6E-8	3E-10	-	-
27	Cobalt-57	W, see ^{55}Co	6E+3	3E+3	3E-6	4E-9	6E-5	6E-4
		Y, see ^{55}Co	4E+3	7E+2	3E-7	3E-10	-	-
27	Cobalt-58m	W, see ^{55}Co	6E+6	3E+6	4E-5	2E-7	6E-4	6E-3
		Y, see ^{55}Co	-	6E+6	2E-5	3E-8	-	-
27	Cobalt-58	W, see ^{55}Co	2E+3	3E+3	3E-7	7E-9	2E-5	2E-4
		Y, see ^{55}Co	3E+3	7E+2	3E-7	3E-9	-	-
27	Cobalt-58m ²	W, see ^{55}Co	3E+6	4E+6	2E-3	6E-6	-	-
		Y, see ^{55}Co	St. unll (3E+6)	-	-	-	2E-2	2E-1
27	Cobalt-60	W, see ^{55}Co	6E+2	2E+2	7E-8	2E-10	2E-6	3E-5
		Y, see ^{55}Co	2E+2	3E+1	3E-8	5E-11	-	-
27	Cobalt-61 ²	W, see ^{55}Co	2E+6	6E+6	3E-5	3E-8	3E-4	3E-3
		Y, see ^{55}Co	2E+6	6E+6	2E-5	3E-8	-	-
27	Cobalt-62m ²	W, see ^{55}Co	4E+6	2E+6	7E-5	2E-7	-	-
		Y, see ^{55}Co	St. unll (5E+6)	-	-	-	7E-4	7E-3
28	Nickel-56	D, all compounds except those given for W	3E+3	2E+3	6E-7	3E-9	2E-8	2E-4
		W, oxides, hydroxides, and carbides Vapor	-	3E+3	6E-7	2E-9	-	-
28	Nickel-57	D, see ^{56}Ni	2E+3	3E+3	2E-6	7E-9	2E-6	2E-4
		W, see ^{56}Ni Vapor	-	6E+3	3E-6	3E-9	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Dose Ingestion AI (μ Ci)	Inhalation		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/ml)	Monthly Average Concentration (μ Ci/ml)
				Col. 2 AI (μ Ci)	Col. 3 DAC (μ Ci/m ³)			
28	Nickel-59	D, see ⁵⁹ Ni	2E+4	4E+3	2E-6	5E-9	5E-4	5E-3
		W, see ⁵⁹ Ni	-	7E+3	3E-6	1E-8	-	-
		Vapor	-	2E+3	8E-7	3E-9	-	-
28	Nickel-63	D, see ⁶³ Ni	9E+3	2E+3	7E-7	2E-9	1E-4	1E-3
		W, see ⁶³ Ni	-	3E+3	1E-6	4E-9	-	-
		Vapor	-	8E+2	3E-7	1E-9	-	-
28	Nickel-65	D, see ⁶⁵ Ni	8E+3	2E+4	1E-6	3E-8	1E-4	1E-3
		W, see ⁶⁵ Ni	-	3E+4	1E-5	4E-8	-	-
		Vapor	-	2E+4	7E-6	2E-8	-	-
28	Nickel-66	D, see ⁶⁶ Ni	4E+2	2E+3	7E-7	2E-9	-	-
		LLI well	(5E+2)	-	-	-	6E-6	6E-5
		W, see ⁶⁶ Ni	-	6E+2	3E-7	9E-10	-	-
29	Copper-60 ²	D, all compounds except those given for W and V	3E+6	9E+6	4E-5	1E-7	-	-
		SI, well	(3E+6)	-	-	-	4E-4	4E-3
		W, sulfides, halides, and nitrates	-	1E+5	5E-5	2E-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	-	-
		V, see ⁶⁰ Cu	-	4E+4	1E-5	5E-8	-	-
29	Copper-64	D, see ⁶⁴ Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ⁶⁴ Cu	-	2E+4	1E-5	3E-8	-	-
		V, see ⁶⁴ Cu	-	2E+4	9E-6	3E-8	-	-
29	Copper-67	D, see ⁶⁷ Cu	5E+3	8E+3	2E-6	1E-8	6E-5	6E-4
		W, see ⁶⁷ Cu	-	5E+3	2E-6	7E-8	-	-
		V, see ⁶⁷ Cu	-	5E+3	2E-6	6E-8	-	-
30	Zinc-62	Y, all compounds	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
30	Zinc-63 ²	Y, all compounds	2E+4	7E+4	3E-5	9E-8	-	-
		SI, well	(3E+4)	-	-	-	3E-4	3E-3
30	Zinc-65	Y, all compounds	4E+2	3E+2	7E-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 ²	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	3E-5	3E-4
30	Zinc-72	Y, all compounds	1E+3	1E+3	6E-7	2E-9	1E-5	1E-4
31	Gallium-65 ²	D, all compounds except those given for W	5E+4	2E+5	7E-5	2E-7	-	-
		SI, well	(6E+4)	-	-	-	9E-4	9E-3
		W, oxides, hydroxides, carbonates, halides, and nitrates	-	2E+5	8E-5	3E-7	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Drain Imposition ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 ALI (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
31	Gallium-66	D. see ⁶⁵ Ge	3E+3	4E+3	3E-6	5E-9	2E-9	2E-6
		V. see ⁶⁵ Ge	-	3E+3	3E-6	4E-9	-	-
31	Gallium-67	D. see ⁶⁵ Ge	7E+3	1E+4	6E-6	2E-8	1E-8	3E-3
		V. see ⁶⁵ Ge	-	1E+4	4E-6	1E-8	-	-
31	Gallium-68 ²	D. see ⁶⁵ Ge	2E+4	4E+4	2E-5	6E-8	2E-8	2E-3
		V. see ⁶⁵ Ge	-	3E+4	2E-5	7E-8	-	-
31	Gallium-70 ²	D. see ⁶⁵ Ge	5E+4	2E+5	7E-5	2E-7	-	-
		V. see ⁶⁵ Ge	St. wall (7E+4)	-	-	-	1E-3	1E-2
31	Gallium-72	D. see ⁶⁵ Ge	1E+3	4E+3	1E-6	3E-8	2E-8	2E-4
		V. see ⁶⁵ Ge	-	3E+3	3E-6	4E-8	-	-
31	Gallium-73	D. see ⁶⁵ Ge	5E+3	2E+4	6E-6	2E-8	7E-8	2E-4
		V. see ⁶⁵ Ge	-	2E+4	6E-6	2E-8	-	-
32	Germanium-66	D. all compounds except those given for V	2E+4	3E+4	1E-5	4E-8	3E-8	3E-3
		V. oxides, sulfides, and halides	-	2E+4	8E-6	2E-8	-	-
32	Germanium-67 ²	D. see ⁶⁶ Ge	2E+4	9E+4	4E-5	1E-7	-	-
		V. see ⁶⁶ Ge	St. wall (4E+4)	-	-	-	5E-4	6E-3
32	Germanium-68	D. see ⁶⁶ Ge	5E+3	4E+3	2E-6	5E-9	6E-9	6E-4
		V. 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-8	2E-3
		V. 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
		V. see ⁶⁶ Ge	-	4E+4	2E-5	6E-8	-	-
32	Germanium-73 ²	D. see ⁶⁶ Ge	4E+6	8E+6	3E-5	1E-7	-	-
		V. see ⁶⁶ Ge	St. wall (7E+4)	-	-	-	9E-4	9E-3
32	Germanium-77	D. see ⁶⁶ Ge	9E+3	1E+4	4E-6	1E-8	1E-8	1E-3
		V. see ⁶⁶ Ge	-	6E+3	2E-6	6E-8	-	-
32	Germanium-78 ²	D. see ⁶⁶ Ge	2E+4	2E+4	9E-6	3E-8	-	-
		V. see ⁶⁶ Ge	St. wall (7E+4)	-	-	-	3E-4	3E-3

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Atomic No.	Radionuclide	Class	Table 1 Occupational values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 ALI (μCi)	Col. 3 SAI ($\mu\text{Ci}/\text{m}^3$)			
33	Arsenic-69 ²	W, all compounds	3E+4 SI, well (4E+4)	1E+5	5E-5	2E-7	-	-
33	Arsenic-70 ²	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	5E+3	2E+3	7E-7	2E-9	1E-4	1E-3
33	Arsenic-74	W, all compounds	1E+3	5E+2	1E-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
33	Arsenic-77	W, all compounds	4E+3 LLI well (5E+3)	5E+3	2E-6	2E-9	-	-
33	Arsenic-78 ²	W, all compounds	5E+3	2E+4	9E-6	3E-8	1E-4	1E-3
34	Selenium-70 ²	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-73a ²	D, see 70Se W, see 70Se	6E+4 3E+4	2E+5 1E+5	6E-5 6E-5	2E-7 2E-7	4E-4	4E-3
34	Selenium-73	D, see 70Se W, see 70Se	3E+3	1E+4 2E+4	5E-6 7E-6	2E-8 2E-8	4E-5	4E-4
34	Selenium-75	D, see 70Se W, see 70Se	5E+2	7E+2 6E+2	3E-7 3E-7	1E-9 6E-10	-	-
34	Selenium-79	D, see 70Se W, see 70Se	6E+2	8E+2 6E+2	3E-7 2E-7	1E-9 6E-10	5E-6	5E-5
34	Selenium-81a ²	D, see 70Se W, see 70Se	4E+4 2E+4	7E+4 7E+4	3E-5 3E-5	9E-8 1E-7	3E-4	3E-3
34	Selenium-81b ²	D, see 70Se	6E+4 SI, well (8E+4)	2E+5	9E-5	3E-7	-	-
		W, see 70Se	-	2E+5	1E-4	3E-7	1E-3	1E-2
34	Selenium-82 ²	D, see 70Se W, see 70Se	4E+4 3E+4	1E+5 1E+5	5E-5 5E-5	2E-7 2E-7	4E-4	4E-3

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Atomic No	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 ALI (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
35	Bromine-76 ²	D, bromides of H, Li, Na, K, Rb, Cs, and Fr	1E+4 St. wall (2E+4)	4E+4	2E-5	5E-8	-	-
		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, Se, Y, Tl, Zr, Hf, V, Mo, Ta, Mn, Tc, and Re	-	4E+4	2E-5	5E-8	-	-
35	Bromine-74 ²	D, see 74aBr	2E+4 St. wall (4E+4)	7E+4	3E-5	1E-7	-	-
		W, see 74aBr	-	8E+4	4E-5	1E-7	5E-4	5E-3
35	Bromine-75 ²	D, see 74aBr	1E+4 St. wall (4E+4)	5E+4	2E-5	7E-8	-	-
		W, see 74aBr	-	5E+4	2E-5	7E-8	5E-4	5E-3
35	Bromine-76	D, see 74aBr	4E+3	5E+3	2E-6	7E-9	5E-6	5E-4
		W, see 74aBr	-	4E+3	2E-6	6E-9	-	-
35	Bromine-77	D, see 74aBr	2E+4	2E+4	1E-5	3E-8	2E-4	2E-3
		W, see 74aBr	-	2E+4	8E-6	3E-8	-	-
35	Bromine-80a	D, see 74aBr	2E+4	2E+4	7E-6	2E-8	3E-4	3E-3
		W, see 74aBr	-	1E+4	4E-6	2E-8	-	-
35	Bromine-80 ²	D, see 74aBr	5E+4 St. wall (9E+4)	2E+5	6E-5	3E-7	-	-
		W, see 74aBr	-	2E+5	9E-5	3E-7	1E-3	1E-2
35	Bromine-82	D, see 74aBr	2E+3	4E+3	2E-6	6E-9	4E-5	4E-4
		W, see 74aBr	-	4E+3	2E-6	5E-9	-	-
35	Bromine-83	D, see 74aBr	5E+4 St. wall (7E+4)	6E+4	3E-5	9E-8	-	-
		W, see 74aBr	-	6E+4	3E-5	9E-8	7E-4	9E-3
35	Bromine-84 ²	D, see 74aBr	2E+4 St. wall (3E+4)	6E+4	2E-5	6E-8	-	-
		W, see 74aBr	-	6E+4	3E-5	9E-8	4E-4	4E-3
36	Krypton-74 ²	Submersion ¹	-	-	3E-6	1E-8	-	-
36	Krypton-76	Submersion ¹	-	-	9E-6	4E-8	-	-
36	Krypton-77 ²	Submersion ¹	-	-	4E-6	2E-8	-	-
36	Krypton-79	Submersion ¹	-	-	2E-6	7E-8	-	-
36	Krypton-81	Submersion ¹	-	-	7E-6	3E-8	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Ingestion AI (μCi)	Col. 2 Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				AI (μCi)	DAI ($\mu\text{Ci}/\text{m}^3$)			
36	Krypton-83m ²	Submersion ¹	-	-	1E-2	9E-5	-	-
36	Krypton-85a	Submersion ¹	-	-	2E-6	1E-7	-	-
36	Krypton-85	Submersion ¹	-	-	1E-4	7E-7	-	-
36	Krypton-87 ²	Submersion ¹	-	-	8E-6	2E-8	-	-
36	Krypton-88	Submersion ¹	-	-	2E-6	9E-8	-	-
37	Rubidium-78 ²	D, all compounds	4E SI (6E+4)	1E+5	9E-5	2E-7	-	-
37	Rubidium-81a ²	D, all compounds	2E+5 SI, well (3E+5)	9E+5	1E-4	5E-7	-	-
37	Rubidium-81	D, all compounds	4E+4	9E+4	2E-5	7E-8	9E-4	9E-3
37	Rubidium-82a	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	9E+2	9E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-86	D, all compounds	9E+2	9E+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 ²	D, all compounds	2E+4 SI, well (3E+4)	6E+4	3E-5	9E-8	-	-
37	Rubidium-89 ²	D, all compounds	4E+4 SI, well (6E+4)	1E+5	6E-5	2E-7	-	-
38	Strontium-80 ²	D, all soluble compounds except SrTiO ₃ Y, all insoluble com- pounds and SrTiO ₃	4E+3	1E+4	9E-6	2E-8	6E-5	6E-4
38	Strontium-81 ²	D, see ⁹⁰ Sr Y, see ⁹⁰ Sr	3E+4 2E+4	6E+4 9E+4	3E-5 3E-5	1E-7 1E-7	3E-4	3E-3
38	Strontium-82	D, see ⁹⁰ Sr Y, see ⁹⁰ Sr	3E+2 LI, well (2E+2)	4E+2	2E-7	6E-10	-	-
38	Strontium-83	D, see ⁹⁰ Sr Y, see ⁹⁰ Sr	3E+3 2E+3	7E+3 4E+3	3E-6 1E-6	1E-8 9E-8	3E-5	3E-4
38	Strontium-85a ²	D, see ⁹⁰ Sr Y, see ⁹⁰ Sr	2E+5	6E+5 9E+5	3E-4 4E-4	9E-7 1E-6	3E-3	3E-2
38	Strontium-85	D, see ⁹⁰ Sr Y, see ⁹⁰ Sr	3E+3	3E+3 2E+3	1E-6 6E-7	4E-9 2E-9	6E-5	6E-4
38	Strontium-87a	D, see ⁹⁰ Sr Y, see ⁹⁰ Sr	9E+4 4E+4	1E+5 2E+5	5E-5 6E-5	3E-7 2E-7	6E-4	6E-3

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Radionuclide No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Dose Injection AI (μ Ci)	Col. 2 Inhalation		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/m ³)	Monthly Average Concentration (μ Ci/m ³)
				Col. 1 AI (μ Ci)	Col. 2 GUL (μ Ci/m ³)			
38	Strontium-89	D, see ^{90}Sr	5E+2 LLI wall (5E+2)	5E+2	4E-7	5E-9	-	-
		Y, see ^{90}Sr	5E+2	3E+2	6E-8	2E-10	-	5E-5
38	Strontium-90	D, see ^{90}Sr	3E+1 Bone surf (4E+1)	2E+1 Bone surf (2E+1)	2E-8	-	-	-
		Y, see ^{90}Sr	-	4E+0	2E-9	2E-11 6E-12	2E-7	6E-6
38	Strontium-91	D, see ^{90}Sr	2E+3	6E+3	2E-4	6E-9	2E-5	2E-4
		Y, see ^{90}Sr	-	4E+3	3E-6	6E-9	-	-
38	Strontium-92	D, see ^{90}Sr	2E+3	9E+3	4E-6	3E-8	4E-5	4E-4
		Y, see ^{90}Sr	-	7E+3	3E-6	9E-9	-	-
39	Yttrium-86 ²	W, all compounds except those given for Y	2E+4	6E+4	2E-5	6E-8	2E-4	2E-3
		Y, oxides and hydroxides	-	6E+4	2E-5	6E-8	-	-
39	Yttrium-86	W, see ^{90}Sr	3E+3	3E+3	3E-6	2E-8	2E-5	2E-4
		Y, see ^{90}Sr	-	3E+3	3E-6	2E-8	-	-
39	Yttrium-87	W, see ^{90}Sr	2E+3	3E+3	3E-6	2E-8	2E-5	2E-4
		Y, see ^{90}Sr	-	3E+3	3E-6	2E-8	-	-
39	Yttrium-88	W, see ^{90}Sr	3E+3	3E+2	3E-7	2E-10	3E-5	3E-4
		Y, see ^{90}Sr	-	2E+2	3E-7	2E-10	-	-
39	Yttrium-89	W, see ^{90}Sr	6E+3	3E+4	5E-6	2E-8	3E-5	3E-3
		Y, see ^{90}Sr	-	3E+4	5E-6	2E-8	-	-
39	Yttrium-90	W, see ^{90}Sr	4E+2 LLI wall (5E+2)	7E+2	2E-7	6E-10	-	-
		Y, see ^{90}Sr	-	6E+2	2E-7	6E-10	7E-6	7E-5
39	Yttrium-91 ²	W, see ^{90}Sr	3E+5	2E+5	3E-4	2E-7	2E-2	2E-2
		Y, see ^{90}Sr	-	2E+5	7E-3	2E-7	-	-
39	Yttrium-91	W, see ^{90}Sr	5E+2 LLI wall (5E+2)	2E+2	7E-8	2E-10	-	-
		Y, see ^{90}Sr	-	3E+2	6E-8	2E-10	6E-6	6E-5
39	Yttrium-92	W, see ^{90}Sr	3E+3	9E+3	4E-6	3E-8	4E-5	4E-4
		Y, see ^{90}Sr	-	6E+3	2E-6	3E-8	-	-
39	Yttrium-93	W, see ^{90}Sr	3E+3	3E+3	3E-6	4E-8	2E-5	2E-4
		Y, see ^{90}Sr	-	2E+3	3E-6	2E-8	-	-
39	Yttrium-94 ²	W, see ^{90}Sr	2E+4 St. wall (3E+4)	6E+4	2E-5	3E-7	-	-
		Y, see ^{90}Sr	-	4E+4	2E-6	3E-7	4E-4	4E-3
39	Yttrium-95 ²	W, see ^{90}Sr	4E+4 St. wall (3E+4)	2E+5	6E-6	2E-7	-	-
		Y, see ^{90}Sr	-	3E+5	6E-6	2E-7	7E-4	7E-3

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Dose Ingestion ALI (μCi)	Col. 2 Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				ALI (μCi)	DAC ($\mu\text{Ci}/\text{m}^3$)			
40	Zirconium-88	D, all compounds except those given for W and Y W, oxides, hydroxides, halides, and nitrates Y, carbide	2E+3	4E+3	2E-6	6E-9	2E-5	2E-4
40	Zirconium-88	D, see 86Zr W, see 86Zr Y, see 86Zr	4E+3	2E+2	9E-8	3E-10	6E-5	6E-6
40	Zirconium-89	D, see 86Zr W, see 86Zr Y, see 86Zr	2E+3	4E+3	2E-6	6E-9	2E-5	2E-4
40	Zirconium-91	D, see 86Zr W, see 86Zr Y, see 86Zr	2E+3 Bone surf (3E+3)	6E+0 Bone surf (2E+1) 2E+1 Bone surf (6E+1) 6E+1 Bone surf (7E+1)	3E-9	-	2E-11 4E-5	- 4E-4
40	Zirconium-95	D, see 86Zr W, see 86Zr Y, see 86Zr	2E+3	2E+2 Bone surf (3E+2) 4E+2	9E-8	-	2E-5 4E-10 6E-10	2E-4
40	Zirconium-97	D, see 86Zr W, see 86Zr Y, see 86Zr	6E+2	2E+3	6E-7	3E-9	9E-6	9E-5
41	Niobium-92	W, all compounds except those given for Y Y, oxides and hydroxides	5E+4 St. wall (7E+4)	2E+5	9E-5	3E-7	-	-
41	Niobium-93m ² (66 min)	W, see 86Nb Y, see 86Nb	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
41	Niobium-95 (122 min)	W, see 86Nb Y, see 86Nb	5E+3	2E+4	6E-6	2E-8	7E-5	7E-4
41	Niobium-90	W, see 86Nb Y, see 86Nb	2E+3	3E+3	2E-6	6E-9	2E-5	2E-4
41	Niobium-93a	W, see 86Nb Y, see 86Nb	9E+3 LLI wall (1E+4)	2E+3	6E-7	3E-9	-	-
41	Niobium-94	W, see 86Nb Y, see 86Nb	9E+2	2E+2	6E-6	3E-10	2E-5	2E-4
41	Niobium-95a	W, see 86Nb Y, see 86Nb	2E+3 LLI wall (2E+3)	3E+3	2E-6	6E-9	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Release to Sewers
			Col. 1 Oral Ingestion ALI (μ Ci)	Inhalation		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/m ³)	Monthly Average Concentration (μ Ci/ml)
				Col. 2 ALL (μ Ci)	Col. 3 DAC (μ Ci/ml)			
41	Isotopes-95	W, see ⁹⁰ Po Y, see ⁹⁰ Po	2E+3	2E+3	6E-7	2E-5	2E-5	2E-4
41	Isotopes-96	W, see ⁹⁰ Po Y, see ⁹⁰ Po	2E+3	2E+3	2E-6	4E-8	2E-5	2E-4
41	Isotopes-97 ²	W, see ⁹⁰ Po Y, see ⁹⁰ Po	2E+4	2E+4	2E-5	2E-7	2E-4	2E-3
41	Isotopes-98 ²	W, see ⁹⁰ Po Y, see ⁹⁰ Po	2E+4	2E+4	2E-5	2E-8	2E-4	2E-3
42	Rhenium-90	D, all compounds except those given for Y Y, oxides, hydroxides, and MoS ₂	4E+3	7E+3	2E-6	2E-8	2E-5	2E-4
42	Rhenium-92a	D, see ⁹⁰ Po Y, see ⁹⁰ Po	4E+3	2E+4	7E-6	2E-8	6E-5	6E-4
42	Rhenium-93	D, see ⁹⁰ Po Y, see ⁹⁰ Po	4E+3	2E+2	2E-6	2E-10	2E-5	2E-4
42	Rhenium-95	D, see ⁹⁰ Po Y, see ⁹⁰ Po	2E+3 (1E+3)	2E+3	2E-6	4E-9	-	-
42	Rhenium-101 ²	D, see ⁹⁰ Po Y, see ⁹⁰ Po	4E+4 (5E+4)	2E+5	6E-5	2E-7	-	-
43	Technetium-92a ²	D, all compounds except those given for W W, oxides, hydroxides, halides, and nitrates	7E+4	2E+5	6E-5	2E-7	2E-3	2E-2
43	Technetium-93	D, see ^{93m} Tc W, see ^{93m} Tc	2E+4	7E+4	2E-5	2E-7	4E-4	4E-3
43	Technetium-94a ²	D, see ^{93m} Tc W, see ^{93m} Tc	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
43	Technetium-94	D, see ^{93m} Tc W, see ^{93m} Tc	2E+3	2E+4	2E-6	2E-8	2E-4	2E-3
43	Technetium-95a	D, see ^{93m} Tc W, see ^{93m} Tc	4E+3	2E+3	2E-6	2E-9	2E-5	2E-4
43	Technetium-95	D, see ^{93m} Tc W, see ^{93m} Tc	2E+4	2E+4	2E-6	2E-8	2E-4	2E-3
43	Technetium-96a ²	D, see ^{93m} Tc W, see ^{93m} Tc	2E+5	2E+5	2E-6	4E-7	2E-3	2E-2
43	Technetium-96	D, see ^{93m} Tc W, see ^{93m} Tc	2E+3	2E+3	2E-6	2E-9	2E-5	2E-4
43	Technetium-97a	D, see ^{93m} Tc W, see ^{93m} Tc	2E+3	7E+3 (7E+3)	2E-6	-	6E-5	6E-4

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Atomic No.	Radioisotope	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion (μCi)	Col. 2 Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				ALL (μCi)	SAC ($\mu\text{Ci}/\text{m}^3$)			
43	Technetium-97	D, see $^{99\text{m}}\text{Tc}$	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
		W, see $^{99\text{m}}\text{Tc}$	-	6E+3	2E-6	8E-9	-	-
43	Technetium-98	D, see $^{99\text{m}}\text{Tc}$	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
		W, see $^{99\text{m}}\text{Tc}$	-	2E+2	1E-7	4E-10	-	-
43	Technetium-99a	D, see $^{99\text{m}}\text{Tc}$	5E+4	2E+5	6E-5	2E-7	1E-3	1E-2
		W, see $^{99\text{m}}\text{Tc}$	-	2E+5	1E-4	3E-7	-	-
43	Technetium-99	D, see $^{99\text{m}}\text{Tc}$	4E+3	5E+3	2E-6	-	6E-5	6E-4
		W, see $^{99\text{m}}\text{Tc}$	-	(6E+3) St. wall 7E+2	-	8E-9 9E-10	-	-
43	Technetium-101 ²	D, see $^{99\text{m}}\text{Tc}$	9E+4 (1E+5) St. wall	3E+5	1E-4	5E-7	-	-
		W, see $^{99\text{m}}\text{Tc}$	-	4E+5	2E-4	5E-7	2E-3	2E-2
43	Technetium-104 ²	D, see $^{99\text{m}}\text{Tc}$	2E+4 (3E+4) St. wall	7E+4	3E-5	1E-7	-	-
		W, see $^{99\text{m}}\text{Tc}$	-	9E+4	4E-5	1E-7	4E-4	4E-3
44	Ruthenium-94 ²	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	5E+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	6E-6	2E-8	-	-
44	Ruthenium-106	D, see ^{94}Ru	2E+2 (2E+2) LLI wall	9E+1	4E-8	1E-10	-	-
		W, see ^{94}Ru	-	5E+1	2E-8	8E-11	3E-6	3E-5
		Y, see ^{94}Ru	-	1E+1	5E-9	2E-11	-	-
45	Rhodium-99a	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 ^{99}Rh	2E+3	3E+3	1E-6	4E-8	7E-5	3E-4
		W, see ^{99}Rh	-	2E+3	9E-7	3E-9	-	-
		Y, see ^{99}Rh	-	2E+3	8E-7	3E-9	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Dose Imposition ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 ALL (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
45	Rhodium-100	D, see ^{100}Rh	2E+3	5E+3	2E-6	7E-9	2E-5	2E-4
		W, see ^{100}Rh	-	4E+2	2E-6	6E-9	-	-
		Y, see ^{100}Rh	-	4E+3	2E-6	5E-9	-	-
45	Rhodium-101a	D, see ^{101}Rh	6E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		W, see ^{101}Rh	-	8E+3	4E-6	1E-8	-	-
		Y, see ^{101}Rh	-	8E+3	3E-6	1E-8	-	-
45	Rhodium-101	D, see ^{101}Rh	2E+3	5E+2	2E-7	7E-10	2E-5	2E-4
		W, see ^{101}Rh	-	5E+2	2E-7	1E-9	-	-
		Y, see ^{101}Rh	-	2E+2	6E-8	2E-10	-	-
45	Rhodium-102a	D, see ^{102}Rh	1E+3	5E+2	2E-7	7E-10	-	-
		W, see ^{102}Rh	LLI well (1E+2)	-	-	-	2E-5	2E-4
		Y, see ^{102}Rh	-	4E+2	2E-7	5E-10	-	-
45	Rhodium-102	D, see ^{102}Rh	6E+2	9E+1	4E-8	1E-10	6E-6	6E-5
		W, see ^{102}Rh	-	2E+2	7E-8	2E-10	-	-
		Y, see ^{102}Rh	-	6E+1	2E-8	6E-11	-	-
45	Rhodium-103a ²	D, see ^{103}Rh	4E+5	1E+6	5E-4	2E-6	6E-3	6E-2
		W, see ^{103}Rh	-	1E+6	5E-4	2E-6	-	-
		Y, see ^{103}Rh	-	1E+6	5E-4	2E-6	-	-
45	Rhodium-105	D, see ^{105}Rh	4E+5	1E+4	5E-6	2E-8	-	-
		W, see ^{105}Rh	LLI well (4E+3)	-	-	-	6E-5	6E-4
		Y, see ^{105}Rh	-	6E+3	2E-6	9E-9	-	-
45	Rhodium-106a	D, see ^{106}Rh	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, see ^{106}Rh	-	4E+4	2E-5	9E-8	-	-
		Y, see ^{106}Rh	-	4E+4	1E-5	5E-8	-	-
45	Rhodium-107 ²	D, see ^{107}Rh	7E+4	2E+5	1E-4	3E-7	-	-
		W, see ^{107}Rh	SI well (9E+4)	-	-	-	1E-3	1E-2
		Y, see ^{107}Rh	-	2E+5	1E-4	4E-7	-	-
46	Palladium-100	D, all compounds except those given for W and Y	1E+3	1E+3	5E-7	2E-9	2E-5	2E-4
		W, nitrates	-	1E+3	5E-7	2E-9	-	-
		Y, oxides and hydrides	-	1E+3	6E-7	2E-9	-	-
46	Palladium-101	D, see ^{101}Pd	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{101}Pd	-	3E+4	1E-5	5E-8	-	-
		Y, see ^{101}Pd	-	3E+4	1E-5	4E-8	-	-
46	Palladium-103	D, see ^{103}Pd	6E+3	6E+3	3E-6	9E-9	-	-
		W, see ^{103}Pd	LLI well (7E+2)	-	-	-	1E-4	1E-3
		Y, see ^{103}Pd	-	4E+3	2E-6	6E-9	-	-
46	Palladium-107	D, see ^{107}Pd	3E+4	2E+4	9E-6	-	-	-
		W, see ^{107}Pd	LLI well (4E+4)	LLI kidneys (2E+4)	-	2E-8	6E-4	6E-3
		Y, see ^{107}Pd	-	7E+3	3E-6	1E-8	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Dose Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)		Col. 1 Air ($\mu\text{Ci}/\text{M}$)	Col. 2 Water ($\mu\text{Ci}/\text{M}$)	Monthly Average Concentration ($\mu\text{Ci}/\text{M}$)
				Col. 3 DAC ($\mu\text{Ci}/\text{M}$)	Col. 1 Air ($\mu\text{Ci}/\text{M}$)			
46	Palladium-109	D, see 100Pd W, see 100Pd Y, see 100Pd	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
47	Silver-107	D, all compounds except those given for W and Y	5E+4 SI, see 11 (6E+4)	2E+5	6E-5	2E-7	-	-
		W, nitrates and sulfides	-	2E+5	6E-5	3E-7	-	-
		Y, oxides and hydroxides	-	2E+5	6E-5	3E-7	-	-
47	Silver-107	D, see 107Ag W, see 107Ag Y, see 107Ag	4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
47	Silver-106m	D, see 107Ag W, see 107Ag Y, see 107Ag	3E+4	9E+4	4E-5	1E-7	4E-4	4E-3
47	Silver-106	D, see 107Ag W, see 107Ag Y, see 107Ag	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
47	Silver-105	D, see 107Ag W, see 107Ag Y, see 107Ag	3E+3	1E+3	4E-7	1E-9	4E-5	4E-4
47	Silver-106a	D, see 107Ag W, see 107Ag Y, see 107Ag	8E+2	7E+2	3E-7	1E-9	1E-5	1E-4
47	Silver-106	D, see 107Ag W, see 107Ag Y, see 107Ag	6E+4 SI, see 11 (6E+4)	2E+5	6E-5	3E-7	-	-
		W, see 107Ag Y, see 107Ag	-	2E+5	6E-5	3E-7	-	-
47	Silver-108m	D, see 107Ag W, see 107Ag Y, see 107Ag	6E+2	2E+2	6E-8	3E-10	9E-6	9E-5
47	Silver-110m	D, see 107Ag W, see 107Ag Y, see 107Ag	5E+2	1E+2	9E-8	2E-10	6E-6	6E-5
47	Silver-111	D, see 107Ag W, see 107Ag Y, see 107Ag	9E+2 LI, see 11 (1E+3)	2E+3 LI, see 11 (2E+3)	6E-7	-	-	-
		W, see 107Ag Y, see 107Ag	-	9E+2	4E-7	1E-9	-	-
47	Silver-112	D, see 107Ag W, see 107Ag Y, see 107Ag	3E+3	6E+3	3E-6	1E-8	4E-5	4E-4

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Dose Ingestion ALI (μCi)	Col. 3 Inhalation ($\mu\text{Ci}/\text{m}^3$)		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 ST. unll (μCi)	Col. 3 ALI ($\mu\text{Ci}/\text{m}^3$)			
47	Silver-115 ²	D, see ¹⁰² Ag	3E-4	9E-4	4E-5	1E-7	-	-
		W, see ¹⁰² Ag	(3E-4)	-	-	-	6E-4	6E-3
		Y, see ¹⁰² Ag	-	9E-4	4E-5	1E-7	-	-
48	Cadmium-104 ²	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	6E-8	3E-4	3E-3
		W, see ¹⁰⁴ Cd	-	6E-4	2E-5	6E-8	-	-
		Y, see ¹⁰⁴ Cd	-	5E-4	2E-5	7E-8	-	-
48	Cadmium-109	D, see ¹⁰⁴ Cd	3E-2 Kidneys (4E+2)	4E+1 Kidneys (5E+1)	1E-8	-	-	-
		W, see ¹⁰⁴ Cd	-	1E+2 Kidneys	5E-8	7E-11	6E-6	6E-5
		Y, see ¹⁰⁴ Cd	-	(1E+2)	-	2E-10	-	-
48	Cadmium-113a	D, see ¹⁰⁴ Cd	2E+1 Kidneys (4E+1)	2E+0 Kidneys (4E+0)	1E-9	-	-	-
		W, see ¹⁰⁴ Cd	-	8E+0 Kidneys (1E+1)	4E-9	5E-12	5E-7	5E-6
		Y, see ¹⁰⁴ Cd	-	1E+1 Kidneys	5E-9	2E-11	-	-
48	Cadmium-113	D, see ¹⁰⁴ Cd	2E+1 Kidneys (3E+1)	2E+0 Kidneys (3E+0)	9E-10	-	-	-
		W, see ¹⁰⁴ Cd	-	6E+0 Kidneys (1E+1)	3E-9	5E-12	4E-7	4E-6
		Y, see ¹⁰⁴ Cd	-	1E+1 Kidneys	6E-9	2E-11	-	-
48	Cadmium-113m	D, see ¹⁰⁴ Cd	3E-2	5E-1 Kidneys (9E-1)	2E-8	-	4E-6	4E-5
		W, see ¹⁰⁴ Cd	-	1E+2	5E-8	1E-10	-	-
		Y, see ¹⁰⁴ Cd	-	1E+2	4E-8	2E-10	-	-
48	Cadmium-115	D, see ¹⁰⁴ Cd	9E-2 LLI unll (1E+2)	1E+3	6E-7	2E-9	-	-
		W, see ¹⁰⁴ Cd	-	-	-	-	1E-5	1E-4
		Y, see ¹⁰⁴ Cd	-	1E+3	5E-7	2E-9	-	-
48	Cadmium-117a	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	-	-

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Atomic No.	Radioisotope	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 AI (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
48	Cesium-137	D, see 10^4Ci W, see 10^4Ci V, see 10^4Ci	BE-3	BE-4 BE-4 BE-4	BE-6 BE-6 BE-6	BE-8 BE-8 BE-8	BE-5 -	BE-4 -
49	Iodine-129	D, all compounds except those given for W W, oxides, hydroxides, halides, and nitrates	BE-4	BE-4	BE-5	BE-8	BE-4	BE-3
49	Iodine-130 ² (68.1 min)	D, see 10^9in W, see 10^9in	BE-4	BE-4	BE-5	BE-8	BE-4	BE-3
49	Iodine-130 (4.9 h)	D, see 10^9in W, see 10^9in	BE-3	BE-4	BE-6	BE-8	BE-5	BE-4
49	Iodine-131	D, see 10^9in W, see 10^9in	BE-3	BE-3	BE-6	BE-8	BE-5	BE-4
49	Iodine-132 ²	D, see 10^9in W, see 10^9in	BE-5	BE-5	BE-6	BE-7	BE-3	BE-2
49	Iodine-133 ²	D, see 10^9in W, see 10^9in	BE-4	BE-5	BE-5	BE-7	BE-4	BE-3
49	Iodine-134	D, see 10^9in W, see 10^9in	BE-2 (ALI see 11) (BE-2)	BE-1	BE-8	BE-11	BE-6	BE-8
49	Iodine-135	D, see 10^9in W, see 10^9in	BE-4	BE-4	BE-5	BE-8	BE-4	BE-3
49	Iodine-135	D, see 10^9in W, see 10^9in	BE-1	BE-0	BE-10	BE-12	BE-7	BE-6
49	Iodine-136 ²	D, see 10^9in W, see 10^9in	BE-4	BE-5	BE-5	BE-7	BE-4	BE-3
49	Iodine-137 ²	D, see 10^9in W, see 10^9in	BE-4	BE-4	BE-5	BE-8	BE-4	BE-3
49	Iodine-137 ²	D, see 10^9in W, see 10^9in	BE-4	BE-5	BE-5	BE-7	BE-4	BE-3
49	Iodine-139 ²	D, see 10^9in W, see 10^9in	BE-4 SI, see 11 (BE-4)	BE-5	BE-5	BE-7	BE-4	BE-3
50	Tin-110	D, all compounds except those given for W W, sulfides, oxides, hydroxides, halides, nitrates, and stannic phosphate	BE-3	BE-4	BE-6	BE-8	BE-5	BE-4
50	Tin-111 ²	D, see 110in W, see 110in	BE-4	BE-5	BE-5	BE-7	BE-3	BE-2

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Atomic No.	Radionuclide	Class	Table 1 Exceptional Values			Table 2 Effluent Concentrations		Table 3 Releases to Source
			Col. 1 Oral Ingestion ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 AI (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
90	Tin-113	D. see ^{110}Sn	2E-3 LLI wall (2E-3)	2E-3	6E-7	2E-9	-	-
		W. see ^{110}Sn	-	6E-2	2E-7	6E-10	6E-5	6E-4
90	Tin-113a	D. see ^{110}Sn	2E-3 LLI wall (2E-3)	2E-3 Same surf (2E-3)	6E-7	-	-	-
		W. see ^{110}Sn	-	2E-3	6E-7	2E-9	6E-5	6E-4
90	Tin-113b	D. see ^{110}Sn	2E-3 LLI wall (4E-3)	2E-3	2E-6	6E-9	-	-
		W. see ^{110}Sn	-	2E-3	4E-7	2E-9	6E-5	6E-4
90	Tin-113c	D. see ^{110}Sn	2E-3 LLI wall (4E-3)	6E-2	4E-7	2E-9	-	-
		W. see ^{110}Sn	-	6E-2	2E-7	6E-10	6E-5	6E-4
90	Tin-121	D. see ^{110}Sn	6E-3 LLI wall (6E-3)	2E-4	6E-6	2E-8	-	-
		W. see ^{110}Sn	-	2E-4	6E-6	2E-8	6E-5	6E-4
90	Tin-123a ²	D. see ^{110}Sn	6E-4	2E-5	6E-5	2E-7	2E-4	2E-3
		W. see ^{110}Sn	-	2E-5	6E-5	2E-7	-	-
90	Tin-123	D. see ^{110}Sn	6E-2 LLI wall (6E-2)	6E-2	2E-7	6E-10	-	-
		W. see ^{110}Sn	-	2E-2	2E-6	2E-10	6E-5	6E-4
90	Tin-125	D. see ^{110}Sn	4E-2 LLI wall (5E-2)	6E-2	4E-7	2E-9	-	-
		W. see ^{110}Sn	-	4E-2	2E-7	6E-10	6E-5	6E-4
90	Tin-126	D. see ^{110}Sn	2E-2	6E-1	2E-8	6E-11	4E-6	4E-5
		W. see ^{110}Sn	-	2E-1	2E-8	6E-11	-	-
90	Tin-127	D. see ^{110}Sn	2E-3	2E-4	6E-6	2E-8	6E-5	6E-4
		W. see ^{110}Sn	-	2E-4	6E-6	2E-8	-	-
90	Tin-128 ²	D. see ^{110}Sn	9E-3	3E-4	2E-5	4E-8	2E-4	2E-3
		W. see ^{110}Sn	-	4E-4	2E-5	6E-8	-	-
81	Antimony-115 ²	D. all compounds except those given for W	6E-4	2E-5	2E-4	2E-7	2E-3	2E-2
		W. oxides, hydroxides, halides, sulfides, sulfates, and nitrates	-	2E-5	2E-4	4E-7	-	-
81	Antimony-116a ²	D. see ^{115}Sb	2E-4	2E-4	6E-5	2E-7	2E-4	2E-3
		W. see ^{115}Sb	-	2E-5	6E-5	2E-7	-	-
81	Antimony-116b ²	D. see ^{115}Sb	2E-4 St. wall (9E-4)	2E-5	2E-4	4E-7	-	-
		W. see ^{115}Sb	-	2E-5	2E-4	6E-7	2E-3	2E-2
81	Antimony-117	D. see ^{115}Sb	2E-4	2E-5	9E-5	2E-7	6E-4	6E-3
		W. see ^{115}Sb	-	2E-5	2E-4	4E-7	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Dose [mrem AL] (μ Ci)	Inhalation		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/m ³)	Monthly Average Concentration (μ Ci/m ³)
				Col. 2 K1 (μ Ci)	Col. 3 DAC (μ Ci/m ³)			
51	Antimony-118m	D. see 115 _{5b}	6E-3	2E+4	6E-6	3E-8	7E-5	7E-4
		W. see 115 _{5b}	5E-3	2E+4	6E-6	3E-8	-	-
51	Antimony-119	D. see 115 _{5b}	2E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		W. see 115 _{5b}	2E+4	3E+4	1E-5	4E-8	-	-
51	Antimony-120 ² (16 min)	D. see 115 _{5b}	1E+5	4E+5	2E-4	6E-7	-	-
		W. see 115 _{5b}	5E+4 (2E+5)	5E+5	2E-4	7E-7	2E-3	2E-2
51	Antimony-120 (5.76 h)	D. see 115 _{5b}	1E+3	2E+3	9E-7	2E-9	1E-5	1E-4
		W. see 115 _{5b}	9E+2	1E+3	9E-7	2E-9	-	-
51	Antimony-122	D. see 115 _{5b}	8E+2	2E+3	1E-6	3E-9	-	-
		W. see 115 _{5b}	1.1E+2 (8E+2) 7E+2	2E+3	4E-7	2E-9	1E-5	1E-4
51	Antimony-126 ²	D. see 115 _{5b}	3E+5	8E+5	4E-4	1E-6	3E-3	3E-2
		W. see 115 _{5b}	2E+5	6E+5	2E-4	8E-7	-	-
51	Antimony-124	D. see 115 _{5b}	6E+2	9E+2	4E-7	1E-9	7E-6	7E-5
		W. see 115 _{5b}	5E+2	2E+2	1E-7	3E-10	-	-
51	Antimony-125	D. see 115 _{5b}	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4
		W. see 115 _{5b}	-	5E+2	2E-7	7E-10	-	-
51	Antimony-126 ²	D. see 115 _{5b}	5E+4	2E+5	6E-5	3E-7	-	-
		W. see 115 _{5b}	5E+4 (7E+4)	2E+5	6E-5	3E-7	9E-6	9E-3
51	Antimony-126	D. see 115 _{5b}	4E+2	1E+3	5E-7	2E-9	7E-6	7E-5
		W. see 115 _{5b}	5E+2	5E+2	2E-7	7E-10	-	-
51	Antimony-127	D. see 115 _{5b}	8E+2	2E+3	9E-7	3E-9	-	-
		W. see 115 _{5b}	1.1E+2 (8E+2) 7E+2	2E+3	4E-7	1E-9	1E-5	1E-4
51	Antimony-128 ² (10.4 min)	D. see 115 _{5b}	8E+4	4E+5	2E-4	3E-7	-	-
		W. see 115 _{5b}	5E+4 (1E+5)	4E+5	2E-4	3E-7	1E-3	1E-2
51	Antimony-128 (9.01 h)	D. see 115 _{5b}	1E+3	4E+3	2E-6	6E-9	2E-6	2E-4
		W. see 115 _{5b}	-	3E+3	1E-6	6E-9	-	-
51	Antimony-129	D. see 115 _{5b}	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		W. see 115 _{5b}	-	9E+3	4E-6	1E-8	-	-
51	Antimony-130 ²	D. see 115 _{5b}	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		W. see 115 _{5b}	-	6E+4	3E-5	1E-7	-	-
51	Antimony-131 ²	D. see 115 _{5b}	1E+4	2E+4	1E-5	-	-	-
		W. see 115 _{5b}	Thyroid (2E+4)	Thyroid (4E+4)	-	6E-8	2E-6	2E-3
				Thyroid (4E+4)		6E-8		

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion AI (μ Ci)	Inhalation		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/m ³)	Monthly Average Concentration (μ Ci/m ³)
				Col. 2 KI (μ Ci)	Col. 3 DAC (μ Ci/m ³)			
52	Tellurium-116	D, all compounds except those given for W W, oxides, hydroxides, and nitrates	5E+3	2E+4	5E-6	5E-8	5E-4	5E-3
52	Tellurium-121a	D, see 116Te W, see 116Te	5E+2 Bone surf (7E+2)	2E+2 Bone surf (4E+2)	5E-8	-	-	-
52	Tellurium-121	D, see 116Te W, see 116Te	5E+3	4E+3	2E-6	5E-9	4E-5	4E-4
52	Tellurium-123a	D, see 116Te W, see 116Te	5E+2 Bone surf (1E+3)	2E+2 Bone surf (5E+2)	5E-8	-	-	-
52	Tellurium-123	D, see 116Te W, see 116Te	5E+2 Bone surf (1E+3)	2E+2 Bone surf (5E+2)	5E-8	-	-	-
52	Tellurium-123b	D, see 116Te W, see 116Te	5E+2 Bone surf (1E+3)	2E+2 Bone surf (5E+2)	5E-8	-	-	-
52	Tellurium-127a	D, see 116Te W, see 116Te	5E+2	3E+2	1E-7	-	5E-6	5E-5
52	Tellurium-127	D, see 116Te W, see 116Te	7E+3	2E+4	5E-6	5E-8	1E-4	1E-3
52	Tellurium-129a	D, see 116Te W, see 116Te	5E+2	5E+2	5E-7	5E-10	7E-6	7E-5
52	Tellurium-129 ^b	D, see 116Te W, see 116Te	5E+4	5E+4	5E-5	5E-8	4E-4	4E-3
52	Tellurium-131a	D, see 116Te W, see 116Te	5E+2 Thyroid (4E+2)	4E+2 Thyroid (1E+3)	2E-7	-	-	-
52	Tellurium-131 ^b	D, see 116Te W, see 116Te	2E+3 Thyroid (5E+3)	5E+3 Thyroid (1E+4)	2E-6	-	-	-

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PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 ALI (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
52	Tellurium-132	D, see ^{132}Te	2E+2 Thyroid (7E+2)	2E+2 Thyroid (8E+2)	9E-8	-	-	9E-5
		W, see ^{132}Te	-	2E+2 Thyroid (6E+2)	9E-8	1E-9	9E-6	-
52	Tellurium-133 ²	D, see ^{133}Te	3E+3 Thyroid (6E+3)	3E+3 Thyroid (2E+4)	2E-6	-	-	-
		W, see ^{133}Te	-	3E+3 Thyroid (2E+4)	2E-6	2E-8	9E-5	9E-4
52	Tellurium-133 ²	D, see ^{133}Te	3E+4 Thyroid (3E+4)	2E+4 Thyroid (6E+4)	9E-6	-	-	-
		W, see ^{133}Te	-	2E+4 Thyroid (6E+4)	9E-6	8E-8	4E-4	4E-3
52	Tellurium-134 ²	D, see ^{134}Te	2E+4 Thyroid (2E+4)	2E+4 Thyroid (5E+4)	2E-5	-	-	-
		W, see ^{134}Te	-	2E+4 Thyroid (5E+4)	2E-5	7E-8	2E-4	2E-3
53	Iodine-129 ²	D, all compounds	1E+4 Thyroid (1E+4)	2E+4	9E-6	2E-8	-	-
53	Iodine-129 ²	D, all compounds	4E+3 Thyroid (8E+3)	9E+3 Thyroid (1E+4)	4E-6	-	-	-
53	Iodine-129	D, all compounds	1E+4 Thyroid (3E+4)	2E+4 Thyroid (5E+4)	9E-6	7E-8	4E-4	4E-3
53	Iodine-129	D, all compounds	3E+3 Thyroid (1E+4)	6E+3 Thyroid (2E+4)	3E-6	2E-8	1E-4	1E-3
53	Iodine-129	D, all compounds	5E+1 Thyroid (2E+2)	8E+1 Thyroid (3E+2)	3E-8	4E-10	2E-6	2E-5
53	Iodine-129	D, all compounds	4E+1 Thyroid (1E+2)	6E+1 Thyroid (2E+2)	3E-8	3E-10	2E-6	2E-5
53	Iodine-129	D, all compounds	2E+1 Thyroid (7E+1)	4E+1 Thyroid (1E+2)	1E-8	2E-10	1E-6	1E-5
53	Iodine-129 ²	D, all compounds	4E+4 St. wall (6E+4)	1E+5	5E-5	2E-7	-	-
53	Iodine-129	D, all compounds	5E+0 Thyroid (2E+1)	9E+0 Thyroid (3E+1)	4E-9	4E-11	2E-7	2E-6

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases To Sewers
			Col. 1 Oral Ingestion AI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 ACI (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
53	Iodine-130	D, all compounds	4E+2 Thyroid (3E+2)	7E+2 Thyroid (2E+2)	3E-7	-	-	-
53	Iodine-131	D, all compounds	2E+1 Thyroid (9E+1)	5E+1 Thyroid (2E+2)	2E-8	-	-	-
53	Iodine-132 ²	D, all compounds	4E+3 Thyroid (3E+4)	8E+3 Thyroid (2E+4)	4E-6	-	-	-
53	Iodine-132	D, all compounds	4E+3 Thyroid (9E+3)	8E+3 Thyroid (3E+4)	3E-6	-	-	-
53	Iodine-133	D, all compounds	3E+2 Thyroid (8E+2)	3E+2 Thyroid (9E+2)	3E-7	-	-	-
53	Iodine-134 ²	D, all compounds	2E+4 Thyroid (3E+4)	5E+4 -	2E-3	5E-8	-	-
53	Iodine-135	D, all compounds	8E+2 Thyroid (3E+3)	2E+3 Thyroid (4E+3)	7E-7	-	-	-
54	Xenon-120 ²	Submersion ¹	-	-	3E-5	6E-8	-	-
54	Xenon-121 ²	Submersion ¹	-	-	2E-6	3E-8	-	-
54	Xenon-127	Submersion ¹	-	-	7E-5	3E-7	-	-
54	Xenon-123	Submersion ¹	-	-	6E-6	2E-8	-	-
54	Xenon-125	Submersion ¹	-	-	2E-5	7E-8	-	-
54	Xenon-127	Submersion ¹	-	-	3E-5	6E-8	-	-
54	Xenon-129a	Submersion ¹	-	-	2E-4	9E-7	-	-
54	Xenon-131a	Submersion ¹	-	-	4E-4	2E-6	-	-
54	Xenon-133a	Submersion ¹	-	-	3E-4	6E-7	-	-
54	Xenon-133	Submersion ¹	-	-	3E-4	5E-7	-	-
54	Xenon-135a ²	Submersion ¹	-	-	9E-6	4E-8	-	-
54	Xenon-135	Submersion ¹	-	-	3E-5	7E-8	-	-
54	Xenon-136 ²	Submersion ¹	-	-	4E-6	2E-8	-	-
55	Cesium-125 ²	D, all compounds	5E+4 St. wall (9E+4)	3E+5	6E-5	2E-7	-	-
55	Cesium-127	D, all compounds	6E+4	9E+4	4E-5	3E-7	9E-4	9E-3

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PART 20. STANDARDS FOR PROTECTION AGAINST RADIATION

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion AI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 AI (μCi)	Col. 3 SI ($\mu\text{Ci}/\text{m}^3$)			
55	Cesium-137	D, all compounds	2E+4	2E+4	2E-5	2E-8	2E-4	2E-3
55	Cesium-137 ²	D, all compounds	6E+4 St. well (2E+5)	2E+5	2E-5	2E-7	-	-
55	Cesium-131	D, all compounds	2E+4	2E+4	2E-5	2E-8	2E-4	2E-3
55	Cesium-132	D, all compounds	2E+3	2E+3	2E-5	2E-8	2E-5	2E-4
55	Cesium-134m	D, all compounds	2E+5 St. well (2E+5)	2E+5	2E-5	2E-7	-	-
55	Cesium-134	D, all compounds	2E+2	2E+2	2E-8	2E-10	2E-7	2E-6
55	Cesium-135m ²	D, all compounds	2E+5	2E+5	2E-5	2E-7	2E-3	2E-2
55	Cesium-135	D, all compounds	2E+2	2E+2	2E-7	2E-9	2E-5	2E-4
55	Cesium-136	D, all compounds	2E+2	2E+2	2E-7	2E-10	2E-6	2E-5
55	Cesium-137	D, all compounds	2E+2	2E+2	2E-8	2E-10	2E-6	2E-5
55	Cesium-138 ²	D, all compounds	2E+4 St. well (2E+4)	2E+4	2E-5	2E-8	-	-
56	Barium-129 ²	D, all compounds	2E+3	2E+4	2E-6	2E-8	2E-5	2E-4
56	Barium-129	D, all compounds	2E+2	2E+3	2E-7	2E-9	2E-6	2E-5
56	Barium-131a ²	D, all compounds	2E+5 St. well (2E+5)	2E+6	2E-4	2E-6	-	-
56	Barium-131	D, all compounds	2E+3	2E+3	2E-6	2E-8	2E-5	2E-4
56	Barium-133m	D, all compounds	2E+3 LLI well (2E+3)	2E+3	2E-6	2E-8	-	-
56	Barium-133	D, all compounds	2E+3	2E+2	2E-7	2E-10	2E-5	2E-4
56	Barium-133m	D, all compounds	2E+2	2E+4	2E-6	2E-8	2E-5	2E-4
56	Barium-135 ²	D, all compounds	2E+4	2E+4	2E-5	2E-8	2E-4	2E-3
56	Barium-140	D, all compounds	2E+2 LLI well (2E+2)	2E+3	2E-7	2E-9	-	-
56	Barium-141 ²	D, all compounds	2E+4	2E+4	2E-5	2E-7	2E-4	2E-3
56	Barium-142 ²	D, all compounds	2E+4	2E+5	2E-5	2E-7	2E-4	2E-3
57	Lanthanum-131 ²	D, all compounds except those given for M	2E+4	2E+5	2E-5	2E-7	2E-4	2E-3
		M, oxides and hydroxides	-	2E+5	2E-5	2E-7	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion All (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 All (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
57	Lanthanum-132	D. see ^{132}La	$3\text{E}+3$	$1\text{E}+4$	$4\text{E}+6$	$1\text{E}-8$	$4\text{E}-5$	$4\text{E}-4$
		W. see ^{132}La	-	$1\text{E}+8$	$5\text{E}+6$	$2\text{E}-8$	-	-
57	Lanthanum-135	D. see ^{135}La	$4\text{E}+4$	$1\text{E}+5$	$4\text{E}+5$	$1\text{E}-7$	$5\text{E}-4$	$5\text{E}-5$
		W. see ^{135}La	-	$5\text{E}+4$	$4\text{E}+5$	$1\text{E}-7$	-	-
57	Lanthanum-137	D. see ^{137}La	$1\text{E}+4$	$6\text{E}+3$	$3\text{E}+8$	-	$2\text{E}-4$	$2\text{E}-3$
		W. see ^{137}La	-	Liver ($7\text{E}+1$)	-	$1\text{E}-10$	-	-
			-	Liver ($2\text{E}+2$)	$1\text{E}-7$	-	-	-
			-	Liver ($3\text{E}+2$)	-	$4\text{E}-10$	-	-
57	Lanthanum-138	D. see ^{138}La	$5\text{E}+2$	$4\text{E}+0$	$1\text{E}+9$	$5\text{E}-12$	$1\text{E}-5$	$1\text{E}-4$
		W. see ^{138}La	-	$1\text{E}+3$	$4\text{E}+9$	$2\text{E}-11$	-	-
57	Lanthanum-140	D. see ^{140}La	$6\text{E}+2$	$1\text{E}+3$	$6\text{E}+7$	$2\text{E}-9$	$5\text{E}-6$	$5\text{E}-6$
		W. see ^{140}La	-	$1\text{E}+3$	$5\text{E}+7$	$2\text{E}-9$	-	-
57	Lanthanum-141	D. see ^{141}La	$4\text{E}+3$	$5\text{E}+3$	$4\text{E}+6$	$1\text{E}-9$	$5\text{E}-5$	$5\text{E}-4$
		W. see ^{141}La	-	$1\text{E}+4$	$5\text{E}+6$	$2\text{E}-8$	-	-
57	Lanthanum-142 ²	D. see ^{142}La	$5\text{E}+3$	$2\text{E}+4$	$5\text{E}+6$	$3\text{E}-8$	$1\text{E}-4$	$1\text{E}-3$
		W. see ^{142}La	-	$2\text{E}+4$	$1\text{E}+5$	$5\text{E}-8$	-	-
57	Lanthanum-143 ²	D. see ^{143}La	$4\text{E}+4$	$1\text{E}+5$	$4\text{E}+5$	$1\text{E}-7$	-	-
		W. see ^{143}La	St. well ($6\text{E}+4$)	-	-	-	$5\text{E}-4$	$5\text{E}-3$
			-	$5\text{E}+4$	$4\text{E}+5$	$1\text{E}-7$	-	-
58	Cerium-134	W. all compounds except those given for Y	$5\text{E}+2$	$7\text{E}+2$	$3\text{E}+7$	$1\text{E}-9$	-	-
			LLI well ($4\text{E}+2$)	-	-	-	$5\text{E}-6$	$5\text{E}-5$
			-	$7\text{E}+2$	$3\text{E}+7$	$5\text{E}-10$	-	-
58	Cerium-135	Y. see ^{134}Ce	$2\text{E}+3$	$4\text{E}+3$	$2\text{E}+6$	$5\text{E}-9$	$2\text{E}-5$	$2\text{E}-4$
		Y. see ^{134}Ce	-	$4\text{E}+3$	$1\text{E}+6$	$5\text{E}-9$	-	-
58	Cerium-137a	W. see ^{134}Ce	$2\text{E}+3$	$4\text{E}+3$	$2\text{E}+6$	$6\text{E}-9$	-	-
		Y. see ^{134}Ce	LLI well ($2\text{E}+3$)	-	-	-	$2\text{E}-5$	$2\text{E}-4$
			-	$4\text{E}+3$	$2\text{E}+6$	$5\text{E}-9$	-	-
58	Cerium-137	W. see ^{134}Ce	$5\text{E}+4$	$1\text{E}+5$	$6\text{E}+5$	$2\text{E}-7$	$7\text{E}-4$	$7\text{E}-3$
		Y. see ^{134}Ce	-	$1\text{E}+5$	$5\text{E}+5$	$2\text{E}-7$	-	-
58	Cerium-139	W. see ^{134}Ce	$5\text{E}+3$	$5\text{E}+2$	$3\text{E}+7$	$1\text{E}-9$	$7\text{E}-5$	$7\text{E}-4$
		Y. see ^{134}Ce	-	$7\text{E}+2$	$3\text{E}+7$	$5\text{E}-10$	-	-
58	Cerium-141	W. see ^{134}Ce	$2\text{E}+3$	$7\text{E}+2$	$3\text{E}+7$	$1\text{E}-9$	-	-
		Y. see ^{134}Ce	LLI well ($2\text{E}+3$)	-	-	-	$2\text{E}-5$	$2\text{E}-4$
			-	$6\text{E}+2$	$2\text{E}+7$	$5\text{E}-10$	-	-
58	Cerium-143	W. see ^{134}Ce	$1\text{E}+3$	$2\text{E}+3$	$5\text{E}+7$	$3\text{E}-9$	-	-
		Y. see ^{134}Ce	LLI well ($1\text{E}+3$)	-	-	-	$2\text{E}-5$	$2\text{E}-4$
			-	$2\text{E}+3$	$7\text{E}+7$	$2\text{E}-9$	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				ALI (μCi)	MDI ($\mu\text{Ci}/\text{m}^3$)			
58	Cerium-144	W, see ¹³⁴ Ce	2E+2 LLI wall (3E+2)	3E+1	1E-8	4E-11	-	-
		Y, see ¹³⁴ Ce	-	1E+1	6E-9	2E-11	3E-4	3E-5
59	Praseodymium-136 ²	W, all compounds except those given for Y	5E+4 SLI wall (7E+4)	2E+5	1E-4	3E-7	-	-
		Y, oxides, hydrides, carbides, and fluorides	-	2E+5	9E-5	3E-7	1E-3	1E-2
59	Praseodymium-137 ²	W, see ¹³⁶ Pr	4E+4	2E+5	6E-5	2E-7	5E-4	6E-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	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	6E-7	3E-9	-	-
59	Praseodymium-143	W, see ¹³⁶ Pr	9E+2 LLI wall (1E+3)	3E+2	3E-7	1E-9	-	-
		Y, see ¹³⁶ Pr	-	7E+2	3E-7	9E-10	2E-5	2E-4
59	Praseodymium-144 ²	W, see ¹³⁶ Pr	3E+4 SLI wall (4E+4)	1E+5	6E-5	2E-7	-	-
		Y, see ¹³⁶ Pr	-	1E+5	6E-5	2E-7	6E-4	6E-3
59	Praseodymium-145	W, see ¹³⁶ Pr	2E+3	9E+3	4E-5	1E-8	4E-5	4E-4
		Y, see ¹³⁶ Pr	-	6E+3	3E-5	1E-8	-	-
59	Praseodymium-147 ²	W, see ¹³⁶ Pr	5E+4 SLI wall (8E+4)	2E+5	6E-5	3E-7	-	-
		Y, see ¹³⁶ Pr	-	2E+5	6E-5	3E-7	1E-3	1E-2
60	Neodymium-136 ²	W, all compounds except those given for Y	1E+4	6E+4	2E-5	8E-8	2E-4	2E-3
		Y, oxides, hydrides, carbides, and fluorides	-	5E+4	2E-5	6E-8	-	-
60	Neodymium-136	W, see ¹³⁶ Nd	2E+3	6E+3	3E-5	9E-9	3E-5	3E-4
		Y, see ¹³⁶ Nd	-	5E+3	2E-5	7E-9	-	-
60	Neodymium-139m	W, see ¹³⁶ Nd	5E+3	2E+4	7E-5	2E-8	7E-5	7E-4
		Y, see ¹³⁶ Nd	-	1E+4	6E-5	2E-8	-	-

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PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Release to Sewers
			Col. 1 Drac Ingestion ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 ALI (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
60	Radium-227 ²	W, see 136	5E+4	3E+5	1E-4	5E-7	1E-3	1E-2
		Y, see 136	-	3E+5	1E-4	4E-7	-	-
60	Radium-241	W, see 136	2E+5	7E+5	3E-4	1E-6	2E-2	2E-2
		Y, see 136	-	6E+5	3E-4	9E-7	-	-
60	Radium-247	W, see 136	1E+3	9E+2	4E-7	1E-9	-	-
		Y, see 136	LLI see 11 (1E+3)	-	-	-	2E-5	2E-4
60	Radium-249 ²	W, see 136	1E+4	3E+4	1E-6	4E-8	1E-4	1E-3
		Y, see 136	-	2E+4	1E-6	3E-8	-	-
60	Radium-251 ²	W, see 136	7E+4	2E+5	6E-5	2E-7	9E-4	9E-3
		Y, see 136	-	2E+5	6E-5	3E-7	-	-
61	Protactinium-241 ²	W, all compounds except those given for Y	5E+4	2E+5	6E-5	3E-7	-	-
		Y, oxides, hydroxides, carbides, and fluorides	St. see 11 (6E+4)	-	-	-	6E-4	6E-3
61	Protactinium-243	W, see 141	3E+3	6E+2	2E-7	6E-10	7E-5	7E-4
		Y, see 141	-	7E+2	3E-7	1E-9	-	-
61	Protactinium-244	W, see 141	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		Y, see 141	-	1E+2	5E-8	2E-10	-	-
61	Protactinium-245	W, see 141	1E+4	2E+2	7E-8	-	1E-4	1E-3
		Y, see 141	-	Some surf (2E+2)	-	3E-10	-	-
61	Protactinium-246	W, see 141	2E+1	5E+1	2E-8	7E-11	5E-5	-
		Y, see 141	-	4E+1	2E-8	6E-11	-	-
61	Protactinium-247	W, see 141	4E+3	1E+2	9E-8	-	-	-
		Y, see 141	LLI see 11 (5E+3)	Some surf (7E+2)	-	7E-10	7E-5	7E-4
61	Protactinium-248a	W, see 141	7E+2	3E+2	1E-7	4E-10	1E-5	1E-4
		Y, see 141	-	3E+2	1E-7	5E-10	-	-
61	Protactinium-248	W, see 141	4E+2	9E+2	2E-7	6E-10	-	-
		Y, see 141	LLI see 11 (5E+2)	-	-	-	7E-6	7E-5
61	Protactinium-249	W, see 141	1E+3	2E+3	6E-7	3E-9	-	-
		Y, see 141	LLI see 11 (1E+3)	-	-	-	2E-5	2E-4
61	Protactinium-250	W, see 141	5E+3	2E+4	6E-6	3E-8	7E-5	7E-4
		Y, see 141	-	2E+4	7E-6	2E-8	-	-
61	Protactinium-251	W, see 141	2E+3	6E+3	1E-6	6E-9	2E-5	2E-4
		Y, see 141	-	3E+3	1E-6	4E-9	-	-

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PART 20 - STANDARDS FOR PROTECTION AGAINST RADIATION

Atomic No.	Radioisotope	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 ALI (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
62	Samarium-147 ²	V, all compounds	3E+4	3E+5	4E-5	2E-7	4E-6	4E-2
62	Samarium-147 ²	V, all compounds	9E+4 St. water (6E+4)	2E+5	9E-5	2E-7	-	-
62	Samarium-147 ²	V, all compounds	8E+3	3E+4	3E-5	4E-8	3E-4	3E-3
62	Samarium-145	V, all compounds	6E+3	5E+2	2E-7	7E-10	8E-5	8E-4
62	Samarium-146	V, all compounds	3E+1 Bone surf (3E+1)	4E+2 Bone surf (6E+2)	3E-11	-	-	-
62	Samarium-146	V, all compounds	3E+1 Bone surf (3E+1)	4E+2 Bone surf (7E+2)	2E-11	-	-	-
62	Samarium-146	V, all compounds	3E+1 Bone surf (3E+1)	4E+2 Bone surf (7E+2)	2E-11	-	-	-
62	Samarium-146	V, all compounds	3E+1 Bone surf (3E+1)	4E+2 Bone surf (7E+2)	2E-11	-	-	-
62	Samarium-151	V, all compounds	3E+4 LLI water (3E+4)	3E+2 Bone surf (2E+2)	4E-8	-	-	-
62	Samarium-151	V, all compounds	3E+4 LLI water (3E+4)	3E+2 Bone surf (2E+2)	4E-8	-	-	-
62	Samarium-153	V, all compounds	2E+3 LLI water (2E+3)	3E+3	3E-6	4E-9	-	-
62	Samarium-153 ²	V, all compounds	6E+4 St. water (8E+4)	2E+5	9E-5	3E-7	-	-
62	Samarium-153 ²	V, all compounds	6E+4 St. water (8E+4)	2E+5	9E-5	3E-7	-	-
62	Samarium-154	V, all compounds	5E+3	9E+3	4E-6	3E-8	7E-5	7E-4
63	Eurapium-145	V, all compounds	2E+3	2E+3	8E-7	3E-9	2E-5	2E-4
63	Eurapium-146	V, all compounds	3E+3	3E+3	8E-7	2E-9	3E-5	3E-4
63	Eurapium-147	V, all compounds	3E+3	2E+3	7E-7	2E-9	4E-5	4E-4
63	Eurapium-148	V, all compounds	3E+3	4E+2	3E-7	5E-10	3E-5	3E-4
63	Eurapium-149	V, all compounds	3E+4	3E+3	3E-6	4E-9	2E-4	2E-3
63	Eurapium-150 (12.62 h)	V, all compounds	3E+3	8E+3	4E-6	3E-8	4E-5	4E-4
63	Eurapium-150 (34.2 y)	V, all compounds	8E+2	2E+1	8E-9	3E-11	3E-5	3E-4
63	Eurapium-152a	V, all compounds	3E+3	6E+3	3E-6	9E-9	4E-5	4E-4
63	Eurapium-152	V, all compounds	8E+2	2E+1	3E-8	3E-11	3E-4	3E-4
63	Eurapium-154	V, all compounds	5E+2	2E+1	8E-9	3E-11	7E-5	7E-5
63	Eurapium-155	V, all compounds	4E+3	9E+1 Bone surf (3E+2)	4E-8	-	5E-5	5E-4
63	Eurapium-156	V, all compounds	6E+2	5E+2	2E-7	6E-10	8E-5	8E-5

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{ft}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{ft}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{ft}^3$)
				Col. 2 ALI (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
63	Eurapium-157	V, all compounds	2E-3	6E-3	2E-6	7E-6	2E-5	2E-4
63	Eurapium-158 ²	V, all compounds	2E-4	6E-4	2E-6	6E-6	2E-6	2E-3
64	Gadolinium-145 ²	D, all compounds except those given for W	6E-4	2E-5	6E-6	2E-7	-	-
		W, oxides, hydroxides, and fluorides	St. wall (6E-4)	-	-	-	6E-6	6E-3
64	Gadolinium-146	D, see ¹⁴⁵ Gd	2E-3	2E-2	6E-6	2E-10	2E-5	2E-4
		W, see ¹⁴⁵ Gd	-	2E-2	2E-7	6E-10	-	-
64	Gadolinium-147	D, see ¹⁴⁵ Gd	2E-3	4E-3	2E-6	6E-9	2E-5	2E-4
		W, see ¹⁴⁵ Gd	-	4E-3	2E-6	2E-9	-	-
64	Gadolinium-148	D, see ¹⁴⁵ Gd	2E-1	6E-1	2E-12	-	-	-
		W, see ¹⁴⁵ Gd	Bone surf (2E-1)	Bone surf (2E-2)	-	2E-14	2E-7	2E-6
		-	-	Bone surf (6E-2)	-	2E-11	-	-
64	Gadolinium-149	D, see ¹⁴⁵ Gd	2E-3	2E-3	9E-7	2E-9	4E-5	4E-4
		W, see ¹⁴⁵ Gd	-	2E-3	2E-6	2E-9	-	-
64	Gadolinium-151	D, see ¹⁴⁵ Gd	6E-3	4E-2	2E-7	-	9E-5	9E-4
		W, see ¹⁴⁵ Gd	-	Bone surf (6E-2)	-	9E-10	-	-
64	Gadolinium-152	D, see ¹⁴⁵ Gd	2E-1	2E-2	4E-12	-	-	-
		W, see ¹⁴⁵ Gd	Bone surf (2E-1)	Bone surf (2E-2)	-	2E-14	4E-7	4E-6
		-	-	Bone surf (6E-2)	-	2E-11	-	-
64	Gadolinium-153	D, see ¹⁴⁵ Gd	2E-3	2E-2	6E-6	-	6E-5	6E-4
		W, see ¹⁴⁵ Gd	-	Bone surf (2E-2)	-	2E-10	-	-
64	Gadolinium-155	D, see ¹⁴⁵ Gd	2E-3	6E-3	2E-6	2E-8	4E-5	4E-4
		W, see ¹⁴⁵ Gd	-	6E-3	2E-6	6E-9	-	-
65	Terbium-147 ²	V, all compounds	9E-3	2E-4	2E-6	2E-6	2E-4	2E-3
65	Terbium-149	V, all compounds	2E-3	7E-2	2E-7	2E-9	7E-5	7E-4
65	Terbium-150	V, all compounds	6E-3	2E-4	9E-6	2E-6	7E-5	7E-4
65	Terbium-151	V, all compounds	4E-3	9E-3	4E-6	2E-6	6E-5	6E-4
65	Terbium-153	V, all compounds	6E-3	7E-2	2E-6	2E-6	7E-5	7E-4
65	Terbium-154	V, all compounds	2E-3	4E-3	2E-6	6E-9	2E-5	2E-4
65	Terbium-155	V, all compounds	6E-3	6E-3	2E-6	2E-6	6E-5	6E-4
65	Terbium-156a (5.0 h)	V, all compounds	2E-4	2E-4	2E-6	4E-6	2E-6	2E-3

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Dose Ingestion ALI (μ Ci)	Inhalation		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/m ³)	Monthly Average Concentration (μ Ci/m ³)
				Col. 2 ALL (μ Ci)	Col. 3 DAC (μ Ci/m 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
65	Terbium-157	W, all compounds	5E-4 LLI wall (5E-4)	3E-2 Bone surf (6E-2)	1E-7	-	-	-
65	Terbium-158	W, all compounds	1E-3	2E-1	6E-9	3E-11	2E-5	2E-4
65	Terbium-160	W, all compounds	8E-2	2E-2	9E-8	3E-10	1E-6	1E-4
65	Terbium-161	W, all compounds	2E-3 LLI wall (2E-3)	2E-3	7E-7	2E-9	-	-
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	2E-4	2E-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 LLI wall (6E-2)	7E-2	2E-7	1E-9	-	-
67	Helium-155 ²	W, all compounds	4E-4	2E-5	6E-5	2E-7	6E-4	6E-3
67	Helium-157 ²	W, all compounds	3E-5	1E-6	6E-6	2E-6	4E-3	4E-2
67	Helium-159 ²	W, all compounds	2E-5	1E-6	4E-4	1E-6	3E-3	3E-2
67	Helium-161	W, all compounds	1E-5	4E-5	2E-4	6E-7	1E-3	1E-2
67	Helium-162a ²	W, all compounds	5E-4	3E-5	1E-4	4E-7	7E-4	7E-3
67	Helium-162 ²	W, all compounds	3E-5 SI. wall (3E-5)	2E-6	1E-2	3E-6	-	-
67	Helium-164a ²	W, all compounds	1E-5	3E-5	1E-4	4E-7	1E-3	1E-2
67	Helium-164 ²	W, all compounds	2E-5 SI. wall (2E-5)	6E-5	3E-4	9E-7	-	-
67	Helium-166a	W, all compounds	6E-2	7E-0	3E-8	9E-12	9E-4	9E-3
67	Helium-166	W, all compounds	9E-2 LLI wall (9E-2)	2E-3	7E-7	2E-9	-	-
67	Helium-167	W, all compounds	2E-4	6E-4	2E-5	8E-8	2E-4	2E-3
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	6E-5	3E-7	9E-4	9E-3

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 ALI (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
64	Erbium-169	W, all compounds	3E+3 LLI wall (4E+2)	3E+3	3E-6	4E-9	-	-
64	Erbium-171	W, all compounds	4E+3	3E+4	4E-6	3E-8	5E-5	5E-4
68	Erbium-172	W, all compounds	3E+3 LLI wall (3E+3)	3E+3	5E-7	2E-9	-	-
69	Thulium-162 ²	W, all compounds	7E+4 SI wall (7E+4)	3E+5	3E-4	4E-7	-	-
69	Thulium-166	W, all compounds	4E+3	3E+4	5E-6	2E-8	5E-5	5E-4
69	Thulium-167	W, all compounds	2E+3 LLI wall (2E+3)	2E+3	5E-7	2E-9	-	-
69	Thulium-170	W, all compounds	5E+2 LLI wall (3E+2)	2E+2	5E-6	3E-10	-	-
69	Thulium-171	W, all compounds	3E+4 LLI wall (3E+4)	3E+2 bone surf (5E+2)	3E-7	-	5E-10	2E-4
69	Thulium-172	W, all compounds	7E+2 LLI wall (5E+2)	3E+3	5E-7	2E-9	-	-
69	Thulium-173	W, all compounds	4E+3	3E+4	5E-6	2E-8	5E-5	5E-4
69	Thulium-175 ²	W, all compounds	7E+4 SI wall (5E+4)	3E+5	3E-4	4E-7	-	-
70	Ytterbium-162 ²	W, all compounds except those given for Y	7E+4	3E+5	3E-4	4E-7	3E-3	3E-2
		Y, oxides, hydroxides, and fluorides	-	3E+5	3E-4	4E-7	-	-
70	Ytterbium-166	W, see 162 Yb Y, see 162 Yb	3E+3	2E+3	5E-7	3E-9	2E-5	2E-4
70	Ytterbium-167 ²	W, see 162 Yb Y, see 162 Yb	-	2E+3	5E-7	2E-9	-	-
70	Ytterbium-167 ²	W, see 162 Yb Y, see 162 Yb	3E+5	5E+5	3E-4	3E-6	4E-3	4E-2
70	Ytterbium-169	W, see 162 Yb Y, see 162 Yb	2E+3	5E+2	4E-7	3E-9	2E-5	2E-4
70	Ytterbium-173	W, see 162 Yb	3E+3 LLI wall (3E+3)	4E+3	3E-6	5E-9	-	-
		Y, see 162 Yb	-	3E+3	3E-6	5E-9	4E-5	4E-4
70	Ytterbium-177 ²	W, see 162 Yb Y, see 162 Yb	2E+4	5E+4	2E-5	2E-8	2E-4	2E-3
		Y, see 162 Yb	-	5E+4	2E-5	5E-8	-	-
70	Ytterbium-179 ²	W, see 162 Yb Y, see 162 Yb	3E+4	4E+4	2E-5	5E-8	2E-4	2E-3
		Y, see 162 Yb	-	4E+4	2E-5	5E-8	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Gral Ingestion AI (μ Ci)	Col. 2 Inhalation		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/m ³)	Monthly Average Concentration (μ Ci/ml)
				AI (μ Ci)	SI (μ Ci/m ³)			
71	Lutetium-169	W, all compounds except those given for Y	BE-3	BE-3	BE-6	BE-9	BE-9	BE-4
		Y, oxides, hydrides, and fluorides	-	BE-3	BE-6	BE-9	-	-
71	Lutetium-170	W, see ¹⁶⁹ Lu Y, see ¹⁶⁹ Lu	BE-3 -	BE-3 BE-3	BE-7 BE-7	BE-9 BE-9	BE-9 -	BE-4 -
71	Lutetium-171	W, see ¹⁶⁹ Lu Y, see ¹⁶⁹ Lu	BE-3 -	BE-3 BE-3	BE-7 BE-7	BE-9 BE-9	BE-9 -	BE-4 -
71	Lutetium-172	W, see ¹⁶⁹ Lu Y, see ¹⁶⁹ Lu	BE-3 -	BE-3 BE-3	BE-7 BE-7	BE-9 BE-9	BE-9 -	BE-4 -
71	Lutetium-173	W, see ¹⁶⁹ Lu	BE-3	BE-2 Bone surf	BE-7	-	BE-9	BE-4
		Y, see ¹⁶⁹ Lu	-	(BE-2) BE-2	BE-7	BE-10 BE-10	-	-
71	Lutetium-174a	W, see ¹⁶⁹ Lu	BE-3 (BE-3)	BE-2 Bone surf (BE-2)	BE-7	BE-10	BE-9	BE-4
		Y, see ¹⁶⁹ Lu	-	BE-2	BE-7	BE-10	-	-
71	Lutetium-174	W, see ¹⁶⁹ Lu	BE-3	BE-2 Bone surf	BE-7	BE-9	BE-9	BE-4
		Y, see ¹⁶⁹ Lu	-	(BE-2) BE-2	BE-7	BE-10	-	-
71	Lutetium-176a	W, see ¹⁶⁹ Lu Y, see ¹⁶⁹ Lu	BE-3 -	BE-4 BE-4	BE-6 BE-6	BE-9 BE-9	BE-9 -	BE-4 -
71	Lutetium-176	W, see ¹⁶⁹ Lu	BE-2	BE-0 Bone surf	BE-9	-	BE-9	BE-4
		Y, see ¹⁶⁹ Lu	-	(BE-1) BE-0	BE-9	BE-11 BE-11	-	-
71	Lutetium-177a	W, see ¹⁶⁹ Lu	BE-2	BE-2 Bone surf	BE-6	-	BE-9	BE-4
		Y, see ¹⁶⁹ Lu	-	(BE-2) BE-1	BE-6	BE-10 BE-10	-	-
71	Lutetium-177	W, see ¹⁶⁹ Lu	BE-3 (BE-3)	BE-3	BE-7	BE-9	BE-9	BE-4
		Y, see ¹⁶⁹ Lu	-	BE-3	BE-7	BE-9	-	-
71	Lutetium-178a ²	W, see ¹⁶⁹ Lu	BE-4 SI, well (BE-4)	BE-5	BE-6	BE-7	BE-9	BE-4
		Y, see ¹⁶⁹ Lu	-	BE-5	BE-6	BE-7	-	-
71	Lutetium-178 ²	W, see ¹⁶⁹ Lu	BE-4 SI, well (BE-4)	BE-5	BE-6	BE-7	BE-9	BE-4
		Y, see ¹⁶⁹ Lu	-	BE-5	BE-6	BE-7	-	-
71	Lutetium-179	W, see ¹⁶⁹ Lu Y, see ¹⁶⁹ Lu	BE-3 -	BE-4 BE-4	BE-6 BE-6	BE-9 BE-9	BE-9 -	BE-4 -

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 AI (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
72	Neptunium-237	D, all compounds except those given for W	3E-3	6E-3	2E-6	9E-9	4E-6	4E-6
		W, oxides, hydroxides, carbides, and nitrates	-	9E-3	2E-6	6E-9	-	-
72	Neptunium-239	D, see 237Np	1E-3	9E-0	4E-9	-	2E-5	2E-4
		W, see 237Np	-	(2E-1) Bone surf	-	2E-11	-	-
			-	4E-1 Bone surf	2E-8	-	-	-
			-	(6E-1)	-	8E-11	-	-
72	Neptunium-241	D, see 237Np	5E-3	1E-4	5E-6	2E-8	7E-5	7E-4
		W, see 237Np	-	1E-4	5E-6	2E-8	-	-
72	Neptunium-243	D, see 237Np	3E-3	9E-2	4E-7	-	4E-5	4E-4
		W, see 237Np	-	(1E-3) Bone surf	-	1E-9	-	-
			-	1E-3	5E-7	2E-9	-	-
72	Neptunium-237 ²	D, see 237Np	2E-4	6E-4	2E-5	8E-8	3E-4	3E-3
		W, see 237Np	-	9E-4	4E-5	1E-7	-	-
72	Neptunium-238m	D, see 237Np	3E-2	1E-0	5E-10	-	3E-6	3E-5
		W, see 237Np	-	(2E-0) Bone surf	-	3E-12	-	-
			-	3E-0 Bone surf	2E-9	-	-	-
			-	(9E-0)	-	1E-11	-	-
72	Neptunium-238u	D, see 237Np	1E-3	3E-2	1E-7	-	1E-5	1E-4
		W, see 237Np	-	(6E-2) Bone surf	-	8E-10	-	-
			-	6E-2	3E-7	8E-10	-	-
72	Neptunium-240m	D, see 237Np	7E-3	2E-4	9E-6	3E-8	1E-4	1E-3
		W, see 237Np	-	3E-4	1E-5	4E-8	-	-
72	Neptunium-241	D, see 237Np	1E-3	2E-2	7E-8	-	2E-5	2E-4
		W, see 237Np	-	(4E-2) Bone surf	-	6E-10	-	-
			-	4E-2	2E-7	6E-10	-	-
72	Neptunium-242a ²	D, see 237Np	4E-4	9E-4	4E-5	1E-7	5E-4	5E-3
		W, see 237Np	-	1E-5	6E-5	2E-7	-	-
72	Neptunium-242	D, see 237Np	2E-2	8E-1	3E-10	-	-	-
		W, see 237Np	(4E-2) Bone surf	(2E-0) Bone surf	-	2E-12	8E-6	8E-5
			-	3E-0 Bone surf	1E-9	-	-	-
			-	(7E-0)	-	1E-11	-	-
72	Neptunium-243 ²	D, see 237Np	2E-4	5E-4	2E-5	6E-8	3E-4	3E-3
		W, see 237Np	-	6E-4	2E-5	8E-8	-	-
72	Neptunium-244	D, see 237Np	2E-3	8E-3	3E-6	1E-8	3E-5	3E-4
		W, see 237Np	-	6E-3	3E-6	9E-9	-	-

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Atomic No.	Radioisotope	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion All (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 All (μCi)	Col. 3 MCL ($\mu\text{Ci}/\text{m}^3$)			
71	Tantalum-172 ²	W, all compounds except those given for Y Y, elemental Ta, oxides, hydroxides, halides, carbides, nitrates, and nitrides	4E+4	1E+5	5E-5	2E-7	5E-4	5E-3
73	Tantalum-173	W, see 172Ta Y, see 172Ta	7E-3	2E+4	5E-6	3E-8	5E-5	5E-4
73	Tantalum-174 ²	W, see 172Ta Y, see 172Ta	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
73	Tantalum-175	W, see 172Ta Y, see 172Ta	6E+3	2E+4	7E-6	2E-8	5E-5	5E-4
73	Tantalum-176	W, see 172Ta Y, see 172Ta	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
73	Tantalum-177	W, see 172Ta Y, see 172Ta	1E+4	2E+4	5E-6	3E-8	2E-4	2E-3
73	Tantalum-178	W, see 172Ta Y, see 172Ta	2E+4	5E+4	4E-5	1E-7	2E-4	2E-3
73	Tantalum-179	W, see 172Ta Y, see 172Ta	2E+4	5E+3	2E-6	5E-9	3E-4	3E-3
73	Tantalum-180a	W, see 172Ta Y, see 172Ta	2E+4	7E+4	3E-5	5E-8	3E-4	3E-3
73	Tantalum-180	W, see 172Ta Y, see 172Ta	1E+3	4E+2	2E-7	5E-10	2E-5	2E-4
73	Tantalum-182a ²	W, see 172Ta Y, see 172Ta	2E+5 (2E+5) SI, well	5E+5	2E-4	5E-7	-	-
73	Tantalum-182	W, see 172Ta Y, see 172Ta	5E+2	3E+2	1E-7	5E-10	1E-5	1E-4
73	Tantalum-183	W, see 172Ta Y, see 172Ta	5E+2 (1E+3) L11 well	1E+3	5E-7	2E-9	-	-
73	Tantalum-184	W, see 172Ta Y, see 172Ta	2E+3	5E+3	2E-6	5E-9	3E-5	3E-4
73	Tantalum-185 ²	W, see 172Ta Y, see 172Ta	2E+4	7E+4	3E-5	1E-8	4E-4	4E-3
73	Tantalum-186 ²	W, see 172Ta Y, see 172Ta	5E+4 (7E+4) SI, well	2E+5	1E-6	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	5E+4	4E-5	1E-7	3E-4	3E-3

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion All (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 All (μCi)	Col. 3 DLT ($\mu\text{Ci}/\text{m}^3$)			
74	Tungsten-178	D, all compounds	5E+3	2E+6	5E-6	2E-8	2E-5	2E-4
74	Tungsten-179 ²	D, all compounds	5E+5	2E+6	2E-4	2E-6	2E-3	2E-2
74	Tungsten-181	D, all compounds	2E+4	2E+4	2E-5	5E-8	2E-4	2E-3
74	Tungsten-185	D, all compounds	2E+3 LLL wall (2E+3)	7E+3	2E-6	5E-9	-	-
						4E-5	4E-4	
74	Tungsten-187	D, all compounds	2E+3	5E+3	4E-6	2E-8	2E-5	2E-4
74	Tungsten-188	D, all compounds	4E+2 LLL wall (5E+2)	2E+3	5E-7	2E-9	-	-
						2E-6	2E-5	
75	Rhenium-177 ²	D, all compounds except those given for W	5E+4 St. wall (2E+5)	2E+5	2E-4	4E-7	-	-
		W, oxides, hydroxides, and nitrates	-	4E+5	2E-4	5E-7	-	-
75	Rhenium-178 ²	D, see 177 Re	2E+4 St. wall (2E+5)	2E+5	2E-4	4E-7	-	-
		W, see 177 Re	-	2E+5	2E-4	4E-7	2E-3	2E-2
75	Rhenium-181	D, see 177 Re W, see 177 Re	5E+3 -	5E+3 5E+3	4E-6 4E-6	2E-8 2E-8	2E-5 -	2E-4 -
75	Rhenium-182 (12.7 h)	D, see 177 Re W, see 177 Re	2E+3 -	2E+4 2E+4	5E-6 4E-6	2E-8 2E-8	2E-5 -	2E-4 -
75	Rhenium-182 (64.0 h)	D, see 177 Re W, see 177 Re	2E+3 -	2E+3 2E+3	2E-6 5E-7	2E-9 2E-9	2E-5 -	2E-4 -
75	Rhenium-184a	D, see 177 Re W, see 177 Re	2E+3 -	2E+3 4E+2	2E-6 2E-7	4E-9 6E-10	2E-5 -	2E-4 -
75	Rhenium-184	D, see 177 Re W, see 177 Re	2E+3 -	4E+3 2E+3	2E-6 6E-7	5E-9 2E-9	2E-5 -	2E-4 -
75	Rhenium-184a	D, see 177 Re W, see 177 Re	2E+3 St. wall (2E+3)	2E+3 St. wall (2E+3)	2E-6 -	4E-9 2E-10	2E-5 -	2E-4 -
					5E-8	2E-10	2E-5	2E-4
75	Rhenium-186	D, see 177 Re W, see 177 Re	2E+3 -	2E+3 2E+3	2E-6 2E-7	4E-9 2E-9	2E-5 -	2E-4 -
75	Rhenium-187	D, see 177 Re W, see 177 Re	5E+5 -	5E+5 St. wall (5E+5)	4E-4 -	- 2E-6	5E-3 -	5E-2 -
						2E-7	-	-
						2E-7	-	-
75	Rhenium-188a ²	D, see 177 Re W, see 177 Re	5E+4 -	2E+5 2E+5	6E-5 6E-5	2E-7 2E-7	2E-3 -	2E-2 -
75	Rhenium-188	D, see 177 Re W, see 177 Re	2E+3 -	2E+3 2E+3	2E-6 2E-6	4E-9 4E-9	2E-5 -	2E-4 -

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Dose Ingestion All (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 All (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
75	Rhenium-185	D, see ¹⁷⁷ Re W, see ¹⁷⁷ Re	3E-3	5E-3	2E-6	7E-9	6E-5	6E-6
76	Cesium-137 ²	D, all compounds except those given for W and Y	1E-5	4E-5	2E-4	6E-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	Cesium-137 ²	D, see ¹³⁷ Cs	1E-4	4E-4	2E-5	6E-8	2E-4	2E-3
		W, see ¹³⁷ Cs	-	5E-4	2E-5	6E-8	-	-
		Y, see ¹³⁷ Cs	-	4E-4	2E-5	6E-8	-	-
76	Cesium-132	D, see ¹³² Cs	2E-2	6E-3	2E-6	6E-9	3E-5	3E-4
		W, see ¹³² Cs	-	4E-3	2E-6	6E-9	-	-
		Y, see ¹³² Cs	-	4E-3	2E-6	6E-9	-	-
76	Cesium-135	D, see ¹³⁵ Cs	2E-3	5E-2	2E-7	7E-10	3E-5	3E-4
		W, see ¹³⁵ Cs	-	3E-2	3E-7	1E-9	-	-
		Y, see ¹³⁵ Cs	-	6E-2	3E-7	1E-9	-	-
76	Cesium-134m	D, see ^{134m} Cs	6E-4	2E-5	1E-4	3E-7	1E-3	1E-2
		W, see ^{134m} Cs	-	2E-5	9E-5	3E-7	-	-
		Y, see ^{134m} Cs	-	2E-5	7E-5	2E-7	-	-
76	Cesium-134	D, see ¹³⁴ Cs	1E-4	3E-4	1E-5	4E-8	2E-4	2E-3
		W, see ¹³⁴ Cs	-	2E-4	6E-6	3E-8	-	-
		Y, see ¹³⁴ Cs	-	2E-4	7E-6	2E-8	-	-
76	Cesium-131	D, see ¹³¹ Cs	2E-3	2E-3	3E-7	3E-9	-	-
		W, see ¹³¹ Cs	-	2E-3	7E-7	2E-9	3E-5	3E-4
		Y, see ¹³¹ Cs	-	1E-3	6E-7	2E-9	-	-
76	Cesium-131	D, see ¹³¹ Cs	2E-3	5E-3	2E-6	6E-9	-	-
		W, see ¹³¹ Cs	-	3E-3	1E-6	4E-9	2E-5	2E-4
		Y, see ¹³¹ Cs	-	3E-3	1E-6	4E-9	-	-
76	Cesium-134	D, see ¹³⁴ Cs	4E-2	4E-1	7E-8	6E-11	-	-
		W, see ¹³⁴ Cs	-	6E-1	2E-8	6E-11	6E-6	6E-5
		Y, see ¹³⁴ Cs	-	6E-0	3E-9	1E-11	-	-
77	Iridium-192 ²	D, all compounds except those given for W and Y	4E-4	1E-5	6E-5	2E-7	-	-
		W, halides, nitrates, and metallic iridium	-	2E-6	6E-5	2E-7	6E-4	6E-3
		Y, oxides and hydroxides	-	1E-5	5E-5	2E-7	-	-
77	Iridium-194	D, see ¹⁹² Ir	6E-3	2E-4	1E-5	3E-8	1E-4	1E-3
		W, see ¹⁹² Ir	-	3E-4	1E-5	3E-8	-	-
		Y, see ¹⁹² Ir	-	3E-4	1E-5	4E-8	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentration		Table 3 Release to Sewer
			Col. 1 Dose ALI (μ Ci)	Col. 2 ALI (μ Ci)	Col. 3 DAC (μ Ci/mi)	Col. 1 Air (μ Ci/mi)	Col. 2 Water (μ Ci/ml)	Monthly Average Concentration (μ Ci/mi)
77	Iridium-185	D, see 182 Ir	5E+3	1E+4	5E-6	2E-6	2E-6	2E-6
		W, see 182 Ir	-	1E+4	5E-6	2E-6	-	-
		Y, see 182 Ir	-	1E+4	5E-6	2E-6	-	-
77	Iridium-186	D, see 182 Ir	2E+3	5E+3	2E-6	1E-6	2E-6	2E-6
		W, see 182 Ir	-	5E+3	2E-6	1E-6	-	-
		Y, see 182 Ir	-	5E+3	2E-6	1E-6	-	-
77	Iridium-187	D, see 182 Ir	1E+4	2E+4	1E-5	5E-6	1E-6	1E-3
		W, see 182 Ir	-	2E+4	1E-5	5E-6	-	-
		Y, see 182 Ir	-	2E+4	1E-5	5E-6	-	-
77	Iridium-188	D, see 182 Ir	2E+3	5E+3	2E-6	1E-6	2E-6	2E-6
		W, see 182 Ir	-	5E+3	2E-6	1E-6	-	-
		Y, see 182 Ir	-	5E+3	2E-6	1E-6	-	-
77	Iridium-189	D, see 182 Ir	5E+3	5E+3	2E-6	2E-6	-	-
		W, see 182 Ir	LLI see 11 (5E+3)	-	-	-	2E-6	2E-6
		Y, see 182 Ir	-	5E+3	2E-6	2E-6	-	-
77	Iridium-190m ²	D, see 182 Ir	2E+5	2E+5	5E-5	2E-7	2E-3	2E-2
		W, see 182 Ir	-	2E+5	5E-5	2E-7	-	-
		Y, see 182 Ir	-	2E+5	5E-5	2E-7	-	-
77	Iridium-190	D, see 182 Ir	1E+3	2E+2	5E-7	1E-9	1E-5	1E-4
		W, see 182 Ir	-	1E+3	5E-7	1E-9	-	-
		Y, see 182 Ir	-	2E+2	5E-7	1E-9	-	-
77	Iridium-192m	D, see 182 Ir	2E+3	5E+3	5E-6	1E-10	5E-5	5E-4
		W, see 182 Ir	-	2E+2	5E-6	2E-10	-	-
		Y, see 182 Ir	-	2E+3	5E-6	2E-11	-	-
77	Iridium-192	D, see 182 Ir	5E+2	2E+2	1E-7	5E-10	1E-5	1E-4
		W, see 182 Ir	-	5E+2	2E-7	5E-10	-	-
		Y, see 182 Ir	-	2E+2	2E-6	2E-10	-	-
77	Iridium-194m	D, see 182 Ir	5E+2	5E+1	5E-6	1E-10	5E-6	5E-5
		W, see 182 Ir	-	2E+2	2E-6	2E-10	-	-
		Y, see 182 Ir	-	1E+2	5E-6	1E-10	-	-
77	Iridium-194	D, see 182 Ir	1E+3	2E+3	1E-6	5E-9	1E-5	1E-4
		W, see 182 Ir	-	2E+3	2E-7	2E-9	-	-
		Y, see 182 Ir	-	2E+3	5E-7	2E-9	-	-
77	Iridium-196m	D, see 182 Ir	5E+3	2E+4	1E-5	2E-6	1E-4	1E-3
		W, see 182 Ir	-	2E+4	1E-5	5E-6	-	-
		Y, see 182 Ir	-	2E+4	5E-6	2E-6	-	-
77	Iridium-195	D, see 182 Ir	1E+4	5E+4	2E-5	5E-6	2E-4	2E-3
		W, see 182 Ir	-	5E+4	2E-5	2E-6	-	-
		Y, see 182 Ir	-	5E+4	2E-5	5E-6	-	-
78	Platinum-186	D, all compounds	1E+4	5E+4	2E-5	5E-6	2E-4	2E-3
78	Platinum-188	D, all compounds	2E+3	2E+3	2E-7	2E-9	2E-5	2E-4
78	Platinum-189	D, all compounds	1E+4	2E+4	1E-5	5E-6	1E-4	1E-3
78	Platinum-191	D, all compounds	5E+3	5E+3	5E-6	1E-6	2E-5	2E-4

PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sources
			Col. 1 Dose Ingestion ALI (μ Ci)	Inhalation		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/m ³)	Monthly Average Concentration (μ Ci/m ³)
				Col. 2 ALI (μ Ci)	Col. 3 DAC (μ Ci/m ³)			
78	Platinum-193a	D, all compounds	2E+3 LLI well (3E+4)	6E+3	2E-6	6E-9	-	4E-4
78	Platinum-193	D, all compounds	4E+4 LLI well (5E+4)	2E+4	2E-5	2E-8	-	6E-3
78	Platinum-195a	D, all compounds	2E+3 LLI well (2E+3)	4E+3	2E-6	6E-9	-	3E-4
78	Platinum-197a ²	D, all compounds	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
78	Platinum-197	D, all compounds	3E+3	2E+4	4E-6	2E-8	4E-5	6E-4
78	Platinum-199 ²	D, all compounds	5E+4	2E+5	6E-5	2E-7	7E-4	7E-2
78	Platinum-200	D, all compounds	2E+3	3E+3	2E-6	6E-9	2E-5	2E-4
79	Gold-193	D, all compounds except those given for W and Y	6E+3	3E+4	2E-5	4E-8	2E-4	2E-3
		W, halides and nitrates	-	2E+4	6E-6	2E-8	-	-
		Y, oxides and hydroxides	-	2E+4	6E-6	2E-8	-	-
79	Gold-194	D, see ¹⁹³ Au	3E+3	6E+3	3E-6	2E-8	4E-5	6E-4
		W, see ¹⁹³ Au	-	5E+3	2E-6	6E-9	-	-
		Y, see ¹⁹³ Au	-	6E+3	2E-6	7E-9	-	-
79	Gold-195	D, see ¹⁹³ Au	6E+3	2E+4	6E-6	2E-8	7E-5	7E-4
		W, see ¹⁹³ Au	-	2E+3	6E-7	2E-9	-	-
		Y, see ¹⁹³ Au	-	4E+2	2E-7	6E-10	-	-
79	Gold-198a	D, see ¹⁹³ Au	2E+3	3E+3	2E-6	4E-9	2E-5	2E-4
		W, see ¹⁹³ Au	-	2E+3	6E-7	2E-9	-	-
		Y, see ¹⁹³ Au	-	2E+3	6E-7	2E-9	-	-
79	Gold-198	D, see ¹⁹³ Au	2E+3	4E+3	2E-6	6E-9	2E-5	2E-4
		W, see ¹⁹³ Au	-	2E+3	6E-7	2E-9	-	-
		Y, see ¹⁹³ Au	-	2E+3	7E-7	2E-9	-	-
79	Gold-199	D, see ¹⁹³ Au	2E+3 LLI well (2E+3)	6E+3	4E-6	2E-8	-	-
		W, see ¹⁹³ Au	-	4E+3	2E-6	6E-9	-	-
		Y, see ¹⁹³ Au	-	4E+3	2E-6	6E-9	-	-
79	Gold-200a	D, see ¹⁹³ Au	2E+3	4E+3	2E-6	6E-9	2E-5	2E-4
		W, see ¹⁹³ Au	-	3E+3	2E-6	4E-9	-	-
		Y, see ¹⁹³ Au	-	2E+4	2E-6	2E-9	-	-
79	Gold-200 ²	D, see ¹⁹³ Au	2E+4	6E+4	3E-5	6E-8	4E-4	4E-3
		W, see ¹⁹³ Au	-	6E+4	3E-5	2E-7	-	-
		Y, see ¹⁹³ Au	-	7E+4	3E-5	2E-7	-	-
79	Gold-201 ²	D, see ¹⁹³ Au	7E+4 St. well (9E+4)	2E+5	6E-5	2E-7	-	-
		W, see ¹⁹³ Au	-	2E+5	2E-6	2E-7	2E-3	2E-2
		Y, see ¹⁹³ Au	-	2E+5	6E-5	2E-7	-	-

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PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Bowers
			Col. 1 Drac Ingestion ALI (μ Ci)	Col. 2 Inhalation		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/ml)	Monthly Average Concentration (μ Ci/ml)
				ALI (μ Ci)	DAI (μ Ci/yr)			
80	Mercury-193a	Vapor	-	8E+3	4E+6	1E-8	-	-
		Organic D	4E+3	1E+4	5E+6	2E-8	8E-5	8E-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	-	-
80	Mercury-193	Vapor	-	3E+4	1E+5	4E-8	-	-
		Organic D	2E+4	4E+4	3E+5	9E-8	3E-4	3E-3
		D, see 193a W, see 193a	2E+4	4E+4	2E+5	4E-8	2E-4	2E-3
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 193a W, see 193a	8E+2	4E+1	2E+8	6E-11	2E-6	1E-4
80	Mercury-195a	Vapor	-	4E+3	2E+6	6E-9	-	-
		Organic D	3E+3	6E+3	3E+6	8E-9	4E-5	4E-4
		D, see 193a W, see 193a	2E+3	5E+3	2E+6	7E-9	3E-5	3E-4
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 193a W, see 193a	1E+4	4E+4	1E+5	5E-8	2E-4	2E-3
80	Mercury-197a	Vapor	-	5E+3	2E+6	7E-9	-	-
		Organic D	4E+3	9E+3	4E+6	1E-8	5E-5	5E-4
		D, see 193a W, see 193a	3E+3	7E+3	3E+6	1E-8	4E-5	4E-4
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 193a W, see 193a	6E+3	1E+4	5E+6	2E-8	8E-5	8E-4
80	Mercury-199a ²	Vapor	-	8E+4	3E+5	1E-7	-	-
		Organic D	6E+4	2E+5	7E+5	2E-7	-	-
		D, see 193a W, see 193a	St. wall (1E+5)	-	-	-	1E-3	1E-2
80	Mercury-203	Vapor	-	8E+2	4E+7	1E-9	-	-
		Organic D	5E+2	1E+2	3E+7	1E-9	7E-6	7E-5
		D, see 193a W, see 193a	2E+2	1E+3	5E+7	2E-9	3E-5	3E-4
81	Thallium-204 ²	D, all compounds	9E+4 St. wall (7E+4)	2E+5	6E+5	2E-7	-	1E-2

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PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Dose Ingestion AI (μ Ci)	Inhalation		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/ml)	Monthly Average Concentration (μ Ci/ml)
				Col. 2 AI (μ Ci)	Col. 3 DAC (μ Ci/m ³)			
81	Thallium-204 ²	D, all compounds	3E+5 St. well (3E+5)	6E+5	2E+4	3E-7	-	-
81	Thallium-205 ²	D, all compounds	6E+4	3E+5	5E+5	2E-7	3E-4	3E-3
81	Thallium-207	D, all compounds	7E+4	3E+5	5E+5	2E-7	3E-3	3E-2
81	Thallium-208 ²	D, all compounds	3E+4	5E+4	2E+5	3E-8	4E-4	4E-3
81	Thallium-208	D, all compounds	2E+4	3E+4	3E+5	3E-8	3E-4	3E-3
81	Thallium-209	D, all compounds	6E+4	3E+4	4E+5	3E-7	3E-4	3E-3
81	Thallium-200	D, all compounds	3E+3	3E+4	5E+4	2E-8	3E-4	3E-3
81	Thallium-201	D, all compounds	2E+4	2E+4	3E+5	3E-8	3E-4	2E-3
81	Thallium-202	D, all compounds	4E+3	5E+3	2E+5	2E-8	3E-5	3E-4
81	Thallium-204	D, all compounds	2E+3	2E+3	3E+7	3E-8	2E-5	2E-4
82	Lead-205 ²	D, all compounds	6E+4	2E+5	3E+5	3E-7	3E-4	3E-3
82	Lead-208	D, all compounds	3E+4	6E+4	3E+5	3E-8	4E-4	4E-3
82	Lead-209 ²	D, all compounds	2E+4	7E+4	3E+5	3E-7	3E-4	3E-3
82	Lead-200	D, all compounds	3E+3	6E+3	3E+6	3E-8	4E-5	4E-4
82	Lead-201	D, all compounds	7E+3	2E+4	3E+5	3E-8	3E-4	3E-3
82	Lead-202a	D, all compounds	3E+3	3E+4	3E+5	4E-8	2E-4	2E-3
82	Lead-202	D, all compounds	3E+2	3E+3	2E+8	2E-11	2E-6	2E-5
82	Lead-203	D, all compounds	5E+3	3E+3	4E+6	3E-8	2E-5	2E-4
82	Lead-205	D, all compounds	4E+3	3E+3	6E+7	2E-8	3E-5	3E-4
82	Lead-209	D, all compounds	2E+4	6E+4	2E+5	3E-8	3E-4	3E-3
82	Lead-210	D, all compounds	6E-1 Bone surf (1E+0)	2E-1 Bone surf (4E-1)	3E-10	-	-	-
82	Lead-211 ²	D, all compounds	3E+4	6E+2	3E-7	3E-10	2E-4	2E-3
82	Lead-212	D, all compounds	3E+1 Bone surf (1E+2)	2E+1	3E+8	3E-11	-	-
82	Lead-214 ²	D, all compounds	3E+3	3E+2	3E-7	3E-8	3E-4	3E-3
83	Bismuth-200 ²	D, nitrates W, all other compounds	3E+4	3E+4	4E+5	3E-7	4E-4	4E-3
83	Bismuth-201 ²	D, see 200 ⁸¹ W, see 200 ⁸¹	3E+4	3E+4	4E+5	3E-7	4E-4	4E-3
83	Bismuth-202 ²	D, see 200 ⁸¹ W, see 200 ⁸¹	3E+4	4E+4	3E+5	3E-7	4E-4	4E-3

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PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 ALI (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
83	Bismuth-203	D. see ZOC B1	2E+3	7E+3	3E-6	9E-9	3E-5	3E-4
		W. see ZOC B1	-	6E+3	3E-6	9E-9	-	-
83	Bismuth-205	D. see ZOC B1	1E+3	3E+3	1E-6	3E-9	2E-5	2E-4
		W. see ZOC B1	-	1E+3	6E-7	2E-9	-	-
83	Bismuth-206	D. see ZOC B1	6E+2	1E+3	6E-7	2E-9	9E-6	9E-5
		W. see ZOC B1	-	9E+2	4E-7	1E-9	-	-
83	Bismuth-207	D. see ZOC B1	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
		W. see ZOC B1	-	4E+2	1E-7	6E-10	-	-
83	Bismuth-210a	D. see ZOC B1	6E+1	6E+0	2E-9	-	-	-
		W. see ZOC B1	(6E+1) Kidneys	(6E+0) Kidneys	-	9E-12	6E-7	6E-6
83	Bismuth-210	D. see ZOC B1	8E+2	2E+2	1E-7	-	1E-5	1E-4
		W. see ZOC B1	-	(4E+2) Kidneys	-	6E-10	-	-
83	Bismuth-212 ²	D. see ZOC B1	5E+3	2E+2	1E-7	3E-10	7E-5	7E-4
		W. see ZOC B1	-	3E+2	1E-7	4E-10	-	-
83	Bismuth-213 ²	D. see ZOC B1	7E+3	3E+2	1E-7	4E-10	1E-4	1E-3
		W. see ZOC B1	-	4E+2	1E-7	6E-10	-	-
83	Bismuth-214 ²	D. see ZOC B1	2E+4 (St. wall)	8E+2	2E-7	1E-9	-	-
		W. see ZOC B1	(2E+4)	-	-	-	3E-4	3E-3
84	Polonium-203 ²	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 ²	D. see ZOC B1	2E+4	4E+4	2E-5	6E-8	3E-4	3E-3
		W. see ZOC B1	-	7E+4	3E-5	1E-7	-	-
84	Polonium-207	D. see ZOC B1	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		W. see ZOC B1	-	3E+4	1E-5	4E-8	-	-
84	Polonium-210	D. see ZOC B1	3E+0	6E-1	3E-10	9E-13	4E-8	4E-7
		W. see ZOC B1	-	6E-1	3E-10	9E-13	-	-
85	Astatine-207 ²	D. halides	6E+3	3E+3	1E-6	4E-9	6E-5	6E-4
		W	-	2E+3	9E-7	3E-9	-	-
85	Astatine-211	D. halides	1E+2	6E+1	3E-8	1E-10	2E-6	2E-5
		W	-	6E+1	2E-8	6E-11	-	-
86	Radon-220	With daughters removed	-	2E+4	7E-6	2E-8	-	-
		With daughters present	-	2E+1 (or 1E working level months)	9E-8 (or 1.0 working level)	3E-11	-	-

PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

Atomic No.	Radioisotope	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sources
			Col. 1 Oral Ingestion AI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 AI (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
86	Radon-222	With daughters removed With daughters present	-	2E+4 2E+2 (or 4 working level months)	4E-6 3E-8 (or 0.23 working level)	2E-8 2E-10	- -	- -
87	Francium-223 ²	D, all compounds	2E+3	3E+2	2E-7	3E-10	3E-5	3E-4
87	Francium-223 ²	D, all compounds	6E+2	3E+2	3E-7	2E-9	3E-6	3E-5
88	Radium-223	W, all compounds	5E+0 Bone surf (5E+0)	7E-1	3E-10	3E-13	-	-
88	Radium-223	W, all compounds	5E+0 Bone surf (5E+0)	-	-	-	2E-7	2E-6
88	Radium-224	W, all compounds	3E+0 Bone surf (2E+1)	2E+0	7E-10	2E-12	-	-
88	Radium-224	W, all compounds	3E+0 Bone surf (2E+1)	-	-	-	2E-7	2E-6
88	Radium-225	W, all compounds	3E+0 Bone surf (2E+1)	7E-1	3E-10	3E-13	-	-
88	Radium-225	W, all compounds	3E+0 Bone surf (2E+1)	-	-	-	2E-7	2E-6
88	Radium-226	W, all compounds	2E+0 Bone surf (5E+0)	6E-1	3E-10	3E-13	-	-
88	Radium-226	W, all compounds	2E+0 Bone surf (5E+0)	-	-	-	6E-8	6E-7
88	Radium-227 ²	W, all compounds	2E+4 Bone surf (2E+4)	2E+4 Bone surf (2E+4)	6E-6	-	-	-
88	Radium-227 ²	W, all compounds	2E+4 Bone surf (2E+4)	-	-	3E-8	3E-4	3E-3
88	Radium-228	W, all compounds	2E+0 Bone surf (4E+0)	2E+0	3E-10	2E-12	-	-
88	Radium-228	W, all compounds	2E+0 Bone surf (4E+0)	-	-	-	6E-8	6E-7
89	Actinium-224	D, all compounds except those given for W and Y	2E+3 LLI wall (2E+3)	3E+1 Bone surf (4E+1)	2E-8	-	-	-
89	Actinium-224	W, halides and nitrates	-	3E+1	2E-8	7E-11	-	-
89	Actinium-224	Y, oxides and hydroxides	-	3E+1	2E-8	6E-11	-	-
89	Actinium-225	D, see ²²⁴ Ac	3E+1 LLI wall (3E+1)	3E+1 Bone surf (3E+1)	2E-10	-	-	-
89	Actinium-225	W, see ²²⁴ Ac	-	4E-1	3E-10	9E-13	-	-
89	Actinium-225	Y, see ²²⁴ Ac	-	6E-1	3E-10	9E-13	-	-
89	Actinium-226	D, see ²²⁴ Ac	2E+2 LLI wall (2E+2)	3E+0 Bone surf (4E+0)	2E-9	-	-	-
89	Actinium-226	W, see ²²⁴ Ac	-	5E+0	2E-9	3E-12	2E-4	2E-3
89	Actinium-226	Y, see ²²⁴ Ac	-	3E+0	2E-9	6E-12	-	-
89	Actinium-227	D, see ²²⁴ Ac	2E+1 Bone surf (4E+1)	4E+4 Bone surf (3E+4)	2E-13	-	-	-
89	Actinium-227	W, see ²²⁴ Ac	-	2E-2	7E-13	-	-	-
89	Actinium-227	Y, see ²²⁴ Ac	-	(3E-3) 4E-3	- 2E-12	4E-15 6E-15	-	-

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Atomic No.	Radioisotope	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Release to Source
			Col. 1 Dose Ingestion ALI (μ Ci)	Inhalation		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/m ³)	Monthly Average Concentration (μ Ci/m ³)
				Col. 2 ALI (μ Ci)	Col. 3 DAC (μ Ci/m ³)			
89	Actinium-228	D, see ²²⁴ Ac	2E+3	9E+0 Bone surf	4E-9	-	2E-8	2E-4
		W, see ²²⁴ Ac	-	(2E+1) 4E+1 Bone surf	2E-8	2E-11	-	-
		Y, see ²²⁴ Ac	-	(6E+1) 4E+1	2E-8	2E-11	4E-11	-
90	Thorium-228 ²	W, all compounds except those given for Y	9E+3 St. wall (5E+3)	2E+2	6E-8	2E-10	-	-
		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 Bone surf (1E+1)	1E-2 Bone surf (2E-2)	4E-12	-	-	-
		Y, see ²²⁶ Th	-	2E-2	7E-12	2E-14	2E-7	2E-6
90	Thorium-229	W, see ²²⁶ Th	6E-1 Bone surf (1E+0)	9E-4 Bone surf (2E-3)	4E-13	-	-	-
		Y, see ²²⁶ Th	-	2E-3 Bone surf (3E-3)	1E-12	2E-15	2E-8	2E-7
90	Thorium-230	W, see ²²⁶ Th	4E+0 Bone surf (9E+0)	6E-3 Bone surf (2E-2)	3E-12	-	-	-
		Y, see ²²⁶ Th	-	2E-2 Bone surf (2E-2)	6E-12	2E-14	1E-7	1E-6
90	Thorium-231	W, see ²²⁶ Th	4E+3	6E-3	3E-6	9E-9	9E-5	9E-4
		Y, see ²²⁶ Th	-	6E-3	3E-6	9E-9	-	-
90	Thorium-232	W, see ²²⁶ Th	7E-1 Bone surf (2E+0)	1E-3 Bone surf (3E-3)	5E-13	-	-	-
		Y, see ²²⁶ Th	-	3E-3 Bone surf (4E-3)	1E-12	4E-15	2E-8	2E-7
90	Thorium-234	W, see ²²⁶ Th	3E+2 LLI wall (4E+2)	2E+2	8E-8	3E-10	-	-
		Y, see ²²⁶ Th	-	2E+2	6E-8	2E-10	5E-6	5E-5
91	Protactinium-227 ²	W, all compounds except those given for Y	6E+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 ²²⁶ Th	1E+3	1E+1 Bone surf (2E+1)	9E-9	-	2E-5	2E-4
		Y, see ²²⁶ Pa	-	1E+1	5E-9	2E-11	-	-

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PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Dose Ingestion ALI (μCi)	Col. 2 Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				ALI (μCi)	DLI ($\mu\text{Ci}/\text{m}^3$)			
81	Protactinium-230	W, see 227Pa	8E-2 Bone surf (9E-2)	8E+0	2E-9	7E-12	-	-
		Y, see 227Pa	-	4E+0	3E-9	8E-12	3E-5	2E-4
81	Protactinium-231	W, see 227Pa	2E-1 Bone surf (3E-1)	2E-3 Bone surf (4E-3)	6E-13	-	-	-
		Y, see 226Pa	-	4E-3 Bone surf (6E-3)	2E-12	8E-15	6E-9	8E-8
81	Protactinium-232	W, see 227Pa	3E+3	2E+1 Bone surf (6E+1)	9E-9	-	2E-5	2E-4
		Y, see 227Pa	-	6E+1 Bone surf (7E+1)	2E-8	8E-11	-	-
81	Protactinium-233	W, see 227Pa	3E+3 LLI see 11 (2E+3)	7E+2	3E-7	3E-9	-	-
		Y, see 227Pa	-	6E+2	2E-7	6E-10	2E-5	2E-4
81	Protactinium-234	W, see 227Pa	2E+3	6E+3	3E-6	3E-8	3E-5	2E-4
		Y, see 227Pa	-	7E+3	3E-6	9E-9	-	-
82	Uranium-230	D, UF ₆ , UO ₂ F ₂ , UO ₂ (NO ₃) ₂	4E+0 Bone surf (6E+0)	-	2E-10	-	-	-
		W, UO ₂ , UF ₆ , UCl ₄ Y, UO ₂ , U ₃ O ₈	-	3E-1 Bone surf	3E-10	8E-13	8E-8	8E-7
82	Uranium-231	D, see 230U	1 (4E-1)	8E+3	3E-6	3E-8	-	-
		W, see 230U Y, see 230U	-	6E+3 5E+3	2E-6 2E-6	8E-9 6E-9	6E-5	8E-4
82	Uranium-232	D, see 230U	2E+0 Bone surf (4E+0)	2E-1 Bone surf (4E-1)	9E-11	-	6E-13	6E-8
		W, see 230U Y, see 230U	-	4E-1 6E-3	2E-10 3E-12	8E-13 3E-14	-	-
82	Uranium-233	D, see 230U	3E+1 Bone surf (2E+1)	3E+0 Bone surf (2E+0)	6E-10	-	3E-12	3E-7
		W, see 230U Y, see 230U	-	7E-1 4E-2	3E-10 2E-11	3E-12 6E-14	-	-
82	Uranium-234 ³	D, see 230U	3E+1 Bone surf (2E+1)	3E+0 Bone surf (2E+0)	9E-10	-	3E-12	3E-7
		W, see 230U Y, see 230U	-	7E-1 4E-2	3E-10 2E-11	3E-12 6E-14	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Dose Ingestion ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 ALL (μCi)	Col. 3 DAC ($\mu\text{Ci}/\text{m}^3$)			
92	Uranium-235 ³	D, see 230U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	6E-10	-	-	-
		W, see 230U	-	6E-1	3E-10	3E-12	3E-7	3E-6
		Y, see 230U	-	4E-2	2E-11	6E-14	-	-
92	Uranium-236	D, see 230U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	6E-10	-	-	-
		W, see 230U	-	6E-1	3E-10	3E-12	3E-7	3E-6
		Y, see 230U	-	4E-2	2E-11	6E-14	-	-
92	Uranium-237	D, see 230U	2E+3 LLI wall (2E+3)	3E+3	1E-6	4E-9	-	-
		W, see 230U	-	2E+3	7E-7	2E-9	3E-6	3E-4
		Y, see 230U	-	2E+3	4E-7	2E-9	-	-
92	Uranium-238 ³	D, see 230U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	6E-10	-	-	-
		W, see 230U	-	6E-1	3E-10	3E-12	3E-7	3E-6
		Y, see 230U	-	4E-2	2E-11	6E-14	-	-
92	Uranium-239 ²	D, see 230U	7E+4	2E+5	6E-5	2E-7	3E-4	3E-3
		W, see 230U	-	2E+5	7E-5	2E-7	-	-
		Y, see 230U	-	2E+5	6E-5	2E-7	-	-
92	Uranium-240	D, see 230U	1E+3	4E+3	2E-6	6E-9	2E-5	2E-4
		W, see 230U	-	3E+3	1E-6	4E-9	-	-
		Y, see 230U	-	2E+3	1E-6	3E-9	-	-
92	Uranium-natural ³	D, see 230U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	6E-10	-	-	-
		W, see 230U	-	6E-1	3E-10	3E-12	3E-7	3E-6
		Y, see 230U	-	4E-2	2E-11	6E-14	-	-
93	Neptunium-237 ²	W, all compounds	1E+5	2E+3 Bone surf (5E+2)	7E-7	-	2E-2	2E-2
93	Neptunium-237 ²	W, all compounds	6E+5	3E+6	1E-3	4E-6	1E-2	1E-1
93	Neptunium-238	W, all compounds	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
93	Neptunium-239	W, all compounds	2E+4 LLI wall (2E+6)	3E+2 Bone surf (1E+3)	3E-7	-	2E-9	3E-4
93	Neptunium-236 (1.15E+5 y)	W, all compounds	3E+0 Bone surf (6E+0)	2E-2 Bone surf (5E-2)	6E-12	-	-	-
93	Neptunium-236 (22.5 h)	W, all compounds	3E+3 Bone surf (4E+3)	3E+1 Bone surf (7E+1)	1E-9	-	1E-10	6E-6
93	Neptunium-237	W, all compounds	6E-1 Bone surf (1E+0)	4E-1 Bone surf (1E-2)	2E-12	-	1E-14	2E-7

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APP. B* PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

Atomic No.	Radioisotope	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Drain Ingestion AI (μ Ci)	Col. 2 Inhalation All (μ Ci)		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/ml)	Monthly Average Concentration (μ Ci/m ³)
				Col. 3 DAC (μ Ci/m ³)	Col. 3 Bone surf (μ Ci/m ²)			
93	Neptunium-236	W, all compounds	1E-3	6E-1 Bone surf (2E-2)	3E-8	-	2E-5	2E-6
93	Neptunium-235	W, all compounds	2E-3 LI well (2E-3)	2E-3	9E-7	3E-9	-	-
93	Neptunium-240 ²	W, all compounds	2E-4	8E-4	3E-5	1E-7	3E-4	3E-3
94	Plutonium-234	W, all compounds except PuO ₂ Y, PuO ₂	3E-3	2E-2 2E-2	9E-8 8E-8	3E-10 3E-10	1E-4	1E-3
94	Plutonium-235 ²	W, see ²³⁴ Pu Y, see ²³⁴ Pu	9E-5	3E-6 3E-6	1E-3 1E-3	4E-6 3E-6	1E-2	1E-1
94	Plutonium-236	W, see ²³⁴ Pu Y, see ²³⁴ Pu	2E-0 Bone surf (4E-0)	2E-2 Bone surf (4E-2) 4E-2	8E-12	-	-	-
94	Plutonium-237	W, see ²³⁴ Pu Y, see ²³⁴ Pu	1E-4	3E-3 3E-3	1E-6 1E-6	5E-9 4E-9	2E-4	2E-3
94	Plutonium-238	W, see ²³⁴ Pu Y, see ²³⁴ Pu	9E-1 Bone surf (2E-0)	7E-3 Bone surf (1E-2) 2E-2	3E-12	-	-	-
94	Plutonium-239	W, see ²³⁴ Pu Y, see ²³⁴ Pu	8E-1 Bone surf (1E-0)	6E-3 Bone surf (1E-2) 2E-2 Bone surf (2E-2)	3E-12	-	-	-
94	Plutonium-240	W, see ²³⁴ Pu Y, see ²³⁴ Pu	8E-1 Bone surf (1E-0)	6E-3 Bone surf (1E-2) 2E-2 Bone surf (2E-2)	3E-12	-	-	-
94	Plutonium-241	W, see ²³⁴ Pu Y, see ²³⁴ Pu	6E-1 Bone surf (7E-1)	3E-1 Bone surf (6E-1) 8E-1 Bone surf (1E-0)	1E-10 -	-	-	-
					3E-10	6E-13	1E-6	1E-8
					-	1E-12	-	-

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Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation (μCi)		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 1 GI ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Respiratory ($\mu\text{Ci}/\text{m}^3$)			
94	Plutonium-242	W, see ^{234}Pu	BE-1 Bone surf (1E+0)	7E-3 Bone surf (1E-2)	3E-12	-	-	-
		Y, see ^{234}Pu	-	2E-2 Bone surf (2E-2)	7E-12	2E-14	2E-6	2E-7
94	Plutonium-243	W, see ^{234}Pu	2E+4	4E+4	2E-5	5E-8	2E-6	2E-3
		Y, see ^{234}Pu	-	4E+4	2E-5	5E-8	-	-
94	Plutonium-244	W, see ^{234}Pu	BE-1 Bone surf (2E+0)	7E-3 Bone surf (1E-2)	3E-12	-	-	-
		Y, see ^{234}Pu	-	2E-2 Bone surf (2E-2)	7E-12	2E-14	2E-6	2E-7
94	Plutonium-245	W, see ^{234}Pu	2E+3	5E+3	2E-6	6E-9	2E-5	2E-4
		Y, see ^{234}Pu	-	4E+3	2E-6	6E-9	-	-
94	Plutonium-246	W, see ^{234}Pu	4E+2 St. wall (4E+2)	3E+2	1E-7	4E-10	-	-
		Y, see ^{234}Pu	-	3E+2	1E-7	4E-10	6E-6	6E-5
95	Americium-237 ²	W, all compounds	3E+4	3E+5	1E-4	4E-7	1E-3	1E-2
95	Americium-238 ²	W, all compounds	4E+4	3E+3 Bone surf (4E+3)	1E-4	-	5E-6	5E-3
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	2E-5	2E-4
95	Americium-241	W, all compounds	BE-1 Bone surf (1E+0)	6E-2 Bone surf (1E-2)	3E-12	-	-	-
95	Americium-242a	W, all compounds	BE-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12	-	-	-
95	Americium-242	W, all compounds	4E+3	5E+1 Bone surf (5E+1)	4E-8	-	5E-5	5E-4
95	Americium-243	W, all compounds	BE-1 Bone surf (1E+0)	6E-2 Bone surf (1E-2)	3E-12	-	-	-
95	Americium-244 ²	W, all compounds	6E+4 St. wall (6E+4)	4E+3 Bone surf (7E+3)	2E-6	-	-	-
95	Americium-244	W, all compounds	2E+3	2E+2 Bone surf (2E+2)	5E-6	-	4E-5	4E-4
95	Americium-245	W, all compounds	2E+4	5E+4	3E-5	1E-7	4E-4	4E-3

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PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

Atomic No.	Radionuclide	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Oral Ingestion AI (μ Ci)	Inhalation		Col. 1 Air (μ Ci/m ³)	Col. 2 Water (μ Ci/m ³)	Monthly Average Concentration (μ Ci/gal)
				Col. 2 AI (μ Ci)	Col. 3 DAC (μ Ci/m ³)			
95	Americium-240 ²	W, all compounds	5E-4 St. cell (6E-4)	2E-5	5E-5	3E-7	-	-
95	Americium-241 ²	W, all compounds	3E-4	1E-5	4E-5	1E-7	4E-6	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)	5E-1 Bone surf (6E-1)	2E-10	-	-	-
96	Curium-241	W, all compounds	1E-3	3E-1 Bone surf (4E-1)	1E-8	-	2E-5	2E-4
96	Curium-242	W, all compounds	3E-1 Bone surf (5E-1)	3E-1 Bone surf (3E-1)	1E-10	-	-	-
96	Curium-243	W, all compounds	1E-0 Bone surf (2E-0)	5E-3 Bone surf (2E-2)	4E-12	-	-	-
96	Curium-244	W, all compounds	1E-0 Bone surf (3E-0)	1E-2 Bone surf (2E-2)	5E-12	-	-	-
96	Curium-245	W, all compounds	7E-1 Bone surf (1E-0)	5E-3 Bone surf (1E-2)	2E-12	-	-	-
96	Curium-246	W, all compounds	7E-1 Bone surf (1E-0)	5E-3 Bone surf (1E-2)	2E-12	-	-	-
96	Curium-247	W, all compounds	5E-1 Bone surf (1E-0)	5E-3 Bone surf (1E-2)	3E-12	-	-	-
96	Curium-248	W, all compounds	2E-1 Bone surf (4E-1)	2E-3 Bone surf (3E-3)	7E-13	-	-	-
96	Curium-249 ²	W, all compounds	5E-4	2E-4 Bone surf (3E-4)	7E-5	-	7E-6	7E-3
96	Curium-250	W, all compounds	4E-2 Bone surf (6E-2)	3E-4 Bone surf (5E-4)	1E-13	-	-	-
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 (5E-3)	2E-12	-	-	-
97	Berkelium-249	W, all compounds	2E-2 Bone surf (5E-2)	2E-0 Bone surf (4E-0)	7E-10	-	-	-

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PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

Atomic No.	Radioisotope	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
			Col. 1 Drain Injection ALI (μCi)	Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
				Col. 2 ALI (μCi)	Col. 3 DLI ($\mu\text{Ci}/\text{m}^3$)			
97	Berkelium-250	W, all compounds	9E+3	9E+2 Bone surf (7E+2)	1E-7	-	1E-4	1E-3
98	Californium-244 ²	W, all compounds except those given for Y	3E+4 St. wall (3E+4)	6E+2	2E-7	9E-10	-	-
		Y, oxides and hydroxides	-	6E+2	2E-7	9E-10	-	-
98	Californium-246	W, see ²⁴⁴ Cf Y, see ²⁴⁴ Cf	4E+2	9E+0	4E-9	1E-11	9E-6	9E-5
98	Californium-248	W, see ²⁴⁴ Cf Y, see ²⁴⁴ Cf	9E+0 Bone surf (2E+2)	6E+2 Bone surf (1E-1) 1E-1	3E-11	-	-	-
		Y, see ²⁴⁴ Cf	-	1E-1	4E-11	1E-13	2E-7	2E-6
98	Californium-249	W, see ²⁴⁴ Cf Y, see ²⁴⁴ Cf	9E+1 Bone surf (1E+0)	4E+3 Bone surf (9E+3) 1E-2 Bone surf (1E-2)	2E-12	-	-	-
		Y, see ²⁴⁴ Cf	-	1E-2	4E-12	1E-14	2E-6	2E-7
98	Californium-250	W, see ²⁴⁴ Cf Y, see ²⁴⁴ Cf	1E+0 Bone surf (2E+0)	9E+2 Bone surf (2E+2) 1E-2	4E-12	-	-	-
		Y, see ²⁴⁴ Cf	-	1E-2	1E-11	4E-14	9E-6	9E-7
98	Californium-251	W, see ²⁴⁴ Cf Y, see ²⁴⁴ Cf	9E+1 Bone surf (1E+0)	4E+3 Bone surf (9E+3) 1E-2 Bone surf (1E-2)	2E-12	-	-	-
		Y, see ²⁴⁴ Cf	-	1E-2	4E-12	1E-14	2E-6	2E-7
98	Californium-252	W, see ²⁴⁴ Cf Y, see ²⁴⁴ Cf	2E+0 Bone surf (5E+0)	2E+2 Bone surf (4E+2) 1E-2	9E-12	-	-	-
		Y, see ²⁴⁴ Cf	-	1E-2	1E-11	9E-14	7E-6	7E-7
98	Californium-253	W, see ²⁴⁴ Cf Y, see ²⁴⁴ Cf	2E+2 Bone surf (4E+2)	2E+0	9E-10	3E-12	-	-
		Y, see ²⁴⁴ Cf	-	2E+0	7E-10	2E-12	3E-6	9E-6
98	Californium-254	W, see ²⁴⁴ Cf Y, see ²⁴⁴ Cf	2E+0	2E+2	9E-12	3E-14	9E-6	9E-7
		Y, see ²⁴⁴ Cf	-	2E+2	7E-12	2E-14	-	-
99	Einsteinium-250	W, all compounds	4E+4	9E+2 Bone surf (1E+3)	2E-7	-	6E-6	6E-3
99	Einsteinium-251	W, all compounds	7E+3	9E+2 Bone surf (1E+3)	6E-7	-	1E-6	1E-3
99	Einsteinium-253	W, all compounds	2E+2	1E+0	6E-10	2E-12	2E-6	2E-6

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Atomic No.	Radioisotope	Class	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers	
			Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation		Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)	
				ALI (μCi)	BAC ($\mu\text{Ci}/\text{ml}$)				
99	Einsteinium-254a	W, all compounds	$2\text{E}+2$ LIJ small ($2\text{E}+2$)	$2\text{E}+1$	$4\text{E}+9$	$2\text{E}-11$	-	$4\text{E}-6$	
99	Einsteinium-254	W, all compounds	$2\text{E}+0$ Bone surf ($2\text{E}+1$)	$7\text{E}-2$ Bone surf ($2\text{E}-1$)	$2\text{E}-11$	-	-	-	
100	Fermium-252	W, all compounds	$2\text{E}+2$	$2\text{E}+1$	$2\text{E}+9$	$2\text{E}-11$	$4\text{E}-6$	$4\text{E}-6$	
100	Fermium-253	W, all compounds	$2\text{E}+3$	$2\text{E}+1$	$4\text{E}+9$	$2\text{E}-11$	$2\text{E}-6$	$2\text{E}-4$	
100	Fermium-254	W, all compounds	$2\text{E}+3$	$2\text{E}+1$	$4\text{E}+9$	$2\text{E}-10$	$4\text{E}-6$	$4\text{E}-4$	
100	Fermium-255	W, all compounds	$2\text{E}+2$	$2\text{E}+1$	$2\text{E}+9$	$2\text{E}-11$	$7\text{E}-6$	$7\text{E}-6$	
100	Fermium-257	W, all compounds	$2\text{E}+1$ Bone surf ($4\text{E}+1$)	$2\text{E}-1$ Bone surf ($2\text{E}-1$)	$7\text{E}-11$	-	-	-	
101	Mendelevium-257	W, all compounds	$7\text{E}+3$	$2\text{E}+1$ Bone surf ($2\text{E}+1$)	$4\text{E}+9$	-	$2\text{E}-4$	$2\text{E}-2$	
			-	($2\text{E}+1$)	-	$2\text{E}-10$	-	-	
101	Mendelevium-258	W, all compounds	$2\text{E}+1$ Bone surf ($2\text{E}+1$)	$2\text{E}-1$ Bone surf ($2\text{E}-1$)	$2\text{E}-10$	-	-	-	
			-	-	-	$2\text{E}-13$	$2\text{E}-7$	$2\text{E}-6$	
-	Any single radioisotope not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours		Subversion ¹	-	$2\text{E}+2$	$2\text{E}-7$	$2\text{E}-9$	-	-
-	Any single radioisotope not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours		-	$2\text{E}-3$	$2\text{E}-10$	$2\text{E}-12$	$2\text{E}-6$	$2\text{E}-7$
-	Any single radioisotope not listed above that decays by alpha emission or spontaneous fission, or any mixture for which either the identity or the concentration of any radioisotope in the mixture is not known		-	$4\text{E}-4$	$2\text{E}-13$	$2\text{E}-15$	$2\text{E}-9$	$2\text{E}-6$

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FOOTNOTES:

¹"Submersion" means that values given are for submersion in a hemispherical semi-infinite cloud of airborne material.

²These 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 $3E-7$ $\mu\text{Ci}/\text{ml}$ 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 § 20.1203.)

³For soluble mixtures of U-238, U-234, and U-235 in air, chemical toxicity may be the limiting factor (see § 20.1201(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) $\mu\text{Ci}\cdot\text{hr}/\text{m}^3$, where SA is the specific activity of the uranium inhaled. The specific activity for natural uranium is $8.77E-7$ curies per gram U. The specific activity for other mixtures of U-238, U-235, and U-234, if not known, shall be:

$$SA = 3.6E-7 \text{ curies/gram U} \quad \text{U-depleted}$$

$$SA = [0.4 + 0.26 (\text{enrichment}) + 0.0034 (\text{enrichment})^2] E-6, \text{ enrichment} \geq 0.72$$

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

Radionuclide	Table 1 Occupational Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
	Col. 1 Dose Ingestion ALI (μCi)	Col. 2 Col. 3 Inhalation DAC ($\mu\text{Ci}/\text{m}^3$)	Col. 3	Col. 1 Air ($\mu\text{Ci}/\text{m}^3$)	Col. 2 Water ($\mu\text{Ci}/\text{m}^3$)	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
	If it is known that Ac-227-D and Ce-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-246-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, Re-223-W, Re-225-W, Re-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	-	$7E-1$	$3E-10$	-	-	-

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Radionuclide	Table 1 Exceptional Values			Table 2 Effluent Concentrations		Table 3 Releases to Sewers
	Col. 1	Col. 2	Col. 3	Col. 1	Col. 2	Monthly Average Concentration ($\mu\text{Ci}/\text{m}^3$)
	Ingestion ALI (μCi)	Inhalation ALI (μCi)	DAC ($\mu\text{Ci}/\text{m}^3$)	Air ($\mu\text{Ci}/\text{m}^3$)	Water ($\mu\text{Ci}/\text{m}^3$)	
<p>If, in addition, it is known that Sr-90, Y-91, Zr-93, Nb-94, Mo-93, Tc-99, Ru-101, Rh-105, Pd-103, Ag-110, Cd-115, In-115, Sn-113, Sb-121, Te-127, I-131, Xe-135, Ba-138, La-138, Ce-138, Pr-143, Nd-147, Pm-147, Sm-147, Eu-152, Gd-153, Tb-160, Dy-163, Ho-164, Er-169, Tm-171, Yb-174, Lu-175, Hf-178, Ta-182, W-186, Re-187, Os-192, Ir-192, Pt-201, Au-203, Hg-203, Tl-205, Pb-210, Bi-210, Po-210, At-210, Rn-222, Ac-227, Th-230, Pa-231, U-233, U-235, U-238, Np-237, Pu-239, Pu-241, Am-241, Cm-244, Cm-246, Bk-247, Cf-249, Cf-251, Cf-253, Es-253, and Fm-253 are not present</p>	-	2E-0	3E-9	-	-	-
<p>If it is known that Ac-227, Th-230, Pa-231, U-233, U-235, U-238, Np-237, Pu-239, Pu-241, Am-241, Cm-244, Cm-246, Bk-247, Cf-249, Cf-251, Cf-253, Es-253, and Fm-253 are not present</p>	-	-	-	1E-14	-	-
<p>If, in addition, it is known that Sr-146, Zr-140, Nb-144, Mo-147, Tc-146, Ru-146, Rh-146, Pd-146, Ag-146, Cd-146, In-146, Sn-146, Sb-146, Te-146, I-146, Xe-146, Ba-146, La-146, Ce-146, Pr-146, Nd-146, Pm-146, Sm-146, Eu-146, Gd-146, Tb-146, Dy-146, Ho-146, Er-146, Tm-146, Yb-146, Lu-146, Hf-146, Ta-146, W-146, Re-146, Os-146, Ir-146, Pt-146, Au-146, Hg-146, Tl-146, Pb-146, Bi-146, Po-146, At-146, Rn-146, Ac-146, Th-146, Pa-146, U-146, Np-146, Pu-146, Am-146, Cm-146, Bk-146, Cf-146, Es-146, Fm-146, and all other radionuclides are not present</p>	-	-	-	1E-13	-	-
<p>If, in addition, it is known that Sr-147, Zr-141, Nb-145, Mo-149, Tc-148, Ru-148, Rh-148, Pd-148, Ag-148, Cd-148, In-148, Sn-148, Sb-148, Te-148, I-148, Xe-148, Ba-148, La-148, Ce-148, Pr-148, Nd-148, Pm-148, Sm-148, Eu-148, Gd-148, Tb-148, Dy-148, Ho-148, Er-148, Tm-148, Yb-148, Lu-148, Hf-148, Ta-148, W-148, Re-148, Os-148, Ir-148, Pt-148, Au-148, Hg-148, Tl-148, Pb-148, Bi-148, Po-148, At-148, Rn-148, Ac-148, Th-148, Pa-148, U-148, Np-148, Pu-148, Am-148, Cm-148, Bk-148, Cf-148, Es-148, Fm-148, and all other radionuclides are not present</p>	-	-	-	1E-12	-	-
<p>If, in addition it is known that Sr-90, Y-91, Zr-93, Nb-94, Mo-93, Tc-99, Ru-101, Rh-105, Pd-103, Ag-110, Cd-115, In-115, Sn-113, Sb-121, Te-127, I-131, Xe-135, Ba-138, La-138, Ce-138, Pr-143, Nd-147, Pm-147, Sm-147, Eu-152, Gd-153, Tb-160, Dy-163, Ho-164, Er-169, Tm-171, Yb-174, Lu-175, Hf-178, Ta-182, W-186, Re-187, Os-192, Ir-192, Pt-201, Au-203, Hg-203, Tl-205, Pb-210, Bi-210, Po-210, At-210, Rn-222, Ac-227, Th-230, Pa-231, U-233, U-235, U-238, Np-237, Pu-239, Pu-241, Am-241, Cm-244, Cm-246, Bk-247, Cf-249, Cf-251, Cf-253, Es-253, and Fm-253 are not present</p>	-	-	-	-	1E-6	1E-5

3. If a mixture of radionuclides consists of uranium and its daughters in any dust (10 μm MMAD 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: 3E-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 B 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:

$$\frac{C_A}{\text{DAC}_A} + \frac{C_B}{\text{DAC}_B} + \frac{C_C}{\text{DAC}_C} \leq 1$$

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APPENDIX C TO §§ 20.1001-20.2401
QUANTITIES¹ OF LICENSED MATERIAL
REQUIRING LABELING

Radionuclide	Quantity (μCi)
Hydrogen-3	1,000
Beryllium-7	1,000
Beryllium-10	1
Carbon-11	1,000
Carbon-14	1,000
Fluorine-18	1,000
Sodium-22	10
Sodium-24	100
Magnesium-28	100
Aluminum-26	10
Silicon-31	1,000
Silicon-32	1
Phosphorus-32	10
Phosphorus-33	100
Sulfur-35	100
Chlorine-36	10
Chlorine-38	1,000
Chlorine-39	1,000
Argon-39	1,000
Argon-41	1,000
Potassium-40	100
Potassium-42	1,000
Potassium-43	1,000
Potassium-44	1,000
Potassium-45	1,000
Calcium-41	100
Calcium-45	100
Calcium-47	100
Scandium-43	1,000
Scandium-44m	100
Scandium-46	100
Scandium-46	10
Scandium-47	100
Scandium-48	100
Scandium-49	1,000
Titanium-44	1
Titanium-45	1,000
Vanadium-47	1,000
Vanadium-48	100
Vanadium-49	1,000
Chromium-48	1,000
Chromium-49	1,000
Chromium-51	1,000
Manganese-51	1,000
Manganese-52m	1,000
Manganese-52	100
Manganese-53	1,000
Manganese-54	100
Manganese-56	1,000
Iron-52	100
Iron-55	100
Iron-58	10
Iron-60	1
Cobalt-55	100
Cobalt-56	10
Cobalt-57	100
Cobalt-58m	1,000
Cobalt-58	100
Cobalt-60m	1,000
Cobalt-60	1
Cobalt-61	1,000
Cobalt-62m	1,000
Nickel-56	100
Nickel-57	100
Nickel-59	100
Nickel-63	100
Nickel-65	1,000
Nickel-66	10
Copper-60	1,000
Copper-61	1,000
Copper-64	1,000

APPENDIX C TO §§ 20.1001-20.2401
QUANTITIES¹ OF LICENSED MATERIAL
REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Copper-67	1,000
Zinc-62	100
Zinc-63	1,000
Zinc-65	10
Zinc-69m	100
Zinc-69	1,000
Zinc-71m	1,000
Zinc-72	100
Gallium-65	1,000
Gallium-66	100
Gallium-67	1,000
Gallium-68	1,000
Gallium-70	1,000
Gallium-72	100
Gallium-73	1,000
Germanium-66	1,000
Germanium-67	1,000
Germanium-68	10
Germanium-69	1,000
Germanium-71	1,000
Germanium-75	1,000
Germanium-77	1,000
Germanium-78	1,000
Arsenic-69	1,000
Arsenic-70	1,000
Arsenic-71	100
Arsenic-72	100
Arsenic-73	100
Arsenic-74	100
Arsenic-76	100
Arsenic-77	100
Arsenic-78	1,000
Selenium-70	1,000
Selenium-73m	1,000
Selenium-73	100
Selenium-75	100
Selenium-76	100
Selenium-81m	1,000
Selenium-81	1,000
Selenium-83	1,000
Bromine-74m	1,000
Bromine-74	1,000
Bromine-75	1,000
Bromine-76	100
Bromine-77	1,000
Bromine-80m	1,000
Bromine-80	1,000
Bromine-82	100
Bromine-83	1,000
Bromine-84	1,000
Krypton-74	1,000
Krypton-76	1,000
Krypton-77	1,000
Krypton-78	1,000
Krypton-81	1,000
Krypton-83m	1,000
Krypton-85m	1,000
Krypton-85	1,000
Krypton-87	1,000
Krypton-78	1,000
Rubidium-79	1,000
Rubidium-81m	1,000
Rubidium-81	1,000
Rubidium-82m	1,000
Rubidium-83	100
Rubidium-84	100
Rubidium-86	100
Rubidium-87	100
Rubidium-88	1,000
Rubidium-89	1,000
Strontium-80	100
Strontium-81	1,000
Strontium-83	100
Strontium-85m	1,000
Strontium-85	100
Strontium-87m	1,000

APPENDIX C TO §§ 20.1001-20.2401
QUANTITIES¹ OF LICENSED MATERIAL
REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Strontium-88	10
Strontium-90	0.1
Strontium-91	100
Strontium-92	100
Yttrium-86m	1,000
Yttrium-86	100
Yttrium-87	100
Yttrium-88	10
Yttrium-90m	1,000
Yttrium-90	10
Yttrium-91m	1,000
Yttrium-91	10
Yttrium-92	100
Yttrium-93	100
Yttrium-94	1,000
Yttrium-95	1,000
Zirconium-86	100
Zirconium-88	10
Zirconium-89	100
Zirconium-93	10
Zirconium-95	10
Zirconium-97	100
Niobium-88	1,000
Niobium-89m (86 min)	1,000
Niobium-89 (127 min)	1,000
Niobium-90	100
Niobium-93m	10
Niobium-94	1
Niobium-95m	100
Niobium-95	100
Niobium-96	100
Niobium-97	1,000
Niobium-98	1,000
Molybdenum-89	100
Molybdenum-90m	100
Molybdenum-93	10
Molybdenum-96	100
Molybdenum-101	1,000
Technetium-89m	1,000
Technetium-93	1,000
Technetium-94m	1,000
Technetium-94	1,000
Technetium-96m	1,000
Technetium-96	100
Technetium-97m	100
Technetium-97	1,000
Technetium-98	10
Technetium-99m	1,000
Technetium-99	100
Technetium-101	1,000
Technetium-104	1,000
Ruthenium-94	1,000
Ruthenium-97	1,000
Ruthenium-103	100
Ruthenium-106	1,000
Ruthenium-108	1
Rhodium-99m	1,000
Rhodium-99	100
Rhodium-100	100
Rhodium-101m	1,000
Rhodium-101	10
Rhodium-102m	10
Rhodium-102	10
Rhodium-103m	1,000
Rhodium-106	100
Rhodium-106m	1,000
Rhodium-107	1,000
Palladium-100	100
Palladium-101	1,000
Palladium-103	100
Palladium-107	10
Palladium-106	100
Silver-102	1,000
Silver-103	1,000
Silver-104m	1,000
Silver-104	1,000

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APPENDIX C TO §§ 20.1001-20.2401
QUANTITIES¹ OF LICENSED MATERIAL
REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Silver-105	100
Silver-106m	100
Silver-106	1,000
Silver-108m	1
Silver-110m	10
Silver-111	100
Silver-112	100
Silver-115	1,000
Cadmium-104	1,000
Cadmium-107	1,000
Cadmium-109	1
Cadmium-113m	0.1
Cadmium-113	100
Cadmium-115m	10
Cadmium-115	100
Cadmium-117m	1,000
Cadmium-117	1,000
Indium-109	1,000
Indium-110 (69.1min.)	1,000
Indium-110 (4.9h)	1,000
Indium-111	100
Indium-112	1,000
Indium-113m	1,000
Indium-114m	10
Indium-115m	1,000
Indium-115	100
Indium-116m	1,000
Indium-117m	1,000
Indium-117	1,000
Indium-119m	1,000
Tin-110	100
Tin-111	1,000
Tin-113	100
Tin-117m	100
Tin-119m	100
Tin-121m	100
Tin-121	1,000
Tin-123m	1,000
Tin-123	10
Tin-125	10
Tin-126	10
Tin-127	1,000
Tin-128	1,000
Antimony-115	1,000
Antimony-116m	1,000
Antimony-116	1,000
Antimony-117	1,000
Antimony-118m	1,000
Antimony-118	1,000
Antimony-120 (16min.)	1,000
Antimony-120 (5.78d)	100
Antimony-122	100
Antimony-124m	1,000
Antimony-124	10
Antimony-125	100
Antimony-126m	1,000
Antimony-126	100
Antimony-127	100
Antimony-128 (10.4min.)	1,000
Antimony-128 (9.01h)	100
Antimony-129	100
Antimony-130	1,000
Antimony-131	1,000
Tellurium-118	1,000
Tellurium-121m	10
Tellurium-121	100
Tellurium-123m	10
Tellurium-123	100
Tellurium-125m	10
Tellurium-127m	10
Tellurium-127	1,000
Tellurium-129m	10
Tellurium-129	1,000
Tellurium-131m	10
Tellurium-131	100

APPENDIX C TO §§ 20.1001-20.2401
QUANTITIES¹ OF LICENSED MATERIAL
REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Tellurium-132	10
Tellurium-133m	100
Tellurium-133	1,000
Tellurium-134	1,000
Iodine-120m	1,000
Iodine-120	100
Iodine-121	1,000
Iodine-123	100
Iodine-124	10
Iodine-125	1
Iodine-126	1
Iodine-128	1,000
Iodine-129	1
Iodine-130	10
Iodine-131	1
Iodine-132m	100
Iodine-132	100
Iodine-133	10
Iodine-134	1,000
Iodine-135	100
Xenon-120	1,000
Xenon-121	1,000
Xenon-122	1,000
Xenon-123	1,000
Xenon-125	1,000
Xenon-127	1,000
Xenon-129m	1,000
Xenon-131m	1,000
Xenon-133m	1,000
Xenon-133	1,000
Xenon-135m	1,000
Xenon-135	1,000
Xenon-136	1,000
Cesium-125	1,000
Cesium-127	1,000
Cesium-129	1,000
Cesium-130	1,000
Cesium-131	1,000
Cesium-132	100
Cesium-134m	1,000
Cesium-134	10
Cesium-135m	1,000
Cesium-135	100
Cesium-136	10
Cesium-137	1,000
Cesium-138	1,000
Barium-126	1,000
Barium-128	100
Barium-131m	1,000
Barium-131	100
Barium-133m	100
Barium-133	100
Barium-135m	100
Barium-136	1,000
Barium-140	1,000
Barium-141	1,000
Barium-142	1,000
Lanthanum-131	1,000
Lanthanum-132	100
Lanthanum-135	1,000
Lanthanum-136	10
Lanthanum-137	100
Lanthanum-138	100
Lanthanum-140	100
Lanthanum-141	100
Lanthanum-142	1,000
Lanthanum-143	1,000
Cerium-134	100
Cerium-135	100
Cerium-137m	100
Cerium-137	1,000
Cerium-139	100
Cerium-141	100
Cerium-143	100
Cerium-144	1
Praseodymium-136	1,000
Praseodymium-137	1,000

APPENDIX C TO §§ 20.1001-20.2401
QUANTITIES¹ OF LICENSED MATERIAL
REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Praseodymium-138m	1,000
Praseodymium-138	1,000
Praseodymium-142m	1,000
Praseodymium-142	100
Praseodymium-143	100
Praseodymium-144	1,000
Praseodymium-145	100
Praseodymium-147	1,000
Neodymium-136	1,000
Neodymium-138m	100
Neodymium-138	1,000
Neodymium-141	1,000
Neodymium-147	100
Neodymium-148	1,000
Neodymium-151	1,000
Promethium-141	1,000
Promethium-143	100
Promethium-144	10
Promethium-145	10
Promethium-146	1
Promethium-147	10
Promethium-148m	10
Promethium-148	10
Promethium-149	100
Promethium-150	1,000
Promethium-151	100
Samarium-141m	1,000
Samarium-141	1,000
Samarium-142	1,000
Samarium-145	100
Samarium-146	1
Samarium-147	100
Samarium-151	10
Samarium-153	100
Samarium-155	1,000
Samarium-156	1,000
Europium-145	100
Europium-146	100
Europium-147	10
Europium-148	100
Europium-149	100
Europium-150 (12.62h)	100
Europium-150 (34.8y)	1
Europium-152m	100
Europium-152	1
Europium-154	1
Europium-155	10
Europium-156	100
Europium-157	100
Europium-158	1,000
Gadolinium-145	1,000
Gadolinium-146	10
Gadolinium-147	100
Gadolinium-148	0.001
Gadolinium-149	100
Gadolinium-151	10
Gadolinium-152	100
Gadolinium-153	10
Gadolinium-156	100
Terbium-147	1,000
Terbium-148	100
Terbium-150	1,000
Terbium-151	100
Terbium-153	1,000
Terbium-154	100
Terbium-155	1,000
Terbium-156m (5.0h)	1,000
Terbium-156m (24.6h)	100
Terbium-156	10
Terbium-157	10
Terbium-158	10
Terbium-160	10
Terbium-161	100
Dysprosium-155	1,000
Dysprosium-157	1,000

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APPENDIX C TO §§ 20.1001-20.2401
QUANTITIES¹ OF LICENSED MATERIAL
REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Dysprosium-159	100
Dysprosium-165	1,000
Dysprosium-166	100
Holmium-165	1,000
Holmium-157	1,000
Holmium-159	1,000
Holmium-171	1,000
Holmium-183	1,000
Holmium-187	1,000
Holmium-184m	1,000
Holmium-184	1,000
Holmium-186m	1
Holmium-186	100
Holmium-187	1,000
Erbium-161	1,000
Erbium-165	1,000
Erbium-169	100
Erbium-171	100
Erbium-172	100
Thulium-162	1,000
Thulium-165	100
Thulium-167	100
Thulium-170	10
Thulium-171	10
Thulium-172	100
Thulium-173	100
Thulium-175	1,000
Ytterbium-162	1,000
Ytterbium-166	100
Ytterbium-167	1,000
Ytterbium-169	100
Ytterbium-176	100
Ytterbium-177	1,000
Ytterbium-178	1,000
Lutetium-166	100
Lutetium-170	100
Lutetium-171	100
Lutetium-172	100
Lutetium-173	10
Lutetium-174m	10
Lutetium-174	10
Lutetium-176m	1,000
Lutetium-176	100
Lutetium-177m	10
Lutetium-177	100
Lutetium-178m	1,000
Lutetium-178	1,000
Lutetium-179	1,000
Hafnium-170	100
Hafnium-172	1
Hafnium-173	1,000
Hafnium-175	100
Hafnium-177m	1,000
Hafnium-178m	0.1
Hafnium-178m	10
Hafnium-180m	1,000
Hafnium-181	10
Hafnium-182m	1,000
Hafnium-182	0.1
Hafnium-183	1,000
Hafnium-184	100
Tantalum-172	1,000
Tantalum-173	1,000
Tantalum-174	1,000
Tantalum-175	1,000
Tantalum-176	100
Tantalum-177	1,000
Tantalum-178	1,000
Tantalum-170	100
Tantalum-180m	1,000
Tantalum-180	100
Tantalum-182m	1,000
Tantalum-182	10
Tantalum-183	100
Tantalum-184	100
Tantalum-184	1,000

APPENDIX C TO §§ 20.1001-20.2401
QUANTITIES¹ OF LICENSED MATERIAL
REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Tantalum-186	1,000
Tungsten-176	1,000
Tungsten-177	1,000
Tungsten-178	1,000
Tungsten-179	1,000
Tungsten-181	1,000
Tungsten-185	100
Tungsten-187	100
Tungsten-188	10
Rhenium-177	1,000
Rhenium-178	1,000
Rhenium-181	1,000
Rhenium-182 (12.7h)	1,000
Rhenium-182 (84.0h)	100
Rhenium-184m	10
Rhenium-184	100
Rhenium-186m	10
Rhenium-186	100
Rhenium-187	1,000
Rhenium-188m	1,000
Rhenium-188	100
Rhenium-189	100
Osmium-180	1,000
Osmium-181	1,000
Osmium-182	100
Osmium-185	100
Osmium-189m	1,000
Osmium-191m	1,000
Osmium-191	100
Osmium-193	100
Osmium-194	1
Indium-182	1,000
Indium-194	1,000
Indium-185	1,000
Indium-186	100
Indium-187	1,000
Indium-188	100
Indium-189	100
Indium-190m	1,000
Indium-190	100
Indium-192 (72.8d)	1
Indium-192m (1.4min.)	10
Indium-194m	10
Indium-194	100
Indium-195m	1,000
Indium-195	1,000
Platinum-186	1,000
Platinum-188	100
Platinum-189	1,000
Platinum-191	100
Platinum-193m	100
Platinum-193	1,000
Platinum-195m	100
Platinum-197m	1,000
Platinum-197	100
Platinum-199	1,000
Platinum-200	100
Gold-183	1,000
Gold-184	100
Gold-185	10
Gold-186m	100
Gold-186	100
Gold-189	100
Gold-200m	100
Gold-200	1,000
Gold-201	1,000
Mercury-183m	100
Mercury-183	1,000
Mercury-184	1
Mercury-195m	100
Mercury-185	1,000
Mercury-187m	100
Mercury-187	1,000
Mercury-196m	1,000
Mercury-203	100
Thallium-184m	1,000

APPENDIX C TO §§ 20.1001-20.2401
QUANTITIES¹ OF LICENSED MATERIAL
REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Thallium-184	1,000
Thallium-185	1,000
Thallium-187	1,000
Thallium-188m	1,000
Thallium-188	1,000
Thallium-189	1,000
Thallium-200	1,000
Thallium-201	1,000
Thallium-202	100
Thallium-204	100
Lead-185m	1,000
Lead-186	1,000
Lead-189	1,000
Lead-200	100
Lead-201	1,000
Lead-202m	1,000
Lead-202	10
Lead-203	1,000
Lead-205	100
Lead-206	1,000
Lead-210	0.01
Lead-211	100
Lead-212	1
Lead-214	100
Bismuth-200	1,000
Bismuth-201	1,000
Bismuth-202	1,000
Bismuth-203	100
Bismuth-205	100
Bismuth-206	100
Bismuth-207	10
Bismuth-210m	0.1
Bismuth-210	1
Bismuth-212	10
Bismuth-213	10
Bismuth-214	100
Polonium-203	1,000
Polonium-205	1,000
Polonium-207	1,000
Polonium-210	0.1
Antoine-207	100
Antoine-211	10
Radon-220	1
Radon-222	1
Francium-222	100
Francium-223	100
Radium-223	0.1
Radium-224	0.1
Radium-225	0.1
Radium-226	0.1
Radium-227	1,000
Radium-228	0.1
Actinium-224	1
Actinium-225	0.01
Actinium-226	0.1
Actinium-227	0.001
Actinium-228	1
Thorium-226	10
Thorium-227	0.01
Thorium-228	0.001
Thorium-229	0.001
Thorium-230	0.001
Thorium-231	100
Thorium-232	100
Thorium-234	10
Thorium-neptunium	100
Protactinium-227	10
Protactinium-228	1
Protactinium-230	0.1
Protactinium-231	0.001
Protactinium-232	1
Protactinium-233	100
Protactinium-234	100
Uranium-230	0.01
Uranium-231	100
Uranium-232	0.001

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APPENDIX C TO §§ 20.1001-20.2401
QUANTITIES¹ OF LICENSED MATERIAL
REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Uranium-233	0.001
Uranium-234	0.001
Uranium-235	0.001
Uranium-236	0.001
Uranium-237	100
Uranium-238	100
Uranium-239	1,000
Uranium-240	100
Uranium-natural	100
Neptunium-232	100
Neptunium-233	1,000
Neptunium-234	100
Neptunium-235	100
Neptunium-236 (1.15x10 ⁶ y)	0.001
Neptunium-236 (22.5h)	1
Neptunium-237	1,001
Neptunium-238	10
Neptunium-239	100
Neptunium-240	1,000
Plutonium-234	10
Plutonium-235	1,000
Plutonium-236	0.001
Plutonium-237	100
Plutonium-238	0.001
Plutonium-239	0.001
Plutonium-240	0.001
Plutonium-241	0.01
Plutonium-242	0.001
Plutonium-243	1,000
Plutonium-244	0.001
Plutonium-245	100
Americium-237	1,000
Americium-238	100
Americium-239	1,000
Americium-240	100
Americium-241	0.001
Americium-242m	0.001
Americium-242	10
Americium-243	0.001

APPENDIX C TO §§ 20.1001-20.2401
QUANTITIES¹ OF LICENSED MATERIAL
REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Americium-244m	100
Americium-244	10
Americium-245	1,000
Americium-246m	1,000
Americium-246	1,000
Curium-238	100
Curium-240	0.1
Curium-241	1
Curium-242	0.01
Curium-243	0.001
Curium-244	0.001
Curium-245	0.001
Curium-246	0.001
Curium-247	0.001
Curium-248	0.001
Curium-249	1,000
Berkelium-245	100
Berkelium-246	100
Berkelium-247	0.001
Berkelium-249	0.1
Berkelium-250	10
Californium-244	100
Californium-246	1
Californium-248	0.01
Californium-249	0.001
Californium-250	0.001
Californium-251	0.001
Californium-252	0.001
Californium-253	0.1
Californium-254	0.001
Any alpha emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	0.001
Einsteinium-250	100
Einsteinium-251	100
Einsteinium-253	0.1
Einsteinium-254m	1
Einsteinium-254	0.01
Fermium-252	1

APPENDIX C TO §§ 20.1001-20.2401
QUANTITIES¹ OF LICENSED MATERIAL
REQUIRING LABELING—Continued

Radionuclide	Quantity (μCi)
Fermium-253	1
Fermium-254	10
Fermium-255	1
Fermium-257	0.01
Mendelevium-257	10
Mendelevium-258	0.01
Any radionuclide other than alpha emitting radionuclides not listed above, or mixtures of beta emitters of unknown composition	0.01

¹ The quantities listed above were derived by taking 1/10th of the most restrictive ALI listed in table 1, columns 1 and 2, of appendix B to §§ 20.1001-20.2401 of this part, rounding to the nearest factor of 10, and arbitrarily constraining the values listed between 0.001 and 1,000 μCi. Values of 100 μCi have been assigned for radionuclides having a radioactive half-life in excess of 10⁴ years (except rhenium, 10,000 μCi) to take into account their low specific activity.

Note: For purposes of §§ 20.18... (e), 20.1805(a), and 20.2201(a) where there is involved a combination of radionuclides in known amounts, the limit for the combination should 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" (i.e., "unity").

Appendix D to §§ 20.1001-20.2401—
United States Nuclear Regulatory Commission Regional Offices

	Address	Telephone (24 hour)
Region I: Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.	USNRC, Region I, 475 Allendale Road, King of Prussia, PA 19406.	(215) 337-5000. (FTS) 346-5000.
Region II: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, Puerto Rico, South Carolina, Tennessee, Virginia, Virgin Islands, and West Virginia.	USNRC, Region II, 101 Marietta Street, NW, Suite 2900, Atlanta, GA 30323.	(404) 331-4503. (FTS) 641-4503.
Region III: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.	USNRC, Region III, 799 Roosevelt Road, Glen Ellyn, IL 60137.	(708) 790-5500. (FTS) 368-5500.
Region IV: Arkansas, Colorado, Idaho, Kansas, Louisiana, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming.	USNRC, Region IV, 611 Ryan Plaza Drive, Suite 1000, Arlington, TX 79011.	(817) 860-6100. (FTS) 726-6100.
Region IV: Field Office	USNRC, Region IV, Uranium Recovery Field Office, 730 Emma Street, Suite 100a, Golden, CO 80401, Msk P.O. Box 25325, Denver, CO 80225.	(303) 251-5800. (FTS) 554-2805.
Region V: Alaska, Arizona, California, Hawaii, Nevada, Oregon, Washington, and U.S. territories and possessions in the Pacific.	USNRC, Region V, 1450 Marie Lane, Suite 210, Walnut Creek, CA 94596.	(510) 875-0200.

Appendix E to §§ 20.1001-20.2401
(Reserved)

Appendix F to §§ 20.1001-20.2401—
Requirements for Low-Level-Waste
Transfer for Disposal at Land Disposal
Facilities and Manifests

1. Manifest

The shipment manifest shall contain the name, address, and telephone number of the person generating the waste. The manifest shall also include the name, address, and telephone number or the name and EPA hazardous waste identification number of the

person transporting the waste to the land disposal facility. The manifest must also indicate as completely as practicable: a physical description of the waste, the volume, radionuclide identity and quantity, the total radioactivity, and the principal chemical form. The solidification agent must be specified. Waste containing more than 0.1% chelating agents by weight must be identified and the weight percentage of the chelating agent estimated. Wastes classified as Class A, Class B, or Class C in § 61.55 of this

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chapter must be clearly identified as such in the manifest. The total quantity of the radionuclides ^3H , ^{14}C , ^{99}Tc , and ^{131}I must be shown. The manifest required by this paragraph may be shipping papers used to meet Department of Transportation or Environmental Protection Agency regulations or requirements of the receiver, provided all the required information is included. Copies of manifests required by this section may be legible carbon copies or legible photocopies.

II. Certification

The waste generator shall include in the shipment manifest a certification that the transported materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and the Commission. An authorized representative of the waste generator shall sign and date the manifest.

III. Control and Tracking

A. Any generating licensee who transfers radioactive waste to a land disposal facility or a licensed waste collector shall comply with the requirements in paragraphs A.1 through B of this section. Any generating licensee who transfers waste to a licensed waste processor who treats or repackages waste shall comply with the requirements of paragraphs A.4 through B of this section. A licensee shall:

1. Prepare all wastes so that the waste is classified according to § 61.55 of this chapter and meets the waste characteristics requirements in § 61.56 of this chapter;
2. Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with § 61.55 of this chapter;
3. Conduct a quality control program to ensure compliance with §§ 61.55 and 61.56 of this chapter; the program must include management evaluation of audits;
4. Prepare shipping manifests to meet the requirements of sections I and II of this appendix;
5. Forward a copy of the manifest to the intended recipient, at the time of shipment, or deliver to a collector at the time the waste is collected, obtaining acknowledgment of receipt in the form of a signed copy of the manifest or equivalent documentation from the collector;
6. Include one copy of the manifest with the shipment;
7. Retain a copy of the manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by parts 30, 40, and 70 of this chapter; and
8. For any shipments or any part of a shipment for which acknowledgment of receipt has not been received within the times set forth in this section, conduct an investigation in accordance with paragraph E of this appendix.

B. Any waste collector licensee who handles only prepackaged waste shall:

1. Acknowledge receipt of the waste from the generator within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation;

2. Prepare a new manifest to reflect consolidated shipments; the new manifest shall serve as a listing or index for the detailed generator manifests. Copies of the generator manifests shall be a part of the new manifest. The waste collector may prepare a new manifest without attaching the generator manifests, provided the new manifest contains for each package the information specified in section I of this appendix. The collector licensee shall certify that nothing has been done to the waste that would invalidate the generator's certification;

3. Forward a copy of the new manifest to the land disposal facility operator at the time of shipment;

4. Include the new manifest with the shipment to the disposal site;

5. Retain a copy of the manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by parts 30, 40, and 70 of this chapter, and retain information from generator manifest until the license is terminated; and

6. For any shipments or any part of a shipment for which acknowledgment of receipt is not received within the times set forth in this section, conduct an investigation in accordance with section III, E of this appendix.

C. Any licensed waste processor who treats or repackages wastes shall:

1. Acknowledge receipt of the waste from the generator within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation;
2. Prepare a new manifest that meets the requirements of sections I and II of this appendix. Preparation of the new manifest reflects that the processor is responsible for the waste;
3. Prepare all wastes so that the waste is classified according to § 61.55 of this chapter and meets the waste characteristics requirements in § 61.56 of this chapter;
4. Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with §§ 61.55 and 61.57 of this chapter;
5. Conduct a quality control program to ensure compliance with §§ 61.55 and 61.56 of this chapter. The program shall include management evaluation of audits;
6. Forward a copy of the new manifest to the disposal site operator or waste collector at the time of shipment, or deliver to a collector at the time the waste is collected, obtaining acknowledgment of receipt in the form of a signed copy of the manifest or equivalent documentation by the collector;
7. Include the new manifest with the shipment;
8. Retain copies of original manifests and new manifests and documentation of acknowledgment of receipt as the record of transfer of licensed material required by parts 30, 40, and 70 of this chapter; and
9. For any shipment or part of a shipment for which acknowledgment is not received within the times set forth in this section, conduct an investigation in accordance with section III, E of this appendix.

D. The land disposal facility operator shall:

1. Acknowledge receipt of the waste within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation to the shipper. The shipper to be notified is the licensee who last possessed the waste and transferred the waste to the operator. The returned copy of the manifest or equivalent documentation shall indicate any discrepancies between materials listed on the manifest and materials received;

2. Maintain copies of all completed manifests or equivalent documentation until the license is terminated; and

3. Notify the shipper (i.e., the generator, the collector, or processor) and the Administrator of the nearest Commission Regional Office listed in appendix D to this part when any shipment or part of a shipment has not arrived within 60 days after the advance manifest was received.

E. Any shipment or part of a shipment for which acknowledgment is not received within the times set forth in this section must:

1. Be investigated by the shipper if the shipper has not received notification or receipt within 20 days after transfer; and
2. Be traced and reported. The investigation shall include tracing the shipment and filing a report with the nearest Commission Regional Office listed in appendix D to this part. Each licensee who conducts a trace investigation shall file a written report with the appropriate NRC Regional Office within 2 weeks of completion of the investigation.

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UNITED STATES NUCLEAR REGULATORY COMMISSION
RULES and REGULATIONS

TITLE 10, CHAPTER 1, CODE OF FEDERAL REGULATIONS — ENERGY

21.1

21.3(a)

**PART
21**

REPORTING OF DEFECTS AND NONCOMPLIANCE

GENERAL PROVISIONS

- Sec.
21.1 Purpose.
21.2 Scope.
21.3 Definitions.
21.4 Interpretations.
21.5 Communications.
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Authority: Sec. 161, 68 Stat. 946, as amended, sec. 234, 63 Stat. 444, as amended [42 U.S.C. 2201, 2262]; secs. 201, as amended, 206, 68 Stat. 1242, as amended 1246 [42 U.S.C. 5641, 5646].

Section 21.2 also issued under secs. 135, 141, Pub. L. 97-425, 90 Stat. 2232, 2241 [42 U.S.C. 10155, 10161].

GENERAL PROVISIONS

§ 21.1 Purpose.

The regulations in this part establish procedures and requirements for implementation of section 206 of the Energy Reorganization Act of 1974. That section requires any individual director or responsible officer of a firm constructing, owning, operating or supplying the components of any facility or activity which is licensed or otherwise regulated pursuant to the Atomic Energy Act of 1954, as amended, or the Energy Reorganization Act of 1974, who obtains information reasonably indicating: (a) That the facility, activity or basic component supplied to such facility or activity fails to comply with the Atomic Energy Act of 1954, as amended, or any applicable rule, regulation, order, or license of the Commission relating to substantial

safety hazards or (b) that the facility, activity, or basic component supplied to such facility or activity contains defects, which could create a substantial safety hazard, to immediately notify the Commission of such failure to comply or such defect, unless he has actual knowledge that the Commission has been adequately informed of such defect or failure to comply.

§ 21.2 Scope.

(a) The regulations in this part apply, except as specifically provided otherwise in parts 31, 34, 35, 39, 40, 60, 61, 70, or part 72 of this chapter, to each individual, partnership, corporation, or other entity licensed pursuant to the regulations in this chapter to possess, use, or transfer within the United States source material, byproduct material, special nuclear material, and/or spent fuel and high level radioactive waste, or to construct, manufacture, possess, own, operate or transfer within the United States, any production or utilization facility or independent spent fuel storage installation (ISFSI) or monitored retrievable storage installation (MRS); and to each director and responsible officer of such a licensee. The regulations in this part apply also to each individual, corporation, partnership or other entity doing business within the United States, and each director and responsible officer of such organization, that constructs a production or utilization facility licensed for manufacture, construction, or operation pursuant to part 50 of this chapter, an ISFSI for the storage of spent fuel licensed pursuant to part 72 of this chapter, a MRS for the storage of spent fuel or high level radioactive waste pursuant to part 72 of this chapter, or a geologic repository for the disposal of high-level radioactive waste under part 60 of this chapter; or supplies basic components for a facility or activity licensed, other than for export, under parts 30, 40, 50, 60, 61, 70, 71, or part 72 of this chapter.

(b) For persons licensed to construct a facility under a construction permit issued under § 50.23 of this chapter, evaluation of potential defects and failures to comply and reporting of defects and failures to comply under § 50.55(e) of this chapter satisfies each person's evaluation, notification, and reporting obligation to report defects

and failures to comply under this part and the responsibility of individual directors and responsible officers of such licensees to report defects under section 206 of the Energy Reorganization Act of 1974.

(c) For persons licensed to operate a nuclear power plant under part 50 of this chapter, evaluation of potential defects and appropriate reporting of defects under §§ 50.72, 50.73 or § 73.71 of this chapter satisfies each person's evaluation, notification, and reporting obligation to report defects under this part and the responsibility of individual directors and responsible officers of such licensees to report defects under section 206 of the Energy Reorganization Act of 1974.

(d) Nothing in these regulations should be deemed to preclude either an individual, a manufacturer, or a supplier of a commercial grade item (see § 21.3(a-1)) not subject to the regulations in this part from reporting to the Commission, a known or suspected defect or failure to comply and, as authorized by law, the identity of anyone so reporting will be withheld from disclosure. NRC regional offices and headquarters will accept collect telephone calls from individuals who wish to speak to NRC representatives concerning nuclear safety-related problems. The location and telephone numbers of the five regions (answered during regular working hours), are listed in appendix D to part 20 of this chapter. The telephone number of the NRC Operations Center (answered 24 hours a day—including holidays) is (301) 951-0550.

§ 21.3 Definitions.

As used in this part:

(a)(1) "Basic component," when applied to nuclear power reactors means a plant structure, system, component or part thereof necessary to assure (i) the integrity of the reactor coolant pressure boundary, (ii) the capability to shut down the reactor and maintain it in a safe shutdown condition, or (iii) the capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to those referred to in § 100.11 of this chapter.

(2) "Basic component," when applied to other facilities and when applied to

other activities licensed pursuant to Parts 30, 40, 50, 60, 61, 70, 71, or 72 of this chapter, means a component, structure, system, or part thereof that is directly procured by the licensee of a facility or activity subject to the regulations in this part and in which a defect (see § 21.3(d)) or failure to comply with any applicable regulation in this chapter, order, or license issued by the Commission could create a substantial safety hazard (see § 21.3(k)).

(3) In all cases, *basic component* includes safety related design, analysis, inspection, testing, fabrication, replacement parts, or consulting services that are associated with the component hardware whether these services are performed by the component supplier or others.

(4) A commercial grade item is not a part of a basic component until after dedication (see § 21.3(o-3)).

(a-1) "Commercial grade item" means an item that is (1) not subject to design or specification requirements that are unique to facilities or activities licensed pursuant to Parts 30, 40, 50, 60, 61, 70, 71, or 72 of this chapter and (2) used in applications other than facilities or activities licensed pursuant to Parts 30, 40, 50, 60, 61, 70, 71, or 72 of this chapter and (3) to be ordered from the manufacturer/supplier on the basis of specifications set forth in the manufacturer's published product description (for example a catalog).

(b) "Commission" means the Nuclear Regulatory Commission or its duly authorized representatives.

(c) *Constructing or construction* means the analysis, design, manufacture, fabrication, placement, erection, installation, modification, inspection, or testing of a facility or activity which is subject to the regulations in this part and consulting services related to the facility or activity that are safety related.

(o-1) "Dedication" of a commercial grade item occurs after receipt when that item is designated for use as a basic component.

(d) "Defect" means:
(1) A deviation (see § 21.3(e)) in a basic component delivered to a purchaser for use in a facility or an activity subject to the regulations in this part if, on the basis of an evaluation (see § 21.3(g)), the deviation could create a substantial safety hazard; or

(2) The installation, use, or operation of a basic component containing a defect as defined in paragraph (d)(1) of this section; or

(3) A deviation in a portion of a facility subject to the construction permit or manufacturing licensing requirements of Part 50 of this chapter provided the deviation could, on the basis of an evaluation, create a substantial safety hazard and the portion of the facility containing the deviation has been offered to the purchaser for acceptance; or

(4) A condition or circumstance involving a basic component that could contribute to the exceeding of a safety limit, as defined in the technical specifications of a license for operation issued pursuant to Part 50 of this chapter.

(e) "Deviation" means a departure from the technical requirements included in a procurement document (see § 21.3(i)).

(f) "Director" means an individual, appointed or elected according to law, who is authorized to manage and direct the affairs of a corporation, partnership or other entity. In the case of an individual proprietorship, "director" means the individual.

(g) *Discovery* means the completion of the documentation first identifying the existence of a deviation or failure to comply potentially associated with a substantial safety hazard within the evaluation procedures discussed in § 21.21. (a).

(h) *Evaluation* means the process of determining whether a particular deviation could create a substantial hazard or determining whether a failure to comply is associated with a substantial safety hazard.

(i) *Notification* means the telephonic communication to the NRC Operations Center or written transmittal of information to the NRC Document Control Desk.

(j) *Operating or operation* means the operation of a facility or the conduct of a licensed activity which is subject to the regulations in this part and consulting services related to operations that are safety related.

(k) "Procurement document" means a contract that defines the requirements which facilities or basic components must meet in order to be considered acceptable by the purchaser.

(l) "Responsible officer" means the president, vice-president or other individual in the organization of a corporation, partnership, or other entity who is vested with executive authority over activities subject to this part.

(m) "Substantial safety hazard" means a loss of safety function to the extent that there is a major reduction in the degree of protection provided to public health and safety for any facility or activity licensed, other than for export, pursuant to Parts 30, 40, 50, 60, 61, 70, 71, or 72 of this chapter.

(n) "Supplying" or "supplies" means contractually responsible for a basic component used or to be used in a facility or activity which is subject to the regulations in this part.

§ 21.4 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

§ 21.5 Communications.

Except where otherwise specified in this part, all written communications and reports concerning the regulations in this part must be addressed to the Document Control Desk, U.S. Nuclear Regulatory Commission, Washington, DC 20555. In the case of a licensee, a copy must also be sent to the appropriate Regional Administrator at the address specified in appendix D to part 20 of this chapter.

§ 21.6 Posting requirements.

(a) Each individual, partnership, corporation or other entity subject to the regulations in this part, shall post current copies of the following documents in a conspicuous position on any premises, within the United States where the activities subject to this part are conducted (1) the regulations in this part, (2) Section 206 of the Energy Reorganization Act of 1974, and (3) procedures adopted pursuant to the regulations in this part.

(b) If posting of the regulations in this part or the procedures adopted pursuant to the regulations in this part is not practicable, the licensee or firm subject to the regulations in this part may, in addition to posting section 206, post a notice which describes the regulations/procedures, including the name of the individual to whom reports may be made, and states where they may be examined.

(c) The effective date of this section has been deferred until January 6, 1978.

§ 21.7 Exemptions.

The Commission may, upon application of any interested person or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not endanger life or property or the common defense and security and are otherwise in the public interest.

Suppliers of commercial grade items are exempt from the provisions of this part to the extent that they supply commercial grade items.

§ 21.8 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control number 3150-0035.

(b) The approved information collection requirements contained in this part appear in §§ 21.21 and 21.51.

NOTIFICATION

§ 21.21 Notification of failure to comply or existence of a defect and its evaluation.

(a) Each individual, corporation, partnership, or other entity subject to the regulations in this part must adopt appropriate procedures to—

(1) Evaluate deviations and failures to comply to identify defects and failures to comply associated with substantial safety hazards as soon as practicable, and, except as provided in paragraph (a)(2) of this section, in all cases within 60 days of discovery, in order to identify a reportable defect or failure to comply that could create a substantial safety hazard, were it to remain uncorrected, and

(2) Ensure that if an evaluation of an identified deviation or failure to comply potentially associated with a substantial safety hazard cannot be completed within 60 days from discovery of the deviation or failure to comply, an interim report is prepared and submitted to the Commission through a director or responsible officer or designated person as discussed in § 21.21(c)(5). The interim report should describe the deviation or failure to comply that is being evaluated and should also state when the evaluation will be completed. This interim report must be submitted in writing within 60 days of discovery of the deviation or failure to comply.

(3) Ensure that a director or responsible officer subject to the regulations of this part is informed as soon as practicable, and, in all cases, within the 5 working days after completion of the evaluation described in § 21.21(a)(1) or § 21.21(a)(2) if the construction or operation of a facility or activity, or a basic component supplied for such facility or activity—

(i) Fails to comply with the Atomic Energy Act of 1954, as amended, or any applicable rule, regulation, order, or license of the Commission relating to a substantial safety hazard, or

(ii) Contains a defect.

(b)(1) If the deviation or failure to comply is discovered by a supplier of basic components, or services associated with basic components, and the supplier determines that it does not have the capability to perform the evaluation to determine if a defect exists, then the supplier must inform the purchasers or affected licensees within five working days of this determination so that the purchasers or affected licensees may evaluate the deviation or failure to comply, pursuant to § 21.21(a).

(c)(1) A director or responsible officer subject to the regulations of this part or a person designated under § 21.21(c)(5) must notify the Commission when he or she obtains information reasonably indicating a failure to comply or a defect affecting—

(i) The construction or operation of a facility or an activity within the United States that is subject to the licensing requirements under parts 30, 40, 50, 60, 61, 70, 71, or 72 of this chapter and that is within his or her organization's responsibility; or

(ii) A basic component that is within his or her organization's responsibility and is supplied for a facility or an activity within the United States that is subject to the licensing requirements under parts 30, 40, 50, 60, 61, 70, 71, or 72 of this chapter.

(2) The notification to NRC of a failure to comply or of a defect under paragraph (c)(1) of this section and the evaluation of a failure to comply or a defect under paragraphs (a)(1) and (a)(2) of this section, are not required if the director or responsible officer has actual knowledge that the Commission has been notified in writing of the defect or the failure to comply.

(3) Notification required by paragraph (c)(1) of this section must be made as follows—

(i) Initial notification by facsimile, which is the preferred method of notification, to the NRC Operations Center at 301-492-8187 or by telephone at 301-851-0550 within two days following receipt of information by the director or responsible corporate officer under paragraph (a)(1) of this section, on the identification of a defect or a failure to comply. Verification that the facsimile

has been received should be made by calling the NRC Operations Center. This paragraph does not apply to interim reports described in § 21.21(a)(2).

(ii) Written notification to the NRC at the address specified in § 21.5 within 30 days following receipt of information by the director or responsible corporate officer under paragraph (a)(3) of this section, on the identification of a defect or a failure to comply.

(4) The written report required by this paragraph shall include, but need not be limited to, the following information, to the extent known:

(i) Name and address of the individual or individuals informing the Commission.

(ii) Identification of the facility, the activity, or the basic component supplied for such facility or such activity within the United States which fails to comply or contains a defect.

(iii) Identification of the firm constructing the facility or supplying the basic component which fails to comply or contains a defect.

(iv) Nature of the defect or failure to comply and the safety hazard which is created or could be created by such defect or failure to comply.

(v) The date on which the information of such defect or failure to comply was obtained.

(vi) In the case of a basic component which contains a defect or fails to comply, the number and location of all such components in use at, supplied for, or being supplied for one or more facilities or activities subject to the regulations in this part.

(vii) The corrective action which has been, is being, or will be taken; the name of the individual or organization responsible for the action; and the length of time that has been or will be taken to complete the action.

(viii) Any advice related to the defect or failure to comply about the facility, activity, or basic component that has been, is being, or will be given to purchasers or licensees.

(5) The director or responsible officer may authorize an individual to provide the notification required by this paragraph, provided that, this shall not relieve the director or responsible officer of his or her responsibility under this paragraph.

(d) Individuals subject to this part may be required by the Commission to supply additional information related to a defect or failure to comply. Commission action to obtain additional information may be based on reports of defects from other reporting entities.

PROCUREMENT DOCUMENTS

21.1 Procurement documents.

Each individual, corporation, partnership or other entity subject to the regulations in this part shall assure that each procurement document for a facility, or a basic component issued by him, her or it on or after January 6, 1978 specifies, when applicable, that the provisions of 10 CFR Part 21 apply.

INSPECTIONS, RECORDS

21.41 Inspections.

Each individual, corporation, partnership or other entity subject to the regulations in this part shall permit duly authorized representatives of the Commission, to inspect its records, premises, activities, and basic components as necessary to effectuate the purposes of this part.

21.51 Maintenance and inspection of records.

(a) Each individual, corporation, partnership, or other entity subject to the regulations in this part must prepare and maintain records necessary to accomplish the purposes of this part, specifically—

(1) Retain evaluations of all deviations and failures to comply for a minimum of five years after the date of the evaluation;

(2) Suppliers of basic components must retain any notifications sent to purchasers and affected licensees for a minimum of five years after the date of the notification.

(3) Suppliers of basic components must retain a record of the purchasers of basic components for 10 years after delivery of the basic component or service associated with a basic component.

(b) Each individual, corporation, partnership, or other entity subject to the regulations in this part must afford the Commission, at all reasonable times, the opportunity to inspect records pertaining to basic components that relate to the discovery, evaluation, and reporting of deviations, failures to comply and defects, including any advice given to purchasers or licensees on the placement, erection, installation, operation, maintenance, modification, or inspection of a basic component.

ENFORCEMENT

21.61 Failure to notify.

Any director or responsible officer subject to the regulations in this part who knowingly and consciously fails to provide the notice required by § 21.21 shall be subject to a civil penalty equal to the amount provided by section 234 of the Atomic Energy Act of 1954, as amended.

[Note removed 49 FR 19623]

21.62 Criminal penalties.

(a) Section 223 of the Atomic Energy Act of 1954, as amended, provides for criminal sanctions for willful violation of, attempted violation of, or conspiracy to violate, any regulation issued under sections 161b, 161i, or 161o of the Act. For purposes of section 223, all the regulations in part 21 are issued under one or more of sections 161b, 161i, or 161o, except for the sections listed in paragraph (b) of this section.

(b) The regulations in part 21 that are not issued under sections 161b, 161i, or 161o for the purposes of section 223 are as follows: §§ 21.1, 21.2, 21.3, 21.4, 21.5, 21.7, 21.8, 21.61, and 21.62.

11 FEB 1981

56 FR 35081

48 FR 1322

57 FR 55062

UNITED STATES NUCLEAR REGULATORY COMMISSION
RULES and REGULATIONS

TITLE 10, CHAPTER 1, CODE OF FEDERAL REGULATIONS—ENERGY

34.1

34.8(a)

**PART
34**

**LICENSES FOR RADIOGRAPHY AND RADIATION SAFETY
REQUIREMENTS FOR RADIOGRAPHIC OPERATIONS**

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APPENDIX A

Authority: Secs. 81, 161, 162, 163, 86 Stat. 835, 846, 853, 854, as amended (42 U.S.C. 2111, 2201, 2232, 2233); sec. 201, 86 Stat. 1242, as amended (42 U.S.C. 5641).
Section 34.32 also issued under sec. 206, 86 Stat. 1246 (42 U.S.C. 5646).

§ 34.1 Purpose and scope.

This part prescribes requirements for the issuance of licenses for the use of sealed sources containing byproduct material and radiation safety requirements for persons using such sealed sources in radiography. The provisions and requirements of this part are in addition to, and not in substitution for, other requirements of this chapter. In particular, the provisions of Part 30 of this chapter apply to applications and licenses subject to this part. Nothing in this part shall apply to uses of byproduct material for medical diagnosis or therapy.

§ 34.2 Definitions.

As used in this part:

"Permanent radiographic installation" means a shielded installation or structure designed or intended for radiography and in which radiography is regularly performed.

"Radiographer" means any individual who performs or who, in attendance at the site where the sealed source or sources are being used, personally supervises radiographic operations and who is responsible to the licensee for assuring compliance with the requirements of the Commission's regulations and the conditions of the license;

"Radiographer's assistant" means any individual who, under the personal supervision of a radiographer, uses radiographic exposure devices, sealed sources or related handling tools, or radiation survey instruments in radiography;

"Radiographic exposure device" means 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;

"Radiography" means the examination of the structure of materials by nondestructive methods, utilizing sealed sources of byproduct materials;

"Sealed source" means any byproduct material that is encased in a

capsule designed to prevent leakage or escape of the byproduct material;

"Source changer" means 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;

"Storage area" means 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" means a device in which sealed sources are transported or stored.

§ 34.3 Applications for specific licenses.

A person may file an application for specific license for use of sealed sources in radiography in duplicate on NRC Form 313, "Application for Material License," in accordance with the provisions of § 30.32 of this chapter.

§ 34.4 Maintenance of records.

Each record required by this part must be legible throughout the retention period specified by each Commission regulation. The record may be the original or a reproduced copy of 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, 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.

§ 34.8 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et

seq.). OMB has approved the information collection requirements contained in this part under control number 3150-0007.

(b) The approved information collection requirements contained in this part appear in §§ 34.31, 34.34, 34.35, 34.36, 34.37, 34.38, 34.39, 34.31, 34.32, 34.33, and 34.43.

(c) This part contains information collection requirements in addition to those approved under the control number specified in paragraph (a) of this section. These information collection requirements and the control numbers under which they are approved are as follows:

(1) In § 34.3, Form NRC-313R is approved under control number 3150-0023.

Subpart A--Specific Licensing Requirements

§ 34.11 Issuance of specific licenses for use of sealed sources in radiography.

An application for a specific license for use of sealed sources in radiography will be approved if:

(a) The applicant satisfies the general requirements specified in § 30.33 of this chapter;

(b) The applicant will have an adequate program for training radiographers and radiographers' assistants and submits to the Commission a schedule or description of such program which specifies the:

- (1) Initial training;
(2) Periodic training;
(3) On-the-job training;

(4) Means to be used by the licensee to determine the radiographer's knowledge and understanding of and ability to comply with Commission regulations and licensing requirements, and the operating and emergency procedures of the applicant; and

(5) In lieu of describing its initial training program for radiographers in the subjects outlined in appendix A of this part, and the description of and the means used to determine the radiographer's knowledge and understanding of these subjects, the applicant affirms that all individuals acting as radiographers will be certified in radiation safety through the Certification Program for Industrial Radiography Radiation Safety Personnel of the American Society for Nondestructive Testing, Inc. (ASNT-IRRSP) prior to commencing duties as radiographers. From April 16, 1991, to the date of the renewal of an existing license, an approved license application is deemed to include the option, for individuals who are certified in

radiation safety through the ASNT-IRRSP, to substitute ANST-IRRSP certification in lieu of the described means to determine a radiographer's knowledge and understanding of the subjects in § 34.31(a)(1). (This paragraph does not affect the licensee's responsibility to assure that radiographers are properly trained in accordance with § 34.31(a)).

(6) Means to be used by the licensee to determine the radiographer's assistant's knowledge and understanding of and ability to comply with the operating and emergency procedures of the applicant;

(c) The applicant has established and submits to the Commission satisfactory written operating and emergency procedures as described in § 34.32;

(d) The applicant has established and submits to the Commission a description of its inspection program adequate to ensure that its radiographers and radiographers' assistants follow the Commission's regulatory requirements and the applicant's operating and emergency procedures. The inspection program must:

- (1) Include observation of the performance of each radiographer and radiographer's assistant during an actual radiographic operation at intervals not to exceed three months;
(2) Provide that, if a radiographer or a radiographer's assistant has not participated in a radiographic operation for more than three months since the last inspection, that individual's performance must be observed and recorded the next time the individual participates in a radiographic operation; and
(3) Include the retention of inspection records on the performance of radiographers or radiographers' assistants for three years.

(e) The applicant submits a description of its over-all organizational structure pertaining to the radiography program, including specified delegations of authority and responsibility for operation of the program; and

(f) The applicant who desires to conduct his own leak tests has established adequate procedures to be followed in leak testing sealed sources, for possible leakage and contamination and submits to the Commission a description of such procedures including:

- (1) Instrumentation to be used,
(2) Method of performing test, e.g., points on equipment to be smeared and method of taking smear, and
(3) Pertinent experience of the person who will perform the test.

Subpart B--Radiation Safety Requirements

EQUIPMENT CONTROL

§ 34.20 Performance requirements for radiography equipment.

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

(a) Each radiographic exposure device and all associated equipment must meet the requirements specified in American National Standard N432-1980 "Radiological Safety for the Design and Construction of Apparatus for Gamma Radiography," (published as NBS Handbook 136, issued January 1981). This publication has been approved for incorporation by reference by the Director of the Federal Register in accordance with 5 U.S.C. 552(a). This publication may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 and from the American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018. Telephone (212) 642-4900. Copies of the document are available for inspection at the NRC Library, 7920 Norfolk Avenue, Bethesda, Maryland 20814. A copy of the document is also on file at the Office of the Federal Register, 1100 L Street NW., Room 8301, Washington, DC 20406.

(b) In addition to the requirements specified in paragraph (a) of this section, the following requirements apply to radiographic exposure devices and associated equipment.

(1) Each radiographic exposure device must have 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 and serial number of the sealed source;
(iv) Manufacturer of the sealed source; and
(v) Licensee's name, address, and telephone number.

(2) Radiographic exposure devices intended for use as Type B transport containers must meet the applicable requirements of 10 CFR part 71.

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

55 FR 843

57 FR 61765

55 FR 843

55 FR 11504

55 FR 11504

55 FR 11504

55 FR 11504

(c) In addition to the requirements specified in paragraphs (a) and (b) of this section, the following requirements apply to radiographic exposure devices and associated equipment that allow the source to be moved out of the device for routine operation.

(1) 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.

(2) 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.

(3) 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.

(4) Each sealed source or source assembly must have attached to it or engraved in 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.

(5) The guide tube must have passed the crushing tests for the control tube as specified in ANSI N432 and a kinking resistance test that closely approximates the kinking forces likely to be encountered during use.

(6) Guide tubes must be used when moving the source out of the device.

(7) 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 radiographic operations.

(8) The guide tube exposure head connection must be able to withstand the tensile test for control units specified in ANSI N432.

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

(d) All newly manufactured radiographic exposure devices and associated equipment acquired by licensees after January 10, 1992 must comply with the requirements of this section.

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

§ 34.21 Limits on levels of radiation for radiographic exposure devices and storage containers.

(a) Radiographic exposure devices measuring less than four (4) inches from the sealed source storage position to any exterior surface of the device shall have no radiation level in excess of 50 milliroentgens per hour at six (6) inches from any exterior surface of the device. Radiographic exposure devices measuring a minimum of four (4) inches from the sealed source storage position to any exterior surface of the device, and all storage containers for sealed sources or for radiographic exposure devices, shall have no radiation level in excess of 200 milliroentgens per hour at any exterior surface, and ten (10) milliroentgens per hour at one meter from any exterior surface. The radiation levels specified are with the sealed source in the shielded (i.e., "off") position.

(b) Paragraph (a) of this section applies to all equipment manufactured prior to January 10, 1992. After January 10, 1992, radiographic equipment other than storage containers and source changers must meet the requirements of § 34.20, and § 34.21 applies only to storage containers (source changers).

§ 34.22 Locking of radiographic exposure devices, storage containers, and source changers.

(a) Each radiographic exposure device shall 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 or its container shall be kept locked when not under the direct surveillance of a radiographer or a radiographer's assistant or as otherwise may be authorized in § 34.61. In addition, during radiographic operations the sealed source assembly shall be secured in the shielded position each time the source is returned to that position.

(b) Each sealed source storage container and source changer shall 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 shall be kept locked when containing sealed sources except when under the direct surveillance of a radiographer or a radiographer's assistant.

§ 34.23 Storage precautions.

Locked radiographic exposure devices and storage containers shall be physically secured to prevent tampering or removal by unauthorized personnel.

§ 34.24 Radiation survey instruments.

The licensee shall maintain sufficient calibrated and operable radiation survey instruments to make physical radiation surveys as required by this part and Part 20 of this chapter.

Each radiation survey instrument shall be calibrated at intervals not to exceed three months and after each instrument servicing and a record shall be maintained of the results of each instrument calibration and date thereof for three years after the date of calibration.

Instrumentation required by this section shall have a range such that two milliroentgens per hour through one roentgen per hour can be measured.

§ 34.25 Leak testing, repair, tagging, opening, modification and replacement of sealed sources.

(a) The replacement of any sealed source fastened to or contained in a radiographic exposure device and leak testing, repair, tagging, opening or any other modification of any sealed source shall be performed only by persons specifically authorized by the Commission to do so.

(b) Each sealed source shall be tested for leakage at intervals not to exceed 6 months. In the absence of a certificate from a transferor that a test has been made within the 6 months prior to the transfer, the sealed source shall not be put into use until tested.

The leak test must be capable of detecting the presence of 0.005 microcurie of removable contamination on the sealed source. An acceptable leak test for sealed sources in the possession of a radiography licensee would be to test at the nearest accessible point to the sealed-source storage position, or other appropriate measuring point, by a procedure to be approved pursuant to § 34.13(f). Each record of leak test results must be kept in units of microcuries [or disintegrations per minute (dpm)] and retained for inspection by the Commission for three years after it is made.

(d) Any test conducted pursuant to paragraphs (b) and (c) of this section which reveals the presence of 0.005 microcurie or more of removable radioactive material shall 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 to be disposed of, in accordance with Commission regulations. A report shall be filed, within 5 days of the test, with the Director of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D. C. 20555, describing the equipment involved, the test results, and the corrective action taken. A copy of such report shall be sent to the Administrator of the appropriate Nuclear Regulatory Commission's Regional Office listed in Appendix D of Part 20 of this chapter "Standards for Protection Against Radiation."

(e) A sealed source which is not fastened to or contained in a radiographic exposure device shall have permanently attached to it a durable tag at least one (1) inch square bearing the prescribed radiation caution symbol in conventional colors, magenta or purple on a yellow background, and at least the instructions: "Danger-Radioactive Material-Do Not Handle-Notify Civil Authorities if Found."

§ 34.26 Quarterly inventory.

Each licensee shall conduct a quarterly physical inventory to account for all sealed sources received and possessed under his license. The records of the inventories shall be maintained for three years from the date of the inventory for inspection by the Commission, and shall include the quantities and kinds of by-product material, location of sealed sources, and the date of the inventory.

§ 34.27 Utilization logs.

Each licensee shall maintain current logs, which shall be kept available for three years from the date of the recorded event, for inspection by the Commission, at the address specified in the license, showing for each sealed source the following information:

- (a) A description (or make and model number) of the radiographic exposure device or storage container in which the sealed source is located;
- (b) The identity of the radiographer to whom assigned; and
- (c) The plant or site where used and dates of use.

§ 34.28 Inspection and maintenance of radiographic exposure devices, storage containers, and source changers.

(a) The licensee shall check for obvious defects in radiographic exposure devices, storage containers, and source changers prior to use each day the equipment is used.

(b) The licensee shall conduct a program for inspection and maintenance of radiographic exposure devices, storage containers, and source changers at intervals not to exceed three months or prior to the first use thereafter to ensure proper functioning of components important to safety. The licensee shall retain records of these inspections and maintenance for three years.

§ 34.29 Permanent radiographic installations.

(a) Permanent radiographic installations having high radiation area entrance controls of the types described in § 20.203(c) (2)(ii), (2)(iii), or (4) or, for licensees implementing the provisions of § 20.1001-20.2401, § 20.1001 (a)(2), (a)(3), or (b) shall also meet the following special requirement.

(b) Each entrance that is used for personnel access to the high radiation area in a permanent radiographic installation to which this section applies shall have both visible and audible warning signals to warn of the presence of radiation. The visible signal shall be actuated by radiation whenever the source is exposed. The audible signal shall be actuated when an attempt is made to enter the installation while the source is exposed.

(c) The alarm system must be tested at intervals not to exceed three months or prior to the first use thereafter of the source in the installation. The licensee shall retain records of these tests for three years.

34.25(c) 34.26 34.27 34.28 34.29

34.25(c) 34.26 34.27 34.28 34.29

34.25(c) 34.26 34.27 34.28 34.29

Reporting

§ 34.30 Reporting requirements.

(a) In addition to the reporting requirements specified in § 30.50 and under other sections of this chapter, each licensee shall provide a written report to the U.S. Nuclear Regulatory Commission; Division of Industrial and Medical Nuclear Safety; Medical, Academic and Commercial Use Safety Branch; Washington, DC 20555, with a copy to the Director, Office for Analysis and Evaluation of Operational Data, U.S. Nuclear Regulatory Commission, Washington, DC 20555, within 30 days of the occurrence of any of the following incidents involving radiographic equipment:

- (1) Unintentional disconnection of the source assembly from the control cable.
- (2) Inability to retract the source assembly to its fully shielded position and secure it in this position.
- (3) Failure of any component (critical to safe operation of the device) to properly perform its intended function.

(b) The licensee shall include the following information in each report submitted under paragraph (a) of this section:

- (1) A description of the equipment problem.
- (2) Cause of each incident, if known.
- (3) Manufacturer and model number of equipment involved in the incident.
- (4) Place, time and date of the incident.
- (5) Actions taken to establish normal operations.
- (6) Corrective actions taken or planned to prevent recurrence.
- (7) Qualifications of personnel involved in the incident.

(c) Reports of overexposure submitted under 10 CFR 20.405 which involve failure of safety components of radiography equipment must also include the information specified in paragraph (b) of this section.

58 FR 40757

55 FR 843

PERSONAL RADIATION SAFETY REQUIREMENTS FOR RADIOGRAPHERS AND RADIOGRAPHERS' ASSISTANTS

§ 34.31 Training.

(a) The licensee shall not permit any individual to act as a radiographer until such individual:

- (1) Has been instructed in the subjects outlined in Appendix A of this part;
- (2) Has received copies of and instruction in NRC regulations contained in this part and in the applicable sections of Parts 19 and 20 of this chapter, NRC license(s) under which the radiographer will perform radiography, and the licensee's operating and emergency procedures;
- (3) Has demonstrated competence to use the licensee's radiographic exposure devices, sealed sources, related handling tools, and survey instruments; and
- (4) Has demonstrated understanding of the instructions in this paragraph (a) by successful completion of a written test and a field examination on the subjects covered.

(b) The licensee shall not permit any individual to act as a radiographer's assistant until such individual:

- (1) Has received copies of and instruction in the licensee's operating and emergency procedures;
- (2) Has demonstrated competence to use, under the personal supervision of the radiographer, the radiographic exposure devices, sealed sources, related handling tools, and radiation survey instruments that the assistant will use; and
- (3) Has demonstrated understanding of the instructions in this paragraph (b) by successfully completing a written or oral test and a field examination on the subjects covered.

(c) Records of the above training, including copies of written tests and dates of oral tests and field examinations, shall be maintained for three years.

41 FR 5095

§ 34.32 Operating and emergency procedures.

The licensee shall retain a copy of current operating and emergency procedures as a record until the Commission terminates the license that authorizes the activity for which the procedures were developed and, if superseded, retain the superseded material for three years after each change. These procedures must include instructions in at least the following:

- (a) The handling and use of licensed sealed sources and radiographic exposure devices to be employed such that no person is likely to be exposed to radiation doses in excess of the limits established in Part 20 of this chapter "Standards for Protection Against Radiation";
- (b) Methods and occasions for conducting radiation surveys;
- (c) Methods for controlling access to radiographic areas;
- (d) Methods and occasions for locking and securing radiographic exposure devices, 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, posting of vehicles and control of the sealed sources during transportation;
- (g) Minimizing exposure of persons in the event of an accident;
- (h) The procedure for notifying proper persons in the event of an accident; and
- (i) Maintenance of records.

58 FR 1890

41 FR 1895

50 FR 5185

PART 34 • LICENSES FOR RADIOGRAPHY AND RADIATION SAFETY--

The inspection and maintenance of radiographic exposure devices and containers.

(k) Steps that must be taken immediately by radiography personnel in the event a pocket dosimeter is found to be off-scale.

(l) The procedure(s) for identifying and reporting defects and noncompliance, as required by Part 21 of this chapter.

§ 34.33 Personnel monitoring.

(a) The licensee may not permit any individual to act as a radiographer or a radiographer's assistant unless, at all times during radiographic operations, each such individual wears a direct reading pocket dosimeter, an alarm ratemeter, and either a film badge or a thermoluminescent dosimeter (TLD) except that for permanent radiography facilities where other appropriate alarming or warning devices are in routine use, the wearing of an alarming ratemeter is not required. Pocket dosimeters must have a range from zero to at least 200 milliroentgens and must be recharged at the start of each shift. Each film badge and TLD must be assigned to and worn by only one individual.

(b) Pocket dosimeters must be read and exposures recorded daily. The licensee shall retain each record of these exposures for three years after the record is made.

(c) Pocket dosimeters shall be checked at periods not to exceed one year for correct response to radiation. Acceptable dosimeters shall read within plus or minus 30 percent of the true radiation exposure.

(d) If an individual's pocket dosimeter is discharged beyond its range, his film badge or TLD shall be immediately sent for processing.

(e) Reports received from the film badge or TLD processor must be retained for inspection until the Commission terminates each license that authorizes the activity that is subject to the recordkeeping requirement.

- (f) Each alarm ratemeter must—
(1) Be checked to ensure that the alarm functions properly (sounds) prior to use at the start of each shift;
(2) Be set to give an alarm signal at a preset dose rate of 500 mR/hr.;
(3) Require special means to change the preset alarm function; and

(4) Be calibrated at periods not to exceed one year for correct response to radiation: Acceptable ratemeters must alarm within plus or minus 20 percent of the true radiation dose rate.

PRECAUTIONARY PROCEDURES IN RADIOGRAPHIC OPERATIONS

§ 34.41 Security.

During each radiographic operation the radiographer or radiographer's assistant shall maintain a direct surveillance of the operation to protect against unauthorized entry into a high radiation area, as defined in Part 20 of this chapter, except (a) where the high radiation area is equipped with a control device or an alarm system as described in § 20.203(c)(2) or, for licensees implementing the provisions of §§ 20.1001-20.2401, § 20.1501 (a)(1), (a)(2), or (a)(3) of this chapter, or (b) where the high radiation area is locked to protect against unauthorized or accidental entry.

§ 34.42 Posting.
Notwithstanding any provisions in § 20.204(c) or, for licensees implementing the provisions of §§ 20.1001-20.2401, § 20.1903 of this chapter, areas in which radiography is being performed shall be conspicuously posted as required by § 20.203 (b) and (c)(1) or, for licensees implementing the provisions of §§ 20.1001-20.2401, § 20.1902 (a) and (b) of this chapter.

§ 34.43 Radiation surveys.
The licensee shall ensure that:
(a) At least one calibrated and operable radiation survey instrument is available at the location of its radiographic operations whenever radiographic operations are being performed, and at the storage area, as defined in § 34.2, whenever a radiographic exposure device, a storage container, or source is being placed in storage.
(b) A survey with a calibrated and operable radiation survey instrument is made after each exposure to determine that the sealed source has been returned to its shielded position. The entire circumference of the radiographic exposure device must be surveyed. If the radiographic exposure device has a source guide tube, the survey must include the guide tube.
(c) A survey with a calibrated and operable radiation survey instrument is made at any time a radiographic exposure device is placed in a storage area, as defined in § 34.2, to determine that the sealed source is in its shielded position. The entire circumference of the radiographic exposure device must be surveyed.
(d) A record of the storage survey required in paragraph (c) is made and is retained for three years when that storage survey is the last one performed in the work day.

§ 34.44 Supervision of radiographers' assistants.

Whenever a radiographer's assistant uses radiographic exposure devices, uses sealed sources or related source handling tools, or conducts radiation surveys required by § 34.43(b) to determine that the sealed source has returned to the shielded position after an exposure, he shall be under the personal supervision of a radiographer. The personal supervision shall include: (a) The radiographer's personal presence at the site where the sealed sources are being used, (b) the ability of the radiographer to give immediate assistance if required, and (c) the radiographer's watching the assistant's performance of the operations referred to in this section.

EXEMPTIONS

§ 34.51 Applications for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

VIOLATIONS

§ 34.61 Violations.

- (a) The Commission may obtain an injunction or other court order to prevent a violation of the provisions of—
(1) The Atomic Energy Act of 1954, as amended;
(2) Title II of the Energy Reorganization Act of 1974, as amended; or
(3) A regulation or order issued pursuant to those Acts.
(b) The Commission may obtain a court order for the payment of a civil penalty imposed under section 234 of the Atomic Energy Act:
(1) For violations of—
(i) Sections 53, 57, 62, 63, 61, 62, 101, 103, 104, 107, or 109 of the Atomic Energy Act of 1954, as amended;
(ii) Section 206 of the Energy Reorganization Act;
(iii) Any rule, regulation, or order issued pursuant to the sections specified in paragraph (b)(1)(i) of this section;
(iv) Any term, condition, or limitation of any license issued under the sections specified in paragraph (b)(1)(i) of this section.
(2) For any violation for which a license may be revoked under Section 106 of the Atomic Energy Act of 1954, as amended.

§ 34.83 Criminal penalties.

(a) Section 223 of the Atomic Energy Act of 1954, as amended, provides for criminal sanctions for willful violation of, attempted violation of, or conspiracy to violate, any regulation issued under sections 181b, 181l, or 181o of the Act. For purposes of section 223, all the regulations in part 34 are issued under one or more of sections 181b, 181l, or 181o, except for the sections listed in paragraph (b) of this section.

(b) The regulations in part 34 that are not issued under sections 181b, 181l, or 181o for the purposes of section 223 are as follows: §§ 34.1, 34.2, 34.3, 34.8, 34.11, 34.51, 34.61, and 34.83.

APPENDIX A

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[Note removed 49 FR 19673]

UNITED STATES NUCLEAR REGULATORY COMMISSION
RULES and REGULATIONS
 TITLE 10, CHAPTER 1, CODE OF FEDERAL REGULATIONS—ENERGY

71.0

71.0(c)

**PART
71**

PACKAGING AND TRANSPORTATION OF RADIOACTIVE MATERIAL

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Appendix A—Determination of A₁ and A₂

Authority: Secs. 53, 57, 62, 83, 81, 161, 162, 183, 86 Stat. 930, 932, 933, 935, 948, 953, 954, as amended (42 U.S.C. 2073, 2077, 2092, 2093, 2111, 2201, 2232, 2233); secs. 201, as amended, 202, 206, 88 Stat. 1242, as amended, 1244, 1246 (42 U.S.C. 5841, 5842, 5846).
 Section 71.97 also issued under sec. 301, Pub. L. 96-285, 94 Stat. 789-790.

Subpart A—General Provisions

§ 71.0 Purpose and scope.

(a) This part establishes: (1) requirements for packaging, preparation for shipment, and transportation of licensed material; and (2) procedures and standards for NRC approval of packaging and shipping procedures for fissile material and for a quantity of other licensed material in excess of a Type A quantity.

(b) The packaging and transport of licensed material are also subject to other parts of this chapter (e.g., Parts 20, 21, 30, 39, 40, 70, and 73) and to the regulations of other agencies (e.g., the U.S. Department of Transportation (DOT) and the U.S. Postal Service (USPS)) having jurisdiction over means of transport. The requirements of this part are in addition to, and not in substitution for, other requirements.

(c) The regulations in this part apply to any certificate holder and to any licensee authorized by specific license issued by the Commission to receive, possess, use, or transfer licensed material if the licensee or certificate holder delivers that material to a common or contract carrier for transport or transports the material outside the confines of the licensee's or certificate holder's facility, plant, or other authorized place of use. No provision of this part authorizes possession of licensed material.

¹ Postal Service Manual (Domestic Mail Manual), section 114.3, which is incorporated by reference at 39 CFR 111.1 (1974).

(d) Exemptions from the requirement for license in § 71.3 are specified in § 71.10. General licenses for which no NRC package approval is required are issued in §§ 71.14-71.24. The general license in § 71.12 requires that an NRC certificate of compliance or other package approval be issued for the package to be used under the general license. Application for package approval must be completed in accordance with Subpart D of this part, demonstrating that the design of the package to be used satisfies the package approval standards contained in Subpart E of this part as related to the tests of Subpart F of this part. The transport of licensed material or delivery of licensed material to a carrier for transport is subject to the operating controls and procedures requirements of Subpart G of this part, to the quality assurance requirements of Subpart H of this part, and to the general provisions of Subpart A of this part, including DOT regulations referenced in § 71.5.

§ 71.1 Communications and records.

(a) All communications concerning the regulations in this part should be addressed to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555, or may be delivered in person at the Commission Office at 2120 L Street, NW, Washington, DC, or its Offices at 71555 Rockville Pike, Rockville, Maryland.

(b) Each record required by this part must be legible throughout the retention period specified by each Commission regulation. 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 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, 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.

§ 71.2 Interpretations.

Only written interpretations of the regulations in this part by the Commission's General Counsel are binding upon the Commission.

§ 71.3 Requirement for license.

A licensee subject to the regulations in this part may not (a) deliver any

licensed material to a carrier for transport or (b) transport licensed material except as authorized in a general license or a specific license issued by the Commission, or as exempted in this part.

§ 71.4 Definitions.

The following terms are as defined here for the purpose of this part. Throughout this part, the standards are expressed in metric units; the approximate English equivalents presented in parentheses are for information only.

A₁ means the maximum activity of special form radioactive material permitted in a Type A package. *A₂* means the maximum activity of radioactive material, other than special form radioactive material, permitted in a Type A package. These values are either listed in Appendix A of this part, Table A-1, or may be derived in accordance with the procedure prescribed in Appendix A of this part.

Carrier means 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 means a person who holds a certificate of compliance, or other package approval issued by the Commission.

Close reflection by water means immediate contact by water of sufficient thickness for maximum reflection of neutrons.

Containment system means the components of the packaging intended to retain the radioactive material during transport.

Conveyance means any vehicle, aircraft, vessel, freight container, or hold, compartment, or defined deck area of an inland waterway craft or seagoing vessel.

Exclusive use (also referred to in other regulations as "sole use" or "full load") means the sole use of a conveyance by a single consignor and for which all initial, intermediate, and final loading and unloading are carried out in accordance with the direction of the consignor or consignee.

Fissile classification means the categorization of fissile material packages into one of the following three classes according to the controls needed to provide nuclear criticality safety during transportation:

(1) *Fissile Class I*: A package which may be transported in unlimited numbers and in any arrangement, and which requires no nuclear criticality safety controls during transportation. A transport index is not assigned for purposes of nuclear criticality safety but may be required because of external radiation levels.

(2) *Fissile Class II*: A package which may be transported together with other packages in any arrangement but for criticality control, in numbers which do not exceed an aggregate transport index of 50. These shipments require no other nuclear criticality safety control during transportation. Individual packages may have a transport index not less than 0.1 and not more than 10.

(3) *Fissile Class III*: A shipment of packages which is controlled in transportation by specific arrangements between the shipper and the carrier to provide nuclear criticality safety.

Fissile material and fissile radionuclides: "Fissile material" means any material consisting of or containing one or more fissile radionuclides. Fissile radionuclides are plutonium-239, plutonium-241, uranium-233, and uranium-235. Neither natural nor depleted uranium is fissile material. Fissile materials are classified in this section according to the controls needed to provide nuclear criticality safety during transportation. Certain exclusions are provided in § 71.53.

Low specific activity material means any of the following:

- (1) Uranium or thorium ores and physical or chemical concentrates of those ores;
- (2) Unirradiated natural or depleted uranium or unirradiated natural thorium;

(3) Tritium oxide in aqueous solutions provided the concentration does not exceed 5.0 millicuries per milliliter;

(4) Material in which the radioactivity is essentially uniformly distributed and in which the estimated average concentration per gram of contents does not exceed:

- (i) 0.0001 millicurie of radionuclides for which the A_2 quantity in Appendix A of this part is not more than 0.06 curie;
- (ii) 0.005 millicurie of radionuclides for which the A_2 quantity in Appendix A of this part is more than 0.06 curie, but not more than 1 curie; or
- (iii) 0.3 millicurie of radionuclides for which the A_2 quantity in Appendix A of this part is more than 1 curie.

(5) Objects of nonradioactive material externally contaminated with radioactive material, provided that the radioactive material is not readily dispersible and the surface contamination, when averaged over an area of 1 square meter, does not exceed 0.0001 millicurie (220,000 disintegrations per minute) per square centimeter of radionuclides for which the A_2 quantity in Appendix A of Part 71 is not more than 0.05 curie, or 0.001 millicurie (2,200,000 disintegrations per minute) per square centimeter for other radionuclides.

Maximum normal operating pressure means the maximum gauge pressure that would develop in the containment system in a period of one year under the heat test specified in § 71.71(c)(1), in the absence of venting, external cooling by an ancillary system, or operational controls during transport.

Natural thorium means thorium with the naturally occurring distribution of thorium isotopes (essentially 100 weight percent thorium-232).

Normal form radioactive material means radioactive material which has not been demonstrated to qualify as "special form radioactive material."

Optimum interspersed hydrogenous moderation means the presence of hydrogenous material between packages to such an extent that the maximum nuclear reactivity results.

Package means the packaging together with its radioactive contents as presented for transport.

(1) **Fissile material package** means a fissile material packaging together with its fissile contents.

(2) **Type B package** means a Type B package 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/in²) gauge or a pressure relief device which would allow the release of radioactive material to the environment under the tests specified in § 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. 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 § 71.12.

Packaging means the assembly of components necessary to ensure compliance with the packaging requirements of this part. 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 designed as part of the packaging.

Special form radioactive material means radioactive material which 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 8 millimeters (0.197 inch); and
- (3) It satisfies the test requirements of § 71.75.

A special form encapsulation designed in accordance with the requirements of § 71.4(o) of this part in effect on June 30, 1983, and constructed prior to July 1, 1985, may continue to be used. A special form encapsulation either designed or constructed after June 30, 1983, must meet requirements of this paragraph

applicable at the time of its design or construction.

Specific activity of a radionuclide means 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.

State means the several States of the Union, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, the trust Territory of the Pacific Islands, and the Commonwealth of the Northern Mariana Islands.

Transport index means the dimensionless number (rounded up to the first decimal place) 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 determined as follows:

(1) The number expressing the maximum radiation level in millirem per hour at 1 meter from the external surface of the package; or

(2) For Fissile Class II packages, the number expressing the maximum radiation level in millirem per hour at 1 meter from the external surface of the package, or the number obtained by dividing 50 by the allowable number of the packages which may be transported together as determined under § 71.56, whichever number is larger.

Type A quantity means 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 Appendix A of this part or may be determined by procedures described in Appendix A of this part.

Type B quantity means a quantity of radioactive material greater than a Type A quantity.

Uranium—natural depleted enriched
(1) **Natural uranium** means uranium with the naturally occurring distribution of uranium isotopes (approximately 0.711 weight percent uranium-235, and the remainder essentially uranium-238).

(2) **Depleted uranium** means uranium containing less uranium-235 than the naturally occurring distribution of uranium isotopes.

(3) **Enriched uranium** means uranium containing more uranium-235 than the naturally occurring distribution of uranium isotopes.

§ 71.5 Transportation of licensed material.

(a) Each licensee who transports licensed material outside of the confines of its plant or other place of use, or who delivers licensed material to a carrier for transport, shall comply with the applicable requirements of the regulations appropriate to the mode of transport of DOT in 49 CFR Parts 170 through 189.

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(1) The licensee shall particularly note DOT regulations in the following areas:

- (i) Packaging—49 CFR Part 173, Subparts A and B and §§ 173.401-173.478.
- (ii) Marking and labeling—49 CFR Part 172, Subpart D and §§ 172.400-172.407; 172.436-172.440.
- (iii) Placarding—49 CFR Part 172.800-172.819, 172.836 and Appendices B and C.
- (iv) Monitoring—49 CFR Part 172, Subpart C.
- (v) Accident reporting—49 CFR Part 171.15 and 171.16.
- (vi) Shipping papers—49 CFR Part 172, Subpart C.

(2) The licensee shall also note DOT regulations pertaining to the following modes of transportation:

- (i) Rail—49 CFR Part 174, Subparts A-D and K.
- (ii) Air—49 CFR Part 178, Subparts A-D and M.
- (iii) Vessel—49 CFR Part 178, Subparts A-D and M.
- (iv) Public Highway—49 CFR Part 177.

(b) If DOT regulations are not applicable to a shipment of licensed material by rail, highway, or water because the shipment or the transportation of the shipment is not in interstate or foreign commerce, or to a shipment of licensed material by air because the shipment is not transported in civil aircraft, the licensee shall conform to the standards and requirements of the DOT specified in paragraph (a) of this section to the same extent as if the shipment or transportation were in interstate or foreign commerce or in civil aircraft. 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 Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

§ 71.6 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control number 3150-0008.

(b) The approved information collection requirements contained in this part appear in §§ 71.5, 71.12, 71.31, 71.33, 71.35, 71.37, 71.55, 71.57, 71.59, 71.61, 71.83, 71.85, 71.87, 71.101, 71.103, 71.105, 71.107, 71.109, 71.111, 71.113, 71.115, 71.117, 71.119, 71.121, 71.123, 71.125, 71.127, 71.129, 71.131, 71.133, 71.135, and 71.137.

§ 71.6a Completeness and accuracy of information.

(a) Information provided to the Commission by an applicant for a license or by a licensee or information required by statute or by the Commission's regulations, orders, or license conditions to be maintained by the applicant or the licensee shall be complete and accurate in all material respects.

(b) Each applicant or licensee shall notify the Commission of information identified by the applicant or licensee as having for the regulated activity a significant implication for public health and safety or common defense and security. An applicant or licensee violates this paragraph only if the applicant or licensee fails to notify the Commission of information that the applicant or licensee has identified as having a significant implication for public health and safety or common defense and security. Notification shall be provided to the Administrator of the appropriate Regional Office within two working days of identifying the information. This requirement is not applicable to information which is already required to be provided to the Commission by other reporting or updating requirements.

Subpart B—Exemptions

§ 71.7 Specific exemptions.

On application of any interested person or on its own initiative, the Commission may grant any exemption from the requirements of the regulations in this part that it determines is authorized by law and will not endanger life or property or the common defense and security.

§ 71.8 (Reserved)

§ 71.9 Exemption of physicians.

Any physician licensed by a State of the United States to dispense drugs in the practice of medicine is exempt from § 71.5 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 under 10 CFR Part 35.

§ 71.10 Exemption for low level materials.

(a) A licensee is exempt from all requirements of this part with respect to shipment or carriage of a package containing radioactive material having a specific activity not greater than 0.002

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microcurie/gram.

(b) A licensee is exempt from all requirements of this part, other than § 71.5 and § 71.88, with respect to shipment or carriage of the following packages:

(1) A package containing no more than a Type A quantity of radioactive material if the package contains no fissile material or if the fissile material exemption standards of § 71.53 are satisfied; or

(2) A package transported between locations within the United States which contains only americium or plutonium in special form with an aggregate radioactivity not to exceed 20 curies, if the package contains no fissile material or if the fissile material exemption standards of § 71.53 are satisfied.

§ 71.11 [Reserved]

Subpart C—General Licenses

§ 71.12 General License: NRC approved package.

(a) A general license is hereby issued to any licensee of the Commission to transport, or to deliver to a carrier for transport, licensed material in a package for which a license, certificate of compliance, or other approval has been issued by the NRC.

(b) This general license applies only to a licensee who has a quality assurance program approved by the Commission as satisfying the provisions of Subpart H of this part.

(c) This general license applies only to a licensee who:

(1) Has a copy of the specific license, certificate of compliance, or other approval of the package and has 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 prior to shipment;

(2) Complies with the terms and conditions of the license, certificate, or other approval, as applicable, and the applicable requirements of Subparts A, G, and H of this part; and

(3) Submits in writing to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555, prior to the licensee's first use of the package, 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 previously approved Type B packages which are not designated as either B(U) or B(M) in the NRC Certificate of Compliance, this general license is subject to the additional restrictions of § 71.13.

§ 71.13 Previously approved Type B package.

(a) A Type B package previously approved by the NRC, but not designated as B(U) or B(M) in the NRC Certificate of Compliance, may be used under the general license of § 71.12 with the following additional limitations:

(1) Fabrication of the packaging was satisfactorily completed before August 31, 1986, as demonstrated by application of its model number in accordance with § 71.85(c); and

(2) The package may not be used for a shipment to a location outside the United States after August 31, 1986, except under special arrangement approved by DOT in accordance with 49 CFR 173.471.

(b) The NRC will approve modifications to the design and authorized contents of a Type B package previously approved by the NRC, but not designated as B(U) or B(M) in the NRC Certificate of Compliance, provided:

(1) The modifications are not significant with respect to the design, operating characteristics, or safe performance of the containment system when the package is subjected to the tests specified in §§ 71.71 and 71.73; and

(2) The modification to the package satisfies the requirements of this part.

(c) The NRC will revise the package identification number to designate previously approved Type B package designs as B(U) or B(M) after receipt of an application demonstrating that the design meets the requirements of this part.

§ 71.14 General License: DOT specification container.

(a) A general license is issued to any licensee of the Commission to transport or to deliver to a carrier for transport licensed material in a specification container for fissile material or for a Type B quantity of radioactive material as specified in the regulations of DOT in 49 CFR Parts 175 and 178.

(b) This general license applies only to a licensee who has a quality assurance program approved by the Commission as satisfying the provisions of Subpart H of this part.

(c) This general license applies only to a licensee who:

(1) Has a copy of the specification; and

(2) Complies with the terms and conditions of the specification and the applicable requirements of Subparts A,

G, and H of this part.

(d) This general license is subject to the limitation that the specification container may not be used for a shipment to a location outside the United States after August 31, 1986, except under special arrangements approved by DOT in accordance with 49 CFR 173.472.

§ 71.16 General License: Use of foreign approved package.

(a) A general license is issued to any licensee of the Commission 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 which has been revalidated by DOT as meeting the applicable requirements of 49 CFR 171.12.

(b) This general license applies only to shipments made to or from locations outside the United States.

(c) This general license applies only to a licensee who:

(1) Has 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 prior to shipment; and

(2) Complies with the terms and conditions of the certificate and revalidation and with the applicable requirements of Subparts A, G, and H of this part. With respect to the quality assurance provisions of Subpart H of this part, the licensee is exempt from design, construction, and fabrication considerations.

§ 71.18 General License: Type A, Fissile Class II package.

(a) A general license is issued to any licensee of the Commission to transport fissile material, or to deliver fissile material to a carrier for transport, without complying with the package standards of Subparts E and F of this part if the material is shipped as a Fissile Class II package.

(b) This general license applies only when a package contains no more than a Type A quantity of radioactive material, including only one of the following:

- (1) Up to 40 grams of uranium-235; or
- (2) Up to 30 grams of uranium-233; or
- (3) Up to 25 grams of the fissile radionuclides of plutonium, except that for encapsulated plutonium-beryllium neutron sources in special form, an A₁ quantity of plutonium may be present; or
- (4) A combination of fissile radionuclides in which the sum of the ratios of the amount of each radionuclide to the corresponding

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maximum amounts in paragraphs (b) (1), (2), and (3) of this section does not exceed unity.

(c) This general license applies only when, except as specified below for encapsulated plutonium-beryllium sources, a package containing more than 15 grams of fissile radionuclides is labeled with a transport index not less than the number given by the following equation, where the package contains x grams of uranium-235, y grams of uranium-233 and z grams of the fissile radionuclides of plutonium:

$$\text{Minimum Transport Index} = (0.40x + 0.67y + z) \left(1 + \frac{15}{x + y + z} \right).$$

For a package in which the only fissile material is in the form of encapsulated plutonium-beryllium neutron sources in special form, the transport index based on criticality considerations may be taken as 0.026 times the number of grams of the fissile radionuclides of plutonium in excess of 15 grams. In all cases, the transport index must be rounded up to one decimal place, and may not exceed 10.0.

§ 71.20 General license: Restricted, Fissile Class II package.

(a) A general license is issued to any licensee of the Commission to transport fissile material, or to deliver fissile material to a carrier for transport, without complying with the package standards of Subparts E and F of this part if the material is shipped as a Fissile Class II package.

(b) This general license applies only when:

- (1) The package contains no more than a Type A quantity of radioactive material; and
- (2) Neither beryllium nor hydrogenous material enriched in deuterium is present; and
- (3) The total mass of graphite present does not exceed 150 times the total mass of uranium-235 plus plutonium; and
- (4) Substances having a higher hydrogen density than water, e.g., certain hydrocarbon oils, are not present, except that polyethylene may be used for packing or wrapping; and
- (5) Uranium-233 is not present, and the amount of plutonium does not exceed 1% of the amount of uranium-235; and

(6) The amount of uranium-235 is limited as follows:

- (i) If the fissile radionuclides are not uniformly distributed, the maximum amount of uranium-235 per package may not exceed the value given in Table I of this part; or
- (ii) If the fissile radionuclides are distributed uniformly (i.e., cannot form a lattice arrangement within the

packaging) the maximum amount of uranium-235 per package may not exceed the value given in Table II of this part; and

(7) The transport index of each package based on criticality considerations is taken as 10 times the number of grams of uranium-235 in the package divided by the maximum allowable number of grams per package in accordance with Table I or Table II of this part as applicable.

TABLE I.—PERMISSIBLE MASS OF URANIUM-235 PER FISSILE CLASS II PACKAGE APPLICABLE TO § 71.20(b)(6)(i)

[Non-uniform distribution]	
Uranium enrichment in weight percent of uranium-235 not exceeding	Permissible maximum grams of uranium-235 per package
20	60
20	62
20	64
21	66
20	61
2.5	62
3	64
3.5	66
4	67
4.5	68
5	69
5.5	70
6	72
6.5	74
7	76
7.5	78
8	80
8.5	82
9	84
9.5	86
10	88
1.25	880
1	880
0.25	1,200

TABLE II.—PERMISSIBLE MASS OF URANIUM-235 PER FISSILE CLASS II PACKAGE APPLICABLE TO § 71.20(b)(6)(ii)

[Uniform distribution]	
Uranium enrichment in weight percent of uranium-235 not exceeding	Permissible maximum grams of uranium-235 per package
4	60
4.5	62
5	112
5.5	140
6	240
1.5	880
1.25	880

§ 71.22 General license: Type A package, Fissile Class III shipment.

(a) A general license is issued to any licensee of the Commission to transport fissile material, or to deliver fissile material to a carrier for transport, without complying with the package standards of Subparts E and F of this part if limited material is shipped as a Fissile Class III shipment.

(b) This general license applies only when a package contains no more than a Type A quantity of radioactive material and no more than 600 grams total of the fissile radionuclides of plutonium encapsulated as plutonium-beryllium neutron sources in special form.

(c) This general license applies only when the fissile radionuclides in the Fissile Class III shipment exceeds none of the following:

- (1) 300 grams of uranium-235; or
- (2) 300 grams total of uranium-233, and the fissile radionuclides of plutonium; or
- (3) A total quantity of uranium-233, uranium-235, and the fissile radionuclides of plutonium such that the sum of the ratios of the quantity of each radionuclide to the quantity specified in paragraphs (c)(1) and (c)(2) of this section exceeds unity; or
- (4) 2500 grams total of the fissile radionuclides of plutonium encapsulated as plutonium-beryllium neutron sources in special form.

(d) This general license applies only when shipment of these packages is made under procedures specifically authorized by DOT in accordance with 49 CFR Part 173 of its regulations to prevent loading, transport or storage of these packages with other Fissile Class II packages or Fissile Class III shipments.

§ 71.24 General license: Restricted, Fissile Class III shipment.

(a) A general license is issued to any licensee of the Commission to transport fissile material, or to deliver fissile material to a carrier for transport, without complying with the package standards of Subparts E and F of this part if limited material is shipped as a Fissile Class III shipment.

(b) This general license applies only when:

- (1) No package contains more than a Type A quantity of radioactive material; and
- (2) The packaging does not incorporate lead shielding exceeding 5 cm in thickness, tungsten shielding, or uranium shielding; and
- (3) Neither beryllium nor hydrogenous material enriched in deuterium is present; and

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(4) The total mass of graphite present does not exceed 150 times the total mass of uranium-235 and plutonium; and

(5) Substances having a higher hydrogen density than water, e.g., certain hydrocarbon oils, are not present, except that polyethylene may be used for packing or wrapping; and

(6) For fissile contents containing no uranium-235 and less than 1% total plutonium:

(i) If the fissile radionuclides are not uniformly distributed, the maximum amount of uranium-235 per consignment does not exceed the value given in Table III of this part; or

(ii) If the fissile radionuclides are distributed uniformly and cannot form a lattice arrangement within the packaging, the maximum amount of uranium-235 per shipment does not exceed the value given in Table IV of this part; and

(7) For fissile contents containing uranium-235 or more than 1% plutonium, the total mass of fissile material per shipment is limited so that the sum of the number of grams of uranium-235 divided by 400, the number of grams of plutonium divided by 225, and the number of grams of uranium-235 divided by 250 does not exceed unity as expressed in the formula

$$\frac{\text{grams uranium 235}}{400 \text{ grams}} + \frac{\text{grams plutonium}}{225 \text{ grams}} +$$

$$\frac{\text{grams uranium 235}}{250 \text{ grams}} \leq 1; \text{ and}$$

(8) The transport must be direct to the consignee without any intermediate transit storage; and

(9) Shipment of these packages is made under procedures specifically authorized by DOT in accordance with 49 CFR Part 173 of its regulations to prevent loading, transport or storage of these packages with other Fissile Class II packages or Fissile Class III shipments.

TABLE III.—PERMISSIBLE MASS OF URANIUM-235 PER FISSILE CLASS III SHIPMENT APPLICABLE TO § 71.24(b)(6)(i)

(Nonuniform distribution)	
Uranium enrichment in weight percent of uranium-235 not exceeding	Permissible maximum grams of uranium-235 per consignment
30	880
15	880
11	800
10	640
9.5	685
9	675
8.5	680
8	710
7.5	730
7	750
6.5	760
6	810
5.5	880
5	900
4.5	980
4	1,000
3.5	1,100
3	1,250
2.5	1,300
2	2,050
1.5	3,400
1.25	4,000
1	5,500
0.80	15,000

TABLE IV.—PERMISSIBLE MASS OF URANIUM-235 PER FISSILE CLASS III SHIPMENT APPLICABLE TO § 71.24(b)(6)(ii)

(Uniform distribution)	
Uranium enrichment in weight percent of uranium-235 not exceeding	Permissible maximum grams of uranium-235 per consignment
4	1,800
5.5	1,180
6	1,480
6.5	1,800
8	3,000
1.5	7,800
1.25	10,000

Subpart D—Application for Package Approval

§ 71.31 Contents of application.

(a) An application for an approval under this part must include, for each proposed packaging design, the following information:

- (1) A package description as required by § 71.33;
- (2) A package evaluation as required by § 71.35;

(3) A quality assurance program description as required by § 71.37;

(4) In the case of fissile material, an identification of the proposed fissile class.

(b) Except as provided in § 71.13, an application for modification of a package design, whether for modification of the packaging or authorized contents, must include sufficient information to demonstrate that the proposed design satisfies the package standards in effect at the time the application is filed.

§ 71.33 Package description.

The application must include a description of the proposed package in sufficient detail to identify the package accurately and provide a sufficient basis for evaluation of the package. The description must include:

- (a) With respect to the packaging:
 - (1) Classification as Type B(U), Type B(M), or fissile material packaging;
 - (2) Gross weight;
 - (3) Model number;
 - (4) Identification of the containment system;
 - (5) Specific materials of construction, weights, dimensions, and fabrication methods of:
 - (i) Receptacles;
 - (ii) Materials specifically used as nonfissile neutron absorbers or moderators;
 - (iii) Internal and external structures supporting or protecting receptacles;
 - (iv) Valves, sampling ports, lifting devices, and tie-down devices;
 - (v) Structural and mechanical means for the transfer and dissipation of heat and
 - (6) Identification and volumes of any receptacles containing coolant.
- (b) With respect to the contents of the package:
 - (1) Identification and maximum radioactivity of radioactive constituents;
 - (2) Identification and maximum quantities of fissile constituents;
 - (3) Chemical and physical form;
 - (4) Extent of reflection, the amount and identity of nonfissile materials used as neutron absorbers or moderators, and the atomic ratio of moderator to fissile constituents;
 - (5) Maximum normal operating pressure;
 - (6) Maximum weight;
 - (7) Maximum amount of decay heat; and
 - (8) Identification and volumes of any coolants.

§ 71.35 Package evaluation.

The application must include: (a) A demonstration that the package satisfies the standards specified in Subparts E and F of this part;

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(b) For a Fissile Class II package, the allowable number of packages which may be transported in the same vehicle in accordance with § 71.59; and

(c) For a Fissile Class III shipment, any proposed special controls and precautions for transport, loading, unloading, and handling, and any proposed special controls in the event of accident or delay.

§ 71.37 Quality assurance.

(a) The applicant shall describe the quality assurance program (see Subpart H of this part) for the design, fabrication, assembly, testing, maintenance, repair, modification, and use of the proposed package.

(b) The applicant shall identify any established codes and standards proposed for use in package design, fabrication, assembly, testing, maintenance, and use. In the absence of any codes and standards, the applicant shall describe the basis and rationale used to formulate the package quality assurance program.

(c) The applicant shall identify any specific provisions of the quality assurance program which are applicable to the particular package design under consideration, including a description of the leak testing procedures.

§ 71.39 Requirement for additional information.

The Commission may at any time require additional information in order to enable it to determine whether a license, certificate of compliance, or other approval should be granted, denied, modified, suspended, or revoked.

Subpart E—Package Approval Standards

§ 71.41 Demonstration of compliance.

(a) The effects on a package of the tests specified in § 71.71 (Normal Conditions of Transport) and the tests specified in § 71.73 (Hypothetical Accident Conditions) must be evaluated by subjecting a sample package or scale model to test, or by other method of demonstration acceptable to the Commission, as appropriate for the particular feature being considered.

(b) Taking into account the type of vehicle, the method of securing or attaching the package, and the controls to be exercised by the shipper, the Commission may permit the shipment to be evaluated together with the transporting vehicle.

(c) Environmental and test conditions different from those specified in § 71.71 and § 71.73 may be approved by the Commission if the controls proposed to be exercised by the shipper are demonstrated to be adequate to assure the safety of the shipment.

§ 71.43 General standards for all packages.

(a) The smallest overall dimension of a package must not be less than 10 cm (four in.).

(b) The outside of a package must incorporate a feature, such as a seal, which is not readily breakable, and which, while intact, would be evidence that the package has not been opened by unauthorized persons.

(c) Each package must include a containment system securely closed by a positive fastening device which cannot be opened unintentionally.

(d) A package must be of materials and construction which assure that there will be no significant chemical, galvanic, or other reaction among the packaging components or between the packaging components and the package contents, including possible reaction resulting from inleakage of water to the maximum credible extent.

(e) A package valve or other device, the failure of which would allow radioactive contents to escape, must be protected against unauthorized operation and, except for a pressure relief device, must be provided with an enclosure to retain any leakage.

(f) A package must be designed, constructed, and prepared for shipment so that under the tests specified in

§ 71.71 (Normal Conditions of Transport) there would be no loss or dispersal of radioactive contents, no significant increase in external radiation levels, and no substantial reduction in the effectiveness of the packaging.

(g) A package must be designed, constructed, and prepared for transport so that in still air at 38°C (100°F) and in the shade, no accessible surface of a package would have a temperature exceeding 50°C (122°F) in a non-exclusive use shipment or 62°C (180°F) in an exclusive use shipment.

(h) A package must not incorporate a feature which is intended to allow continuous venting during transport.

§ 71.45 Lifting and tie-down standards for all packages.

(a) Any lifting attachment that is a structural part of a package must be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner, and must be designed so that failure of any lifting device under excessive load would not impair the ability of the package to meet other requirements of this subpart. Any other structural part of the package which could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport or must be designed with strength equivalent to that required for lifting attachments.

(b) Tie-down devices:

(1) If there is a system of tie-down devices which is a structural part of the package, the system must be capable of withstanding, without generating stress in any material of the package in excess of its yield strength, a static force applied to the center of gravity of the package having a vertical component of two times the weight of the package with its contents, a horizontal component along the direction in which the vehicle travels of 10 times the weight of the package with its contents, and a horizontal component in the transverse direction of five times the weight of the package with its contents.

(2) Any other structural part of the package which could be used to tie down the package must be capable of being rendered inoperable for tying down the package during transport, or must be designed with strength equivalent to that required for tie-down devices.

(3) Each tie-down device which is a structural part of a package must be designed so that failure of the device under excessive load would not impair the ability of the package to meet other requirements of this part.

§ 71.47 External radiation standards for all packages.

A package must be designed and prepared for shipment so that the radiation level does not exceed 200 millirem per hour at any point on the external surface of the package and the transport index does not exceed 10 (See § 71.4 "Definitions"). For a package transported as exclusive use by rail, highway, or water, radiation levels external to the package may exceed those limits, but must not exceed any of the following:

(a) 200 millirem/hour on the accessible external surface of the package unless the following conditions are met, in which case the limit is 1000 millirem per hour:

(1) The shipment is made in a closed transport vehicle;

(2) Provisions are made to secure the package so that its position within the vehicle remains fixed during transportation; and

(3) There are no loading or unloading operations between the beginning and end of the transportation;

(b) 200 millirem/hour at any point on the outer surface of the vehicle, including the upper and lower surfaces, or, in the case of an open vehicle, at any point on the vertical planes projected from the outer edges of the vehicle, on the upper surface of the load, and on the lower external surface of the vehicle;

(c) 10 millirem/hour at any point two

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meters from the vertical planes represented by the outer lateral surfaces of the vehicle, or, in the case of an open vehicle, at any point two meters from the vertical planes projected from the outer edges of the conveyance; and

(d) Two millirem/hour in any normally occupied positions of the vehicle, except that this provision does not apply to private motor carriers when persons occupying these positions are provided with special health supervision, personnel radiation exposure monitoring devices, and training in accordance with § 18.12 of this chapter.

§ 71.51 Additional requirements for Type B packages.

(a) A Type B package, in addition to satisfying the requirements of §§ 71.41-71.47 must be designed, constructed, and prepared for shipment so that under the tests specified in:

(1) Section 71.71 (Normal Conditions of Transport), there would be no loss or dispersal of radioactive contents, as demonstrated to a sensitivity of 10^{-6} A₂ per hour, no significant increase in external radiation levels, and no substantial reduction in the effectiveness of the packaging; and

(2) Section 71.73 (Hypothetical Accident Conditions), there would be no escape of krypton-85 exceeding 10,000 curies in one week, no escape of other radioactive material exceeding a total amount A₂ in one week, and no external radiation dose rate exceeding one rem per hour at one meter from the external surface of the package.

(b) Compliance with the permitted activity release limits of paragraph (a) of this section must not depend upon filters or upon a mechanical cooling system.

§ 71.52 Exemption for low specific activity (LSA) packages.

A package need not satisfy the requirements of § 71.51 if it contains only low specific activity material and is transported as exclusive use, but is subject to §§ 71.41-71.47 of this part, including § 71.43(f).

§ 71.53 Fissile material exemptions.

The following packages are exempt from fissile material classification and from the fissile material standards of §§ 71.55-71.81, but are subject to all other requirements of this part:

(a) A package containing not more than 15 grams of fissile radionuclides. If material is transported in bulk, the quantity limitation applies to the conveyance; or

(b) A package containing irradiated natural or depleted uranium including the products of irradiation if the irradiation has taken place only in a thermal reactor; or

(c) A package containing homogenous

hydrogenous solutions or mixtures where:

(1) The minimum ratio of the number of hydrogen atoms to the number of atoms of fissile radionuclides(H/X) is 8200;

(2) The maximum concentration of fissile radionuclides is five grams/liter; and

(3) The maximum mass of fissile radionuclides in the package is 800 grams, except for a mixture where the total mass of plutonium and uranium-233 exceeds one percent of the mass of uranium-235 the limit is 500 grams. If the material is transported in bulk, the quantity limitations apply to the vehicle, to a hold or compartment of an inland waterway craft, or to a hold, compartment, or defined deck area of a seagoing vessel; or

(d) A package containing uranium enriched in uranium-235 to a maximum of one percent by weight, and with a total plutonium and uranium-233 content of up to one percent of the mass of uranium-235, if the fissile radionuclides are distributed homogeneously throughout the package contents, and do not form a lattice arrangement within the package; or

(e) A package containing any fissile material if it does not contain more than five grams of fissile radionuclides in any 10-liter volume, and if the material is packaged so as to maintain this limit of fissile radionuclide concentration during normal transport; or

(f) A package containing not more than one kilogram of plutonium of which not more than 20% by mass may consist of plutonium-239, plutonium-241, or any combination of those radionuclides; or

(g) A package containing liquid solutions of uranyl nitrate enriched in uranium-235 to a maximum of two percent by weight, with total plutonium and uranium-233 not more than one-tenth percent of the mass of uranium-235.

§ 71.55 General requirements for all fissile material packages.

(a) A package used for the shipment of fissile material must be designed and constructed in accordance with §§ 71.41-71.47. When required by the total amount of radioactive material, a package used for the shipment of fissile material must also be designed and constructed in accordance with § 71.51.

(b) Except as provided in paragraph (c) of this section, a package used for the shipment of fissile material must be so designed and constructed and its contents so limited that it would be subcritical if water were to leak into the containment system or liquid contents were to leak out of the containment system so that, under the following conditions, maximum reactivity of the fissile material would be attained:

(1) The most reactive credible configuration consistent with the chemical and physical form of the material;

(2) Moderation by water to the most reactive credible extent; and

(3) Close reflection by water on all sides.

(c) The Commission may approve exceptions to the requirements of paragraph (b) of this section if the package incorporates special design features that ensure that no single packaging error would permit leakage, and if appropriate measures are taken before each shipment to ensure the containment system does not leak.

(d) A package used for the shipment of fissile material must be so designed and constructed and its contents so limited that under the tests specified in § 71.71 (Normal Conditions of Transport):

(1) The contents would be subcritical;

(2) The geometric form of the package contents would not be substantially altered;

(3) There would be no leakage of water into the containment system unless, in the evaluation of undamaged packages under §§ 71.57(a), 71.59(b)(1), and 71.61(a), it has been assumed that moderation is present to such an extent as to cause maximum reactivity consistent with the chemical and physical form of the material; and

(4) There will be no substantial reduction in the effectiveness of the packaging, including:

(i) No more than five percent reduction in the total effective volume of the packaging on which nuclear safety is assessed;

(ii) No more than five percent reduction in the effective spacing between the fissile contents and the outer surface of the packaging; and

(iii) No occurrence of an aperture in the outer surface of the packaging large enough to permit the entry of a 10 cm (four in.) cube.

(e) A package used for the shipment of fissile material must be so designed and constructed and its contents so limited that under the tests specified in § 71.73 (Hypothetical Accident Conditions), the package would be subcritical. For this determination, it must be assumed that:

(1) The fissile material is in the most reactive credible configuration consistent with the damaged condition of the package and the chemical and physical form of the contents;

(2) Water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package and the chemical and physical form of the contents; and

(3) There is reflection by water on all sides, as close as is consistent with the damaged condition of the package.

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§ 71.57 Specific standards for a Fissile Class I package.

A Fissile Class I package must be so designed and constructed and its contents so limited that:

(a) Any number of undamaged packages would be subcritical in any arrangement and with optimum interspersed hydrogenous moderation unless there is a greater amount of interspersed moderation in the packaging, in which case the greater amount may be assumed for this determination; and

(b) Two hundred fifty (250) packages, if each package were subjected to the tests specified in § 71.73 (Hypothetical Accident Conditions), would be subcritical if stacked together in any arrangement, closely reflected on all sides of the stack by water, and with optimum interspersed hydrogenous moderation.

§ 71.59 Specific standards for a Fissile Class II package.

(a) A Fissile Class II package must be controlled by the carrier during transport. To provide this control, the designer of a Fissile Class II package must determine the allowable number of packages of that design which can be safely transported in a vehicle under the conditions specified in this section. This allowable number of packages determines the minimum transport index which the shipper of the package marks on the package label when the package is shipped. By limiting to 50 the total number of transport indexes in a vehicle or storage area, the carrier provides adequate criticality control.

(b) A Fissile Class II package must be designed and constructed and its contents so limited, and the allowable number of these packages in a Fissile Class II shipment so determined, that:

(1) Five times the allowable number of undamaged packages would be subcritical if stacked together in any arrangement and closely reflected on all sides of the stack by water; and

(2) Twice the allowable number of packages, if each package were subjected to the tests specified in § 71.73 (Hypothetical Accident Conditions), would be subcritical if stacked together in any arrangement, closely reflected on all sides of the stack by water, and with optimum interspersed hydrogenous moderation.

(c) The transport index with respect to criticality control for each Fissile Class II package must be calculated by dividing the number 50 by the allowable number of Fissile Class II packages which may be transported together as determined under the limitations of paragraph (b) of this section. The transport index so determined must not

exceed 10 and must be rounded up to the first decimal place.

§ 71.61 Specific standards for a Fissile Class III shipment.

A package for Fissile Class III shipment must be so designed and constructed and its contents so limited, and the number of packages in a Fissile Class III shipment must be so limited, that:

(a) Twice this number of undamaged packages would be subcritical if stacked together in any arrangement, assuming close reflection on all sides of the stack by water; and

(b) This number of packages would be subcritical if stacked together in any arrangement, closely reflected on all sides of the stack by water, and with optimum interspersed hydrogenous moderation. Except as permitted under § 71.61, each package must be considered to have been subjected to the tests specified in § 71.73 (Hypothetical Accident Conditions).

§ 71.63 Special requirements for plutonium shipments.

(a) Plutonium in excess of 20 curies per package must be shipped as a solid.

(b) Plutonium in excess of 20 curies per package must be packaged in a separate inner container placed within outer packaging that meets the requirements of Subparts E and F for packaging of material in normal form. If the entire package is subjected to the tests specified in § 71.71 (Normal Conditions of Transport), the separate inner container must not release plutonium, as demonstrated to a sensitivity of 10^{-6} A_0 per hour. If the entire package is subjected to the tests specified in § 71.73 (Hypothetical Accident Conditions), the separate inner container must restrict the loss of plutonium to not more than A_0 in one week. Solid plutonium in the following forms is exempt from the requirements of this paragraph:

- (1) Reactor fuel elements;
- (2) Metal or metal alloy; and
- (3) Other plutonium bearing solids that the Commission determines should be exempt from the requirements of this section.

§ 71.65 Additional requirements.

The Commission may, by rule, regulation, or order, impose requirements upon any licensee in addition to those established in this part as it deems necessary or appropriate to protect health or to minimize danger to life or property.

Subpart F—Package and Special Form Tests*

§ 71.71 Normal conditions of transport.

(a) *Evaluation.* Evaluation of each package design under normal conditions of transport must include a determination of the effect on that design of the conditions and tests specified in this section. Separate specimens may be used for the free drop test, the compression test, and the penetration test if each specimen is subjected to the water spray test before being subjected to any of the other tests.

(b) *Initial conditions.* With respect to the initial conditions for the tests in this section, the demonstration of compliance with the requirements of this Part must be based on the ambient temperature preceding and following the tests remaining constant at that value between -20°C (-20°F) and $+38^{\circ}\text{C}$ (100°F) which is most unfavorable for the feature under consideration. The initial internal pressure within the containment system must be considered to be the maximum normal operating pressure, unless a lower internal pressure consistent with the ambient temperature considered to precede and follow the tests is more unfavorable.

(c) *Conditions and tests.* (1) *Heat.* An ambient temperature of 38°C (100°F) in still air, and insulation according to the following table:

INSULATION DATA

Form and location of surface	Total insulation for a 12-hour period in cm^2/gm^2
Flat surfaces transported horizontally—	
—Basic	None
—Other surfaces	200
Flat surfaces not transported horizontally	200
Curved surfaces	400

(2) *Cold.* An ambient temperature of -40°C (-40°F) in still air and shade.

(3) *Reduced external pressure.* An external pressure of 24.5 kilopascal (2.5 psi) absolute.

(4) *Increased external pressure.* An external pressure of 140 kilopascal (20 psi) absolute.

(5) *Vibration.* Vibration normally incident to transport.

(6) *Water spray.* A water spray that simulates exposure to rainfall of approximately five cm (two in.) per hour for at least one hour.

(7) *Free drop.* Between 1½ and 2½ hours after the conclusion of the water spray test, a free drop through the distance specified below onto a flat, essentially unyielding, horizontal surface, striking the surface in a position for which maximum damage is expected. For Fissile Class II packages, this free drop must be preceded by a

* The package standards related to the tests in this subpart are contained in Subpart E.

free drop from a height of 0.3 m (one ft.) on each corner or, in the case of a cylindrical fissile Class II package, onto each of the quarters of each rim.

CRITERIA FOR FREE DROP TEST (WEIGHT/DISTANCE)

Package weight		Free drop distance	
kilograms	Pounds	meters	Feet
5,000 or less	(11,000)	1.2	(4)
5,000 to 10,000	(11,000 to 22,000)	0.9	(3)
10,000 to 15,000	(22,000 to 33,000)	0.6	(2)
More than 15,000	(More than 33,000)	0.3	(1)

(8) *Corner drop.* A free drop onto each corner of the package in succession, or in the case of a cylindrical package onto each quarter of each rim, from a height of 0.3 m (one ft.) onto a flat, essentially unyielding, horizontal surface. This test applies only to fiberboard or wood rectangular packages not exceeding 80 kg (110 pounds) and fiberboard or wood cylindrical packages not exceeding 100 kg (220 pounds).

(9) *Compression.* For packages weighing up to 5000 kg, the package must be subjected, for a period of 24 hours, to a compressive load applied uniformly to the top and bottom of the package in the position in which the package would normally be transported. The compressive load must be the greater of the following:

- (i) The equivalent of five times the weight of the package; or
- (ii) The equivalent of 12.75 kilopascal (1.85 lb/in²) multiplied by the vertically projected area of the package.

(10) *Penetration.* Impact of the hemispherical end of a vertical steel cylinder of 3.2 cm (1 1/4 in) diameter and six kg (13 lb) mass, dropped from a height of one m (40 in) onto the exposed surface of the package which is expected to be most vulnerable to puncture. The long axis of the cylinder must be perpendicular to the package surface.

§ 71.73 Hypothetical accident conditions.

(a) *Test procedures.* Evaluation for hypothetical accident conditions is to be based on sequential application of the tests specified in this section, in the order indicated, to determine their cumulative effect on a package or array of packages. An undamaged specimen must be used for the water immersion test specified in paragraph (c)(5) of this section.

(b) *Test conditions.* With respect to the initial conditions for the tests, except for the water immersion tests, to demonstrate compliance with the requirements of this part during testing, the ambient air temperature before and after the tests must remain constant at that value between -20°C (-20°F) and +38°C (100°F) which is most

unfavorable for the feature under consideration. The initial internal pressure within the containment system must be the maximum normal operating pressure unless a lower internal pressure consistent with the ambient temperature assumed to precede and follow the tests is more unfavorable.

(c) *Tests.* Tests for hypothetical accident conditions must be conducted as follows:

(1) *Free Drop.* A free drop of the specimen through a distance of nine m (30 ft) onto a flat, essentially unyielding, horizontal surface, striking the surface in a position for which maximum damage is expected.

(2) *Puncture.* A free drop of the specimen through a distance of one m (40 in) in a position for which maximum damage is expected, onto the upper end of a solid, vertical, cylindrical, mild steel bar mounted on an essentially unyielding, horizontal surface. The bar must be 35 cm (six in) in diameter, with the top horizontal and its edge rounded to a radius of not more than six mm (1/4 in) and of a length as to cause maximum damage to the package, but not less than 20 cm (eight in) long. The long axis of the bar must be vertical.

(3) *Thermal.* Exposure of the whole specimen for not less than 30 minutes to a heat flux not less than that of a radiation environment of 800°C (1475°F) with an emissivity coefficient of at least 0.8. For purposes of calculation, the surface absorptivity must be either that value which the package may be expected to possess if exposed to a fire or 0.8, whichever is greater. In addition, when significant, convective heat input must be included on the basis of still, ambient air at 800°C (1475°F). Artificial cooling must not be applied after cessation of external heat input and any combustion of materials of construction must be allowed to proceed until it terminates naturally. The effects of solar radiation may be neglected prior to, during, and following the test.

(4) *Immersion—fissile material.* For fissile material, in those cases where water leakage has not been assumed for criticality analysis, the specimen must be immersed under a head of water of at least 0.9 m (three ft) for a period of not less than eight hours and in the attitude for which maximum leakage is expected.

(5) *Immersion—all packages.* A separate, undamaged specimen must be subjected to water pressure equivalent to immersion under a head of water of at least 15 m (50 ft) for a period of not less than eight hours. For test purposes, an external pressure of water of 147 kilopascal (21 psi) gauge is considered to meet these conditions.

§ 71.75 Qualification of special form radioactive material.

(a) Evaluation of the contents of a single package for qualification as special form must include a determination of the effect on a specimen of those contents of the tests specified in § 71.77.

(1) Specimens (solid radioactive material or capsules) to be tested must be as normally prepared for loading in a single package, with the radioactive material duplicated as closely as practicable.

(2) A different specimen may be used for each of the tests.

(b) The specimen must not break or shatter when subjected to the impact, percussion, or bending tests.

(c) The specimen must not melt or disperse when subjected to the heat test.

(d) After each test, leak-tightness or indisparability of the specimen must be determined by a method no less sensitive than the following leaching assessment procedure. For a capsule resistant to corrosion by water, and which has an internal void volume greater than 0.3 milliliters, an alternative to the leaching assessment is a demonstration of leak-tightness of 10⁻⁴ torr-l/s (1.3 × 10⁻⁶ atm cm³/s) (based on air at 25°C and one atmosphere differential pressure) for solid radioactive content, or 10⁻⁶ torr-l/s (1.3 × 10⁻⁸ atm cm³/s) for liquid or gaseous radioactive content.

(1) The specimen must be immersed for seven days in water at ambient temperature. The water must have a pH of 6-8 and a maximum conductivity of 10 μmho/cm at 20°C (68°F). Encapsulated material is not subject to the seven-day requirement.

(2) The water with specimen must then be heated to a temperature of 50 ± 5°C (122 ± 9°F) and maintained at this temperature for four hours.

(3) The activity of the water must be determined at that time.

(4) The specimen must then be stored for at least seven days in still air of humidity not less than 90% and a temperature not less than 30°C (86°F).

(5) The specimen must then be immersed in water having a pH of 6-8 and a maximum conductivity of 10 μmho/cm at 20°C, and the water with specimen heated to 50 ± 5°C (122 ± 9°F) and maintained at this temperature for four hours.

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(6) The activity of the water must be determined at that time.

(7) The activities determined in paragraphs (c)(3) and (c)(6) of this section must not exceed 0.05 μCi .

§ 71.77 Tests for special form radioactive material.

(a) *Impact test.* The specimen must fall onto a flat, horizontal, essentially unyielding surface from a height of not less than nine m (30 ft).

(b) *Percussion test.* The specimen must be placed on a sheet of lead which is supported by a smooth solid surface and struck by the flat face of a steel billet so as to produce an impact equivalent to that resulting from a free fall of 1.4 kg (three lb.) through one m (40 in.). The flat face of the billet must be 25 mm (one in.) in diameter with the edges rounded to a radius of three mm (0.12 in.) \pm 0.3 mm (0.012 in.). The lead, of hardness number 3.5 to 4.5 on the Vickers scale and not more than 25 mm (one in.) thick, must cover an area greater than that covered by the specimen. A fresh surface of lead must be used for each impact. The billet must strike the specimen so as to cause maximum damage.

(c) *Bending test.* The test is applicable only to long, slender sources with both a minimum length of 10 cm (four in.) and a length to minimum width ratio not less than 10. The specimen must be rigidly clamped in a horizontal position so that one-half of its length protrudes from the face of the clamp. The orientation of the specimen must be such that the specimen will suffer maximum damage when its free end is struck by the flat face of a steel billet. The billet must strike the specimen so as to produce an impact equivalent to that resulting from a free vertical fall of 1.4 kg (three lb.) through one m (40 in.). The flat face of the billet must be 25 mm (one in.) in diameter with the edges rounded off to a radius of three mm (0.12 in.) \pm 0.3 mm (0.012 in.).

(d) *Heat test.* The specimen must be heated to a temperature of not less than 800°C (1475°F) in an atmosphere which is essentially air, and held at that temperature for a period of 10 minutes and must then be allowed to cool.

Subpart G—Operating Controls and Procedures

§ 71.81 Applicability of operating controls and procedures.

A licensee subject to this part, 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 Subpart G, with the

quality assurance requirements of Subpart H of this part, and with the general provisions of Subpart A of this part.

§ 71.83 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 nuclear reactivity.

§ 71.85 Preliminary determinations.

Prior to the first use of any packaging for the shipment of licensed material:

(a) The licensee shall ascertain that there are no cracks, pinholes, uncontrolled voids, or other defects which could significantly reduce the effectiveness of the packaging;

(b) Where the maximum normal operating pressure will exceed 34.3 kilopascal (5 psi) gauge, the licensee shall test the containment system at an internal pressure at least 50% higher than the maximum normal operating pressure to verify the capability of that system to maintain its structural integrity at that pressure.

(c) The licensee shall conspicuously and durably mark the packaging with its model number, gross weight, and a package identification number assigned by the Nuclear Regulatory Commission. Prior to applying the model number, the licensee shall determine that the packaging has been fabricated in accordance with the design approved by the Commission.

§ 71.87 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 part and of 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 and 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;

(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 which could be used to lift or tie down the package during transport is rendered inoperable for that purpose unless it satisfies the design requirements of § 71.45;

(i)(1) The level of non-fixed (removable) radioactive contamination on the external surfaces of each package offered for shipment is as low as reasonably achievable. The level of non-fixed radioactive contamination may be determined by wiping an area of 300 square centimeters of the surface concerned with an absorbent material, using moderate pressure, and measuring the activity on the wiping material. Sufficient measurements must be taken in the most appropriate locations to yield a representative assessment of the non-fixed contamination levels. Except as provided under paragraph (i)(2) of this section, the amount of radioactivity measured on any single wiping material when averaged over the surface wiped, must not exceed the limits given in Table V of this part at any time during transport. Other methods of assessment of equal or greater efficiency may be used. When other methods are used, the detection efficiency of the method used must be taken into account and in no case may the non-fixed contamination on the external surfaces of the package exceed ten times the limits listed in Table V.

TABLE V.—REMOVABLE EXTERNAL RADIOACTIVE CONTAMINATION WIPE LIMITS

Contaminant	Maximum permissible limits	
	$\mu\text{Ci}/\text{cm}^2$	$\mu\text{mCi}/\text{cm}^2$
Beta-gamma emitting radionuclides; all radionuclides with half-lives less than ten days, natural uranium, natural thorium, uranium-235, uranium-238, thorium-232, thorium-230 and thorium-230 when contained in ore or physical concentrates; all other alpha emitting radionuclides.	10^{-6}	22
	10^{-6}	2.2

(2) In the case of packages transported as exclusive use shipments by rail or highway only, the non-fixed radioactive contamination at any time during transport must not exceed ten times the levels prescribed in paragraph (i)(1) of this section. The levels at the beginning of transport must not exceed the levels prescribed in paragraph (i)(1) of this section:

(j) External radiation levels around the package and around the vehicle, if applicable, will not exceed the limits specified in § 71.47 at any time during transportation; and

(k) Accessible package surface

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temperatures will not exceed the limits specified in § 71.43(g) at any time during transportation.

§ 71.85 Air transport of plutonium.

(e) Notwithstanding the provisions of any general licenses and notwithstanding any exemptions stated directly in this part or included indirectly by citation of 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 not greater than 0.002 microcuries per gram of material and in which the radioactivity is essentially uniformly distributed; or

(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 § 71.5 of this part; 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 Commission.

(b) Nothing in paragraph (a) of this section is to be interpreted as removing or diminishing the requirements of § 73.24 of this chapter.

(c) There have been two orders issued by the NRC restricting the air shipment of plutonium in accordance with Pub. L. 94-78. The first order, issued on August 15, 1975 was superseded by the second order dated September 1, 1978, which has remained in effect since that time. As of the effective date of this rule, the outstanding order dated September 1, 1978 is revoked.

§ 71.86 Opening instructions.

Prior to 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 § 20.205 of this chapter.

§ 71.87 Records.

(a) Each licensee shall maintain for a period of three years after shipment a record of each shipment of licensed material not exempt under § 71.10, showing, where applicable:

(1) Identification of the packaging by model number;

(2) Verification that there are 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.

(5) For each item of irradiated fissile material:

(i) Identification by model number and/or serial number;

(ii) Irradiation and decay history to the extent appropriate to demonstrate that its nuclear and thermal characteristics comply with license conditions; and

(iii) Any abnormal or unusual condition relevant to radiation safety.

(6) Date of the shipment;

(7) For Fissile Class III and for Type B packages, any special controls exercised;

(8) Name and address of the transferor;

(9) Address to which the shipment was made; and

(10) Results of the determinations required by § 71.87 and by the conditions of the package approval.

(b) The licensee shall make available to the Commission for inspection, upon reasonable notice, all records required by this part. Records are valid only if stamped, initialed, or signed and dated by authorized personnel or otherwise authenticated.

(c) Each 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 § 71.85; design, fabrication, and assembly records; results of reviews, inspections, tests, and audits; results 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. The records must be retained for three years after the life of the packaging to which they apply.

§ 71.88 Inspection and tests.

(a) The licensee or certificate holder shall permit the Commission at all reasonable times to inspect the licensed material, packaging, premises, and facilities in which the licensed material or packaging is used, provided, constructed, fabricated, tested, stored, or shipped.

(b) The licensee shall perform, and permit the Commission to perform, tests as the Commission deems necessary or appropriate for the administration of the regulations in this chapter.

(c) The licensee shall notify the Regional Administrator of the appropriate Nuclear Regulatory Commission Regional Office listed in Appendix A of Part 73 of this

chapter at least 45 days prior to fabrication of a package to be used for the shipment of licensed material having a decay heat load in excess of five kilowatts or with a maximum normal operating pressure in excess of 103 kilopascal (15psi) gauge.

§ 71.89 Reports.

The licensee shall report to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555, within 30 days:

(a) Any instance in which there is significant reduction in the effectiveness of any authorized packaging during use; and

(b) Details of any defects with safety significance in the packaging after first use, with the means employed to repair the defects and prevent their recurrence.

§ 71.87 Advance notification of shipment of nuclear wastes.

(a) Except as specified in paragraph (b) of this section, prior to 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, each licensee shall provide advance notification to the governor of a state, or the governor's designee, of the shipment to, through, or across the boundary of the state.

(b) Advance notification is required only when—

(1) The licensed material is required by this part to be in Type B packaging for transportation;

(2) The licensed material other than irradiated fuel is being transported to, through, or across state boundaries to a disposal site or to a collection point for transport to a disposal site;

(3) The quantity of licensed material in a single package exceeds:

(i) 5,000 curies of special form radionuclides;

(ii) 5,000 curies of uncompressed gases of Argon-41, Krypton-85m, Krypton-87, Xenon-135m, or Xenon-135;

(iii) 50,000 curies of Argon-37, or of uncompressed gases of Krypton-85 or Xenon-135, or of Hydrogen-3 as a gas, as luminous paint, or adsorbed on solid material;

(iv) 20 curies of other non-special form radionuclides for which A_2 is less than, or equal to four curies; or

(v) 200 curies of other non-special form radionuclides for which A_2 is greater than four curies; and

(4) The quantity of irradiated fuel is less than that subject to advance notification requirements of 30 CFR Part 78.

(c) Procedures for submitting advance notification. (1) The notification must be made in writing to the office of each appropriate governor or governor's

designee and to the Regional Administrator of the appropriate Nuclear Regulatory Commission Regional Office listed in Appendix A of Part 73 of this chapter.

(2) A notification delivered by mail must be postmarked at least seven days before the beginning of the seven-day period during which departure of the shipment is estimated to occur.

(3) A notification delivered by messenger must reach the office of the governor or of the governor's designee at least four days before the beginning of the seven-day period during which departure of the shipment is estimated to occur.

(i) A list of the names and mailing addresses of the governors' designees receiving advance notification of transportation of nuclear waste was published in the Federal Register on June 30, 1983 (48 FR 30221).

(ii) The list will be published annually in the Federal Register on or about June 30 to reflect any changes in information.

(iii) A list of the names and mailing addresses of the governors' designees is available upon request from the Director, Office of Governmental and Public Affairs, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

(4) The licensee shall retain a copy of the notification as a record for three years.

(d) *Information to be furnished in advance notification of shipment.* Each advance notification of shipment of nuclear waste must contain the following information:

(1) The name, address, and telephone number of the shipper, carrier, and receiver of the nuclear waste shipment;

(2) A description of the nuclear waste contained in the shipment, as required by the regulations of DOT in 49 CFR 172.202 and 172.203(d);

(3) The point of origin of the shipment and the seven-day period during which departure of the shipment is estimated to occur;

(4) The seven-day period during which arrival of the shipment at state boundaries is estimated to occur;

(5) The destination of the shipment, and the seven-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 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 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 years.

(f) *Cancellation notice.* (1) Each licensee who cancels a nuclear waste shipment for which advance notification has been sent, shall send a cancellation notice to the governor of each state or the governor's designee previously notified and to the Regional Administrator of the appropriate Nuclear Regulatory Commission Regional Office listed in Appendix A of Part 73 of this chapter.

(2) The licensee shall state in the notice that it is a cancellation and shall identify the advance notification which is being cancelled. The licensee shall retain a copy of the notice as a record for three years.

§ 71.99 Violations.

(a) The Commission may obtain an injunction or other court order to prevent a violation of the provisions of—

(1) The Atomic Energy Act of 1954, as amended;

(2) Title II of the Energy Reorganization Act of 1974, as amended; or

(3) A regulation or order issued pursuant to those Acts.

(b) The Commission may obtain a court order for the payment of a civil penalty imposed under section 234 of the Atomic Energy Act:

(1) For violations of—

(i) Sections 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Atomic Energy Act of 1954, as amended;

(ii) Section 206 of the Energy Reorganization Act;

(iii) Any rule, regulation, or order issued pursuant to the sections specified in paragraph (b)(1)(i) of this section;

(iv) Any term, condition, or limitation of any license issued under the sections specified in paragraph (b)(1)(i) of this section.

(2) For any violation for which a license may be revoked under section 186 of the Atomic Energy Act of 1954, as amended.

§ 71.100 Criminal penalties.

(a) Section 223 of the Atomic Energy Act of 1954, as amended, provides for criminal sanctions for willful violation of, attempted violation of, or conspiracy to violate, any regulation issued under sections 161b, 161i, or 161c of the Act. For purposes of section 223, all the regulations in part 71 are issued under one or more of sections 161b, 161i, or 161c, except for the sections listed in paragraph (b) of this section.

(b) The regulations in part 71 that are not issued under sections 161b, 161i, or 161c for the purposes of section 223 are as follows: §§ 71.0, 71.2, 71.4, 71.6, 71.7, 71.9, 71.10, 71.31, 71.33, 71.35, 71.37, 71.39, 71.41, 71.43, 71.45, 71.47, 71.51, 71.52, 71.53, 71.65, 71.71, 71.73, 71.75, 71.77, 71.99, and 71.100.

Subpart H—Quality Assurance

§ 71.101 Quality assurance requirements.

(a) *Purpose.* This subpart 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 which are important to safety. As used in this subpart, "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.

(b) Each licensee shall establish, maintain, and execute a quality assurance program satisfying each of the applicable criteria of §§ 71.101 through 71.137 of this subpart and satisfying any specific provisions that are applicable to the licensee's activities, including procurement of packaging. The licensee shall apply each of the applicable criteria in a graded approach, i.e., to an extent that is consistent with its importance to safety.

(c) *Approval of program.* Prior to the use of any package for the shipment of licensed material subject to this subpart, each licensee shall obtain Commission approval of its quality assurance program. Each licensee shall file a description of its quality assurance program, including a discussion of which requirements of this subpart are applicable and how they will be satisfied, with the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

(d) *Existing package designs.* The provisions of this paragraph deal with packages which have been approved for use in accordance with this part prior to January 1, 1979, and which have been designed in accordance with the provisions of this part in effect at the time of application for package approval. Those packages will be accepted as having been designed in accordance with a quality assurance program which satisfies the provisions of paragraph (b) of this section.

(e) *Existing packages.* The provisions of this paragraph deal with packages which have been approved for use in accordance with this part prior to January 1, 1979, have been at least partially fabricated prior to that date, and for which the fabrication is in accordance with the provisions of this part in effect at the time of application for approval of package design. These packages will be accepted as having been fabricated and assembled in accordance with a quality assurance program which satisfies the provisions of paragraph (b) of this section.

(f) *Previously approved programs.* A Commission-approved quality assurance program which satisfies the applicable criteria of Appendix B of Part 50 of this chapter and which is established, maintained, and executed with regard to transport packages will be accepted as satisfying the requirements of paragraph (b) of this section. Prior to first use, the licensee shall notify the Director, Office of Nuclear Material Safety and

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Safeguards, U.S. Nuclear Regulatory Commission, Washington, DC 20555, of its intent to apply its previously approved Appendix B program to transportation activities. The licensee shall identify the program by date of submittal to the Commission, Docket Number, and date of Commission approval.

§ 71.103 Quality assurance organization.

The licensee^a 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. The licensee shall clearly establish and delineate in writing the authority and duties of persons and organizations performing activities affecting the safety-related functions of structures, systems and components. These activities include performing the functions associated with attaining quality objectives and the quality assurance functions. The quality assurance functions are (a) assuring that an appropriate quality assurance program is established and effectively executed and (b) verifying, by procedures such as checking, auditing, and inspection, that activities affecting the safety-related functions have been correctly performed. The persons and organizations performing quality assurance functions must have sufficient authority and organizational freedom to identify quality problems; to initiate, recommend, or provide solutions; and to verify implementation of solutions. The persons and organizations performing quality assurance functions shall report to a management level which assures that the required authority and organizational freedom, including sufficient independence from cost and schedule when opposed to safety considerations, are provided. 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

^a While the term "licensee" is used in these criteria, the requirements are applicable to whatever design, fabrication, assembly, and testing of the package is accomplished with respect to a package prior to the time a package approval is issued.

authority and organizational freedom. 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.

§ 71.105 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 the requirements of §§ 71.101 through 71.137 of this subpart. 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 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 shall take into account 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.

(c) The licensee shall base the requirements and procedures of its quality assurance program on the following considerations 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 regularly review the status and adequacy of that part of the quality assurance program which they are executing.

§ 71.107 Package design control.

(a) The licensee shall establish measures to assure that applicable regulatory requirements and the package design, as specified in the license for those materials and components to which this section applies, are correctly translated into specifications, drawings, procedures, and instructions. These measures must include provisions to assure that appropriate quality standards are specified and included in design documents and that deviations from standards are controlled. Measures must be established for the selection and review for suitability of application of materials, parts, equipment, and processes that are essential to the safety-related functions of the materials, parts, and components of the packaging.

(b) The licensee shall establish measures for the identification and control of design interfaces and for coordination among participating design organizations. These measures must include the establishment of written procedures among participating design organizations for the review, approval, release, distribution, and revision of documents involving design interfaces. The design control measures must provide for verifying or checking the adequacy of design, by methods such as design reviews, alternate or simplified calculational methods, or by a suitable testing program. For the verifying or checking process, the licensee shall designate individuals or groups other than those who were responsible for the original design, but who may be from the same organization. Where a test program is used to verify the adequacy of a specific design feature in lieu of other verifying or checking processes, the licensee shall include suitable qualification testing of a prototype or sample unit under the most adverse design conditions. The licensee shall

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apply design control measures to items such as the following: criticality physics, radiation shielding, stress, thermal, hydraulic, and accident analyses; compatibility of materials; accessibility for in-service inspection, maintenance, and repair; features to facilitate decontamination; and delineation of acceptance criteria for inspections tests.

(c) The licensee shall subject design changes, including field changes, to design control measures commensurate with those applied to the original design. Changes in the conditions specified in the package approval require NRC approval.

§ 71.109 Procurement document control.

The licensee shall establish measures to assure adequate quality is required in the documents for procurement of material, equipment, and services, whether purchased by the licensee or by its contractors or subcontractors. To the extent necessary, the licensee shall require contractors or subcontractors to provide a quality assurance program consistent with the applicable provisions of this part.

§ 71.111 Instructions, procedures, and drawings.

The licensee shall prescribe activities affecting quality by documented instructions, procedures, or drawings of a type appropriate to the circumstances and shall require that these instructions, procedures, and drawings be followed. The instructions, procedures, and drawings must include appropriate quantitative or qualitative acceptance criteria for determining that important activities have been satisfactorily accomplished.

§ 71.113 Document control.

The licensee shall establish measures to control the issuance of documents such as instructions, procedures, and drawings, including changes, which prescribe all activities affecting quality. These measures must assure that documents, including changes, are reviewed for adequacy, approved for release by authorized personnel, and distributed and used at the location where the prescribed activity is performed. These measures must assure that changes to documents are reviewed and approved.

§ 71.115 Control of purchased material, equipment, and services.

(a) The licensee shall establish measures to assure that purchased material, equipment, and services, whether purchased directly or through contractors and subcontractors, conform to the procurement documents. These

measures must include provisions, as appropriate, for source evaluation and selection, objective evidence of quality furnished by the contractor or subcontractor, inspection at the contractor or subcontractor source, and examination of products upon delivery.

(b) The licensee shall have available documentary evidence that material and equipment conform to the procurement specifications prior to installation or use of the material and equipment. The licensee shall retain or have available this documentary evidence for the life of the package to which it applies. The licensee shall assure that the evidence is sufficient to identify the specific requirements met by the purchased material and equipment.

(c) The licensee or designee shall assess the effectiveness of the control of quality by contractors and subcontractors at intervals consistent with the importance, complexity, and quantity of the product or services.

§ 71.117 Identification and control of materials, parts, and components.

The licensee shall establish measures for the identification and control of materials, parts, and components. These measures must assure that identification of the item is maintained by heat number, part number, or other appropriate means, either on the item or on records traceable to the item, as required throughout fabrication, installation, and use of the item. These identification and control measures must be designed to prevent the use of incorrect or defective materials, parts, and components.

§ 71.119 Control of special processes.

The licensee shall establish measures to assure that special processes, including welding, heat treating, and nondestructive testing, are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements.

§ 71.121 Internal inspection.

The licensee shall establish and execute a program for inspection of activities affecting quality by or for the organization performing the activity to verify conformance with the documented instructions, procedures, and drawings for accomplishing the activity. The inspection must be performed by individuals other than those who performed the activity being inspected. Examination, measurements, or tests of material or products processed must be performed for each work operation where necessary to

assure quality. If direct inspection of processed material or products is not carried out, indirect control by monitoring processing methods, equipment, and personnel must be provided. Both inspection and process monitoring must be provided when quality control is inadequate without both. If mandatory inspection hold points, which require witnessing or inspecting by the licensee's designated representative and beyond which work should not proceed without the consent of its designated representative, are required, the specific hold points must be indicated in appropriate documents.

§ 71.123 Test control.

The licensee shall establish a test program to assure that all testing required to demonstrate that the packaging components will perform satisfactorily in service is identified and performed in accordance with written test procedures which incorporate the requirements of this part and the requirements and acceptance limits contained in the package approval. The test procedures must include provisions for assuring that all prerequisites for the given test are met, that adequate test instrumentation is available and used, and that the test is performed under suitable environmental conditions. The licensee shall document and evaluate the test results to assure that test requirements have been satisfied.

§ 71.125 Control of measuring and test equipment.

The licensee shall establish measures to assure that tools, gages, instruments, and other measuring and testing devices used in activities affecting quality are properly controlled, calibrated, and adjusted at specified times to maintain accuracy within necessary limits.

§ 71.127 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.

§ 71.129 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 which 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.

§ 71.121 Nonconforming materials, parts, or components.

The licensee shall establish measures to control materials, parts, or components which do not conform to the licensee's requirements in order 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.

§ 71.123 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.

§ 71.125 Quality assurance records.

The licensee shall maintain sufficient written records to describe the activities affecting quality. The records must include the instructions, procedures, and drawings required by § 71.111 to prescribe quality assurance activities and must include closely related specifications such as required qualifications of personnel, procedures, and equipment. The records must include the instructions or procedures which establish a records retention program that is consistent with applicable regulations and designates factors such as duration, location, and assigned responsibility. The licensee shall retain these records for three 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 written procedures or instructions is superseded, the licensee shall retain the superseded material for three years after it is superseded.

§ 71.127 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.

Appendix A—Determination of A_1 and A_2

I. Single radionuclides.

(1) For a single radionuclide of known identity, the values of A_1 and A_2 are taken from Table A-1 if listed there. The values A_1 and A_2 in Table A-1 are also applicable for radionuclides contained in (a, n) or (y, n) neutron sources.

(2) For any single radionuclide whose identity is known but which is not listed in Table A-1, the values of A_1 and A_2 are determined according to the following procedure:

(a) If the radionuclide emits only one type of radiation, A_1 is determined according to the rules in paragraphs (i), (ii), (iii) and (iv) of this paragraph. For radionuclides emitting different kinds of radiation, A_1 is the most restrictive value of those determined for each kind of radiation. However, in both cases, A_1 is restricted to a maximum of 1000 Ci. If a parent nuclide decays into a shorter lived daughter with a half-life not greater than 10 days, A_1 is calculated for both the parent and the daughter, and the more limiting of the two values is assigned to the parent nuclide.

(i) For gamma emitters, A_1 is determined by the expression:

$$A_1 = \frac{S}{\Gamma} \text{ curies}$$

where Γ is the gamma-ray constant, corresponding to the dose in R/h at 1 m per Ci; the number 6 results from the choice of 1 rem/h at a distance of 3 m as the reference dose-equivalent rate.

(ii) For X-ray emitters, A_1 is determined by the atomic number of the nuclide:

for $Z < 85$ — $A_1 = 1000 \text{ Ci}$

for $Z > 85$ — $A_1 = 300 \text{ Ci}$

where Z is the atomic number of the nuclide.

(iii) For beta emitters, A_1 is determined by the maximum beta energy (E_{max}) according to Table A-2:

(iv) For alpha emitters, A_1 is determined by the expression:

$$A_1 = 1000 A_2$$

where A_2 is the value listed in Table A-2:

(b) A_2 is the more restrictive of the following two values:

(i) The corresponding A_1 ; and

(ii) The value A_2 obtained from Table A-2.

(3) For any single radionuclide whose identity is unknown, the value of A_1 is taken to be two Ci and the value of A_2 is taken to be 0.002 Ci. However, if the atomic number of the radionuclide is known to be less than 82, the value of A_1 is taken to be 10 Ci and the value of A_2 is taken to be 0.4 Ci.

II. Mixtures of radionuclides, including radioactive decay chains.

(1) For mixed fission products the following activity limits may be assumed if a detailed analysis of the mixture is not carried out:

$A_1 = 10 \text{ Ci}$

$A_2 = 0.4 \text{ Ci}$

(2) A single radioactive decay chain is considered to be a single radionuclide when the radionuclides are present in their naturally occurring proportions and no daughter nuclide has a half-life either longer than 10 days or longer than that of the parent nuclide. The activity to be taken into account and the A_1 or A_2 value from Table A-1 to be applied are those corresponding to the parent nuclide of that chain. When calculating A_1 or A_2 values, radiation emitted by daughters must be considered. However, in the case of radioactive decay chains in which any daughter nuclide has a half-life either longer than 10 days or greater than that of the parent nuclide, the parent and daughter nuclides are considered to be mixtures of different nuclides.

(3) In the case of a mixture of different radionuclides, where the identity and activity of each radionuclide are known, the permissible activity of each radionuclide R_1, R_2, \dots, R_n is such that $F_1 + F_2 + \dots + F_n$ is not greater than unity, where

$$F_1 = \frac{\text{Total activity of } R_1}{A_1(R_1)}$$

$$F_2 = \frac{\text{Total activity of } R_2}{A_2(R_2)}$$

$$F_n = \frac{\text{Total activity of } R_n}{A_n(R_n)}$$

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A_1 (R_1 , R_2 , R_3) is the value of A_1 or A_2 as appropriate for the nuclide R_1 , R_2 , R_3 .

(4) When the identity of each radionuclide is known but the individual activities of some of the radionuclides are not known, the formula given in paragraph (3) is applied to establish the values of A_1 or A_2 as appropriate. All the radionuclides whose individual activities are not known (their total activity will, however, be known) are classed in a single group and the most restrictive value of A_1 and A_2 applicable to any one of them is used as the value of A_1 or A_2 in the denominator of the fraction.

(5) Where the identity of each radionuclide is known but the individual activity of none of the radionuclides is known, the most restrictive value of A_1 or A_2 applicable to any one of the radionuclides present is adopted as the applicable value.

(6) When the identity of none of the nuclides is known, the value of A_1 is taken to be two Ci and the value of A_2 is taken to be 0.002 Ci. However, if alpha emitters are known to be absent, the value of A_2 is taken to be 0.4 Ci.

TABLE A-1.— A_1 AND A_2 VALUES FOR RADIONUCLIDES

(See footnotes at end of table)

Symbol of radionuclide	Element and atomic number	A_1 (Ci)	A_2 (Ci)	Specific activity (Ci/g)
$^{227}_{Ac}$	Actinium (89)	1000	0.003	7.2×10^4
$^{228}_{Ac}$		10	4	2.2×10^4
$^{105}_{Ag}$	Silver (47)	40	40	3.1×10^4
$^{110m}_{Ag}$		7	7	4.7×10^4
$^{111}_{Ag}$		100	20	1.8×10^4
$^{241}_{Am}$	Americium (95)	8	0.006	3.2
$^{243}_{Am}$		8	0.006	1.9×10^{-1}
$^{37}_{Ar}$ (compressed or uncompressed)*	Argon (18)	1000	1000	1.0×10^4
$^{41}_{Ar}$ (uncompressed)*		20	20	4.3×10^4
$^{41}_{Ar}$ (compressed)*		1	1	4.3×10^4
$^{73}_{As}$	Arsenic (33)	1000	400	2.4×10^4
$^{74}_{As}$		20	20	1.0×10^4
$^{76}_{As}$		10	10	1.8×10^4
$^{77}_{As}$		300	20	1.1×10^4
$^{211}_{At}$	Astatine (85)	200	7	2.1×10^4
$^{193}_{Au}$	Gold (79)	200	200	9.3×10^4
$^{196}_{Au}$		30	30	1.2×10^4
$^{198}_{Au}$		40	20	2.5×10^4
$^{199}_{Au}$		200	25	2.1×10^4
$^{131}_{Ba}$	Barium (56)	40	40	6.7×10^4
$^{133}_{Ba}$		40	10	4.0×10^4
$^{140}_{Ba}$		20	20	7.3×10^4
$^{7}_{Be}$	Beryllium (4)	300	200	3.5×10^4
$^{206}_{Bi}$	Bismuth (83)	5	5	9.9×10^4
$^{207}_{Bi}$		10	25	2.2×10^4
$^{210}_{Bi}$		100	4	1.2×10^4
$^{210_{m}}_{Bi}$		5	5	1.5×10^4
$^{212}_{Bi}$		8	6	1.8×10^4
$^{249}_{Bk}$	Berkelium (97)	1000	1	1.8×10^4
$^{77}_{Br}$	Bromine (35)	70	25	7.1×10^4

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TABLE A-1.— A_1 AND A_2 VALUES FOR RADIONUCLIDES—Continued

(See footnotes at end of table)

Symbol of radionuclide	Element and atomic number	A_1 (Ci)	A_2 (Ci)	Specific activity (Ci/g)
82 _{pb}		6	6	1.1×10^4
11 _c	Carbon (6)	20	20	8.4×10^4
14 _c		1000	80	4.8
45 _{ca}	Calcium (20)	1000	25	1.9×10^4
47 _{ca}		20	20	8.9×10^4
109 _{co}	Cadmium (48)	1000	70	2.6×10^4
115 _{mco}		30	30	2.6×10^4
115 _{co}		80	20	5.1×10^4
139 _{ce}	Cerium (58)	100	100	6.5×10^4
141 _{ce}		300	25	2.6×10^4
143 _{ce}		80	20	6.8×10^4
144 _{ce}		10	7	2.2×10^4
249 _{cf}	Californium (98)	2	0.002	3.1
250 _{cf}		7	0.007	1.3×10^4
252 _{cf}		2	0.006	6.5×10^4
36 _{cl}	Chlorine (17)	300	10	3.2×10^4
38 _{cl}		10	10	1.3×10^4
242 _{cm}	Curium (96)	300	0.2	2.3×10^4
243 _{cm}		8	0.006	4.2×10^4
244 _{cm}		10	0.01	8.2×10^4
245 _{cm}		6	0.006	1.0×10^4
246 _{cm}		6	0.006	3.6×10^4
56 _{co}	Cobalt (27)	5	5	3.0×10^4
57 _{co}		80	80	8.5×10^4
58 _{mco}		1000	1000	8.9×10^4
58 _{co}		20	20	3.1×10^4
60 _{co}		7	7	1.1×10^4
51 _{cr}	Chromium (24)	800	800	8.2×10^4
129 _{cs}	Cesium (55)	40	40	7.8×10^4
131 _{cs}		1000	1000	1.0×10^4
134 _{mcs}		1000	10	7.4×10^4
134 _{cs}		10	10	1.2×10^4
135 _{cs}		1000	25	8.8×10^4
136 _{cs}		7	7	7.4×10^4
137 _{cs}		30	10	8.8×10^4
64 _{cu}	Copper (29)	80	25	3.8×10^4
67 _{cu}		200	25	7.9×10^4
165 _{dy}	Dysprosium (66)	100	20	8.2×10^4
166 _{dy}		1000	200	2.3×10^4
169 _{dy}	Erbium (68)	1000	25	8.2×10^4
171 _{dy}		80	20	2.4×10^4
152 _{mEu}	Europium (63)	30	30	2.2×10^4
152 _{Eu}		20	10	1.9×10^4
154 _{Eu}		10	6	1.5×10^4
155 _{Eu}		400	80	1.4×10^4
18 _f	Fluorine (9)	20	20	8.3×10^4
52 _{fe}	Iron (26)	6	6	7.3×10^4
55 _{fe}		1000	1000	2.2×10^4
59 _{fe}		10	10	4.8×10^4
67 _{ga}	Gallium (31)	100	100	6.0×10^4
68 _{ga}		20	20	4.0×10^4
72 _{ga}		7	7	2.1×10^4
153 _{gd}	Gadolinium (64)	200	100	3.8×10^4
159 _{gd}		300	20	1.1×10^4
68 _{ge}	Germanium (32)	20	10	7.0×10^4
71 _{ge}		1000	1000	1.6×10^4
3 _h	Hydrogen (1) see T-Tritium	30	25	1.6×10^4
181 _{hl}	Hassium (72)	200	200	6.6×10^4
197 _{mHg}	Mercury (80)	200	200	2.5×10^4
197 _{hg}		80	25	1.4×10^4
203 _{mTl}		30	30	6.9×10^4
186 _{ho}	Holmium (67)	80	80	1.9×10^4
123 _i	Iodine (53)	1000	70	1.7×10^4
125 _i		40	10	7.8×10^4
126 _i		1000	2	1.6×10^4
129 _i		40	10	1.2×10^4
131 _i		7	7	1.1×10^4
132 _i				

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TABLE A-1.— A_1 AND A_2 VALUES FOR RADIONUCLIDES—Continued

(See footnotes at end of table)

Symbol of radionuclide	Element and atomic number	A_1 (Ci)	A_2 (Ci)	Specific activity (Ci/g)
133 _I		30	10	1.1×10^6
134 _I		8	8	2.7×10^5
135 _I		10	10	2.5×10^6
111 _{In}	Indium (49)	30	25	4.2×10^6
113 _m _{In}		80	80	1.8×10^7
114 _m _{In}		30	20	2.3×10^6
115 _m _{In}		100	20	8.1×10^6
190 _{Tl}	Indium (77)	10	10	6.2×10^6
192 _{Tl}		20	10	8.1×10^6
194 _{Tl}		10	10	8.5×10^6
42 _K	Potassium (19)	10	10	6.0×10^6
43 _K		20	10	2.3×10^6
85 _m _K (uncompressed)*	Krypton (36)	100	100	8.4×10^6
85 _m _K (compressed)*		3	3	8.4×10^6
85 _K (uncompressed)*		1000	1000	4.0×10^6
85 _K (compressed)*		5	5	4.0×10^6
87 _K (uncompressed)*		20	20	2.8×10^7
87 _K (compressed)*		0.8	0.8	2.8×10^7
140 _{La}	Lanthanum (57)	30	30	5.6×10^6
177 _{Lu}	Low specific activity material—see § 71.4	300	25	1.1×10^6
26 _{Mg}	Mixed fission products	10	0.4	
52 _{Mn}	Magnesium (12)	5	5	5.2×10^6
54 _{Mn}	Manganese (25)	5	5	4.4×10^6
56 _{Mn}		20	20	8.3×10^6
99 _{Mo}		5	5	2.2×10^7
99 _m _{Tc}	Molybdenum (42)	100	20	4.7×10^6
13 _N	Nitrogen (7)	20	10	1.5×10^6
22 _{Na}	Sodium (11)	8	8	6.3×10^6
24 _{Na}		5	5	8.7×10^6
93 _{Nb}	Niobium (41)	1000	200	1.1×10^6
95 _{Nb}		20	20	3.9×10^6
97 _{Nb}		20	20	2.6×10^7
147 _{Nd}	Neodymium (60)	100	20	8.0×10^6
149 _{Nd}		30	20	1.1×10^7
59 _{Ni}	Nickel (28)	1000	900	8.1×10^6
63 _{Ni}		1000	100	4.6×10^6
65 _{Ni}		10	10	1.9×10^7
237 _{Np}	Neptunium (93)	5	0.005	8.9×10^6
239 _{Np}		200	25	2.3×10^6
185 _{Og}	Osmium (76)	20	20	7.3×10^6
191 _{Og}		800	200	4.6×10^6
191 _m _{Og}		200	200	1.2×10^6
193 _{Og}		100	20	6.3×10^6
32 _P	Phosphorus (15)	30	30	2.9×10^6
230 _{Pa}	Protactinium (91)	20	0.8	3.2×10^6
231 _{Pa}		2	0.002	4.5×10^6
233 _{Pa}		100	100	2.1×10^6
201 _{Pb}	Lead (82)	20	20	1.7×10^6
210 _{Pb}		100	0.2	8.8×10^6
212 _{Pb}		6	6	1.4×10^6
103 _{Pd}	Palladium (46)	1000	700	7.5×10^6
109 _{Pd}		100	20	2.1×10^6
147 _{Pm}	Promethium (61)	1000	25	8.4×10^6
149 _{Pm}		100	20	4.2×10^6
210 _{Po}	Polonium (84)	200	0.2	4.5×10^6
142 _{Pr}	Praseodymium (59)	10	10	1.2×10^6
143 _{Pr}		300	20	6.6×10^6
191 _{Pt}	Platinum (78)	100	100	2.3×10^6
193 _m _{Pt}		200	200	2.0×10^6
197 _m _{Pt}		300	20	1.2×10^6
197 _{Pt}		300	20	6.3×10^6
238 _{Pu}	Plutonium (94)	3	0.003	1.7×10^6
239 _{Pu}		2	0.002	6.2×10^6
240 _{Pu}		2	0.002	2.3×10^6
241 _{Pu}		1000	0.1	1.1×10^6
242 _{Pu}		3	0.003	3.9×10^6
223 _{Ra}	Radium (88)	50	0.2	5.0×10^6

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TABLE A-1.—A₁ AND A₂ VALUES FOR RADIONUCLIDES—Continued

(See footnotes at end of table)

Symbol of radionuclide	Element and atomic number	A ₁ (Ci)	A ₂ (Ci)	Specific activity (Ci/g)
224 _{ra}		8	0.5	1.6 × 10 ⁶
226 _{ra}		10	0.05	1.0
228 _{ra}		10	0.05	2.3 × 10 ⁶
81 _{rb}	Rubidium (37)	30	25	8.2 × 10 ⁶
86 _{rb}		30	30	8.1 × 10 ⁶
87 _{rb}		Unlimited.	Unlimited.	6.8 × 10 ⁶
87 _{rb} (natural)		Unlimited.	Unlimited.	1.8 × 10 ⁷
186 _{rh}	Rhenum (75)	100	20	1.9 × 10 ⁶
187 _{rh}		Unlimited.	Unlimited.	3.8 × 10 ⁶
188 _{rh}		10	10	1.0 × 10 ⁶
188 _{rh} (natural)		Unlimited.	Unlimited.	2.4 × 10 ⁷
103 _{rh}	Rhodium (45)	1000	1000	3.2 × 10 ⁶
105 _{rh}		200	25	8.2 × 10 ⁶
222 _{rn}	Radon (86)	10	2	1.5 × 10 ⁶
97 _{ru}	Ruthenium (44)	80	80	5.5 × 10 ⁶
103 _{ru}		30	25	3.2 × 10 ⁶
105 _{ru}		20	30	6.5 × 10 ⁶
106 _{ru}		10	7	2.4 × 10 ⁶
35 _s	Sulphur (16)	1000	80	4.3 × 10 ⁶
122 _{sb}	Antimony (51)	30	30	3.9 × 10 ⁶
124 _{sb}		8	8	1.8 × 10 ⁶
125 _{sb}		40	25	1.4 × 10 ⁶
46 _{sc}	Scandium (21)	8	8	3.4 × 10 ⁶
47 _{sc}		200	20	8.2 × 10 ⁶
48 _{sc}		8	8	1.5 × 10 ⁶
75 _{se}	Selenium (34)	40	40	1.4 × 10 ⁶
31 _{si}	Silicon (14)	100	20	3.9 × 10 ⁶
147 _{sm}	Samarium (62)	Unlimited.	Unlimited.	2.0 × 10 ⁶
151 _{sm}		1000	80	2.6 × 10 ⁶
153 _{sm}		300	20	4.4 × 10 ⁶
113 _{sn}	Tin (50)	80	80	1.0 × 10 ⁶
119 _{sn}		100	100	4.4 × 10 ⁶
125 _{sn}		10	10	1.1 × 10 ⁶
85 _{sr}	Strontium (38)	80	80	3.2 × 10 ⁶
85 _{sr}		30	30	2.4 × 10 ⁶
87 _{sr}		80	80	1.2 × 10 ⁶
89 _{sr}		100	10	2.9 × 10 ⁶
90 _{sr}		10	0.4	1.5 × 10 ⁶
91 _{sr}		10	10	3.6 × 10 ⁶
92 _{sr}		10	10	1.3 × 10 ⁶
T ₂ (uncompressed)*	Tritium (1)	1000	1000	8.7 × 10 ⁶
T ₂ (compressed)*		1000	1000	8.7 × 10 ⁶
T ₂ (activated luminous paint)		1000	1000	8.7 × 10 ⁶
T ₂ (adsorbed on solid carrier)		1000	1000	8.7 × 10 ⁶
T ₂ (tritiated water)		1000	1000	8.7 × 10 ⁶
T ₂ (other forms)		20	20	8.7 × 10 ⁶
182 _{ta}	Tantalum (73)	20	20	6.2 × 10 ⁶
180 _{tb}	Terbium (65)	20	10	1.1 × 10 ⁶
95 _{tc}	Technetium (43)	1000	1000	3.8 × 10 ⁶
96 _{tc}		8	8	3.2 × 10 ⁶
97 _{tc}		1000	200	1.5 × 10 ⁶
97 _{tc}		1000	400	1.4 × 10 ⁶
97 _{tc}		100	100	5.2 × 10 ⁶
99 _{tc}		1000	25	1.7 × 10 ⁶
98 _{tc}		1000	100	1.8 × 10 ⁶
125 _{te}	Tellurium (52)	300	20	4.0 × 10 ⁶
127 _{te}		300	20	2.6 × 10 ⁶
127 _{te}		30	10	2.5 × 10 ⁶
129 _{te}		100	20	2.0 × 10 ⁶
129 _{te}		10	10	6.0 × 10 ⁶
131 _{te}		7	7	3.1 × 10 ⁶
132 _{th}		200	0.2	3.2 × 10 ⁶
227 _{th}	Thorium (90)	8	0.008	8.3 × 10 ⁶
228 _{th}		3	0.003	1.9 × 10 ⁶
230 _{th}		1000	25	5.3 × 10 ⁶
231 _{th}		Unlimited.	Unlimited.	1.1 × 10 ⁷
232 _{th}		10	10	2.3 × 10 ⁶
234 _{th}		Unlimited.	Unlimited.	2.2 × 10 ⁷
234 _{th} (natural)				

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TABLE A-1.— A_1 AND A_2 VALUES FOR RADIONUCLIDES—Continued

(See footnotes at end of table)

Symbol of radionuclide	Element and atomic number	A_1 (Ci)	A_2 (Ci)	Specific activity (Ci/g)
^{200}Tl (irradiated)**	Thallium (81)	20	20	5.8×10^6
^{201}Tl		200	200	2.2×10^6
^{202}Tl		40	40	5.4×10^6
^{204}Tl		300	10	4.3×10^6
^{170}Th	Thulium (69)	300	10	8.0×10^6
^{171}Th		1000	100	1.1×10^6
^{230}U	Uranium (92)	100	0.1	2.7×10^6
^{232}U		30	0.03	2.1×10^6
^{233}U		100	0.1	8.5×10^5
^{234}U		100	0.1	6.2×10^5
^{235}U		100	0.2	2.1×10^6
^{236}U		200	0.2	6.3×10^5
^{238}U		Unlimited	Unlimited	3.3×10^7
$^{\text{U}}$ (natural)	Unlimited	Unlimited	(SEE TABLE A-4)	
$^{\text{U}}$ (enriched) < 20%	Unlimited	Unlimited	(SEE TABLE A-4)	
20% or greater	100	0.1	(SEE TABLE A-4)	
$^{\text{U}}$ (depleted)	Unlimited	Unlimited	(SEE TABLE A-4)	
$^{\text{U}}$ (irradiated)***				
^{48}V	Vanadium (23)	6	6	1.7×10^6
^{181}W	Tungsten (74)	200	100	5.0×10^6
^{185}W		1000	25	6.7×10^5
^{187}W	Xenon (54)	40	20	7.0×10^6
^{127}Xe (uncompressed)*		70	70	2.8×10^6
^{127}Xe (compressed)*		5	5	2.8×10^6
^{131}mXe (compressed)*		10	10	1.0×10^6
^{131}mXe (uncompressed)*		100	100	1.0×10^6
^{133}Xe (uncompressed)*		1000	1000	1.8×10^6
^{133}Xe (compressed)*		5	5	1.9×10^6
^{135}Xe (uncompressed)*		70	70	2.5×10^6
^{135}Xe (compressed)*	2	2	2.5×10^6	
^{87}Y	Yttrium (39)	20	20	4.5×10^6
^{90}Y		10	10	2.5×10^6
$^{91\text{m}}\text{Y}$		30	30	4.1×10^7
^{91}Y		30	30	2.5×10^6
^{92}Y		10	10	8.5×10^6
^{93}Y	10	10	3.2×10^6	
^{169}Yb	Ytterbium (70)	80	80	2.3×10^6
^{175}Yb		400	25	1.8×10^6
^{65}Zn	Zinc (30)	30	30	8.0×10^6
$^{69\text{m}}\text{Zn}$		40	20	3.3×10^6
^{69}Zn		300	20	5.3×10^7
^{93}Zr	Zirconium (40)	1000	200	3.5×10^5
^{95}Zr		20	20	2.1×10^6
^{97}Zr		20	20	2.0×10^6

* For the purpose of Table A-1, compressed gas means a gas at a pressure which exceeds the ambient atmospheric pressure at the location where the containment system was closed.

** The values of A_1 and A_2 must be calculated in accordance with the procedure specified in Appendix A, paragraph II(3), taking into account the activity of the fission products and of the uranium-233 in addition to that of the thorium.

*** The values of A_1 and A_2 must be calculated in accordance with the procedure specified in Appendix A, paragraph II(3), taking into account the activity of the fission products and plutonium isotopes in addition to that of the uranium.

TABLE A-2

RELATIONSHIP BETWEEN A_1 AND E_{MAX} FOR BETA EMITTERS

E_{MAX} (MeV)	A_1 (Ci)
< 0.5	1000
0.5 - < 1.0	300
1.0 - < 1.5	100
1.5 - < 2.0	30
≥ 2.0	10

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TABLE A-3

RELATIONSHIP BETWEEN A_3 AND THE ATOMIC NUMBER
OF THE RADIONUCLIDE

A_3			
Atomic Number	Half-life less than 1000 days	Half-life 1000 days to 10^6 years	Half-life greater than 10^6 years
1 to 81	3 Ci	.05 Ci	3 Ci
82 and above	.002 Ci	.002 Ci	3 Ci

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TABLE A-4.—ACTIVITY-MASS RELATIONSHIPS
FOR URANIUM/THORIUM

Thorium and uranium enrichment ¹ wt % ²³⁵ U present	Specific activity	
	ci/g	g/ci
0.45.....	5.0×10^{-1}	2.0×10^6
0.72 (natural).....	7.06×10^{-1}	1.42×10^6
1.0.....	7.6×10^{-1}	1.3×10^6
1.5.....	1.0×10^{-6}	1.0×10^6
5.0.....	2.7×10^{-6}	3.7×10^5
10.0.....	4.8×10^{-6}	2.1×10^5
20.0.....	1.0×10^{-5}	1.0×10^5
35.0.....	2.0×10^{-5}	5.0×10^4
50.0.....	2.5×10^{-5}	4.0×10^4
90.0.....	5.8×10^{-5}	1.7×10^4
93.0.....	7.0×10^{-5}	1.4×10^4
95.0.....	9.1×10^{-5}	1.1×10^4
Natural Thorium.....	2.2×10^{-1}	4.6×10^6

¹ The figures for uranium include representative values for the activity of the uranium-234 which is concentrated during the enrichment process. The activity for Thorium includes the equilibrium concentration of Thorium-228.