DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

Hazardous Materials and Waste Management Division

RADIATION CONTROL - RADIATION SAFETY REQUIREMENTS FOR WIRELINE SERVICE OPERATIONS AND SUBSURFACE TRACER STUDIES; TRANSPORTATION OF RADIOACTIVE MATERIAL; LICENSING REQUIREMENTS FOR URANIUM AND THORIUM PROCESSING; LICENSES AND RADIATION SAFETY REQUIREMENTS FOR IRRADIATORS; RESERVED

6 CCR 1007-1 Parts 16-20

[Editor's Notes follow the text of the rules at the end of this CCR Document.]

PART 16: RADIATION SAFETY REQUIREMENTS FOR WIRELINE SERVICE OPERATIONS AND SUBSURFACE TRACER STUDIES

RADIATION SAFETY REQUIREMENTS FOR WIRELINE SERVICE OPERATIONS AND SUBSURFACE TRACER STUDIES

16.1 Purpose and Scope.

16.1.1 Authority.

Rules and regulations set forth herein are adopted pursuant to the provisions of Sections 25-1-108, 25-1.5-101(1)(l), and 25-11-104, CRS.

16.1.2 Basis and Purpose.

A statement of basis and purpose accompanies this part and changes to this part. A copy may be obtained from the Department.

16.1.3 Scope.

The regulations in this part establish radiation safety requirements for using sources of radiation for wireline service operations including mineral-logging, radioactive markers, and subsurface tracer studies.

16.1.4 Applicability.

The regulations in this part apply to all applicants, licensees or registrants who use sources of radiation for wireline service operations including mineral-logging, radioactive markers, or subsurface tracer studies. The requirements of this part are in addition to, and not in substitution for, the requirements of Parts 1, 2, 3, 4, and 10 of these regulations.

16.1.5 Published Material Incorporated by Reference.

Published material incorporated in Part 16 by reference is available in accord with Part 1, Section 1.4.

16.2 Definitions.

As used in this part, these terms have the definitions set forth as follows.

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

“Field station” means a facility where radioactive sources may be stored or used and from which equipment is dispatched to temporary jobsites.

“Injection tool” means a device used for controlled subsurface injection of radioactive tracer material.

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

“Logging assistant” means any individual who, under the personal supervision of a logging supervisor, handles sealed sources or tracers that are not in logging tools or shipping containers or who performs surveys required by 16.22.

“Logging supervisor” means the individual who uses sources of radiation or provides personal supervision of the utilization of sources of radiation at the well site.

“Logging tool” means a device used subsurface to perform well-logging.

“Mineral logging” means any logging performed for the purpose of mineral exploration other than oil or gas.

“Personal supervision” means guidance and instruction by the supervisor who is physically present at the jobsite and watching the performance of the operation in such proximity that contact can be maintained and immediate assistance given as required.

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

“Safety review” means a periodic review provided by the licensee for its employees on radiation safety aspects of well-logging, with opportunities for employees to ask safety questions. The review shall include, as appropriate, the results of internal inspections, new procedures or equipment, and accidents or errors that have been observed.

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

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

“Temporary jobsite” means a location where radioactive materials are present for the purpose of performing wireline service operations or subsurface tracer studies.

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

“Uranium sinker bar” means a weight containing depleted uranium used to pull a logging tool down toward the bottom of a well.

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

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

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

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

PROHIBITION

16.4 Prohibition.

No licensee shall perform wireline service operations with a sealed source(s) unless, prior to commencement of the operation, the licensee has a written agreement with the well-operator, well-owner, drilling contractor, or land owner that:

16.4.1 In the event a sealed source is lodged downhole, a reasonable effort at recovery will be made; and

16.4.2 In the event a decision is made to abandon the sealed source downhole, the requirements of 16.25 and of any other State agency having applicable regulations shall be met.

EQUIPMENT CONTROL

16.5 Limits on Levels of Radiation.

Sources of radiation shall be used, stored, and transported in such a manner that the transportation requirements of Part 17 and the dose limitation requirements of Part 4 of these regulations are met.

16.6 Storage Precautions.

16.6.1 Each source of radiation, except an accelerator, shall be provided with a storage or transport container. The container shall be provided with a lock, or tamper seal for calibration sources, to prevent unauthorized removal of, or exposure to, the source of radiation.

16.6.2 Sources of radiation shall be stored in a manner which will minimize danger from explosion or fire.

16.7 Transport Precautions.

Transport containers shall be physically secured to the transporting vehicle to prevent accidental loss, tampering, or unauthorized removal.

16.8 Radiation Survey Instruments.

16.8.1 The licensee or registrant shall keep a calibrated and operable radiation survey instrument capable of detecting beta and gamma radiation at each field station and temporary jobsite to make the radiation surveys required by this part and by Part 4 of these regulations. To satisfy this requirement, the radiation survey instrument must be capable of measuring 0.001 mSv (0.1 mrem) per hour through at least 0.5 mSv (50 mrem) per hour.

16.8.2 Each radiation survey instrument shall be calibrated:

16.8.2.1 At intervals not to exceed 6 months and after each instrument servicing;

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

16.8.2.3 So that accuracy within 20 percent of the true radiation level can be demonstrated on each scale.

16.8.3 Calibration records shall be maintained for a period of 2 years for inspection by the Department.

16.9 Leak Testing of Sealed Sources.

16.9.1 Requirements.

Each licensee using sealed sources of radioactive material shall have the sources tested for leakage. Records of leak test results shall be kept in units of becquerel (Bq) (or microcurie, μCi) and maintained for inspection by the Department for 6 months after the next required leak test is performed or until transfer or disposal of the sealed source.

16.9.2 Method of Testing.

16.9.2.1 Tests for leakage shall be performed using a leak test kit or method approved by the Department, the U.S. Nuclear Regulatory Commission, an Agreement State, or a Licensing State.

16.9.2.2 The test sample shall be taken from the nearest accessible point to the surface of the sealed source where contamination is likely to accumulate.

16.9.2.3 The test sample shall be analyzed for radioactive contamination.

16.9.2.4 The analysis shall be capable of detecting the presence of 185 Bq (0.005 microcurie) of radioactive material on the test sample and must be performed by a person specifically approved by the Department, the U.S. Nuclear Regulatory Commission, an Agreement State, or a Licensing State to perform the analysis.

16.9.3 Interval of Testing.

16.9.3.1 Each sealed source of radioactive material (except an energy compensation source (ECS)) shall be tested at intervals not to exceed 6 months. In the absence of a certificate from a transferor indicating that a test has been made within 6 months prior to the transfer, the sealed source shall not be used until tested.

16.9.3.2 Each ECS that is not exempt from testing in accordance with 16.9.5 must be tested at intervals not to exceed 3 years. In the absence of a certificate from a transferor indicating that a test has been made within the 3 years prior to the transfer, the ECS shall not be used until tested.

16.9.4 Leaking or Contaminated Sources.

If, for any reason, it is suspected that a sealed source may be leaking, it shall be removed from service immediately and tested for leakage as soon as practical.

16.9.4.1 If the test reveals the presence of 185 Bq (0.005 microcurie) or more of removable radioactive material, the licensee shall immediately withdraw the source from use and shall cause it to be decontaminated and repaired, or disposed of, by a licensee authorized by the Department, U.S. Nuclear Regulatory Commission, Agreement State, or a Licensing State to perform these functions.

16.9.4.2 The licensee shall check the equipment associated with the leaking source for radioactive contamination and, if contaminated, have it decontaminated or disposed of by a licensee authorized by the Department, U.S. Nuclear Regulatory Commission, Agreement State, or a Licensing State to perform these functions.

16.9.4.3 A report describing the equipment involved, the test results, and the corrective action taken shall be filed with the Department within 5 days of receiving the test results.

16.9.5 Exemptions.

The following sources are exempted from the periodic leak test requirements of 16.9.1 through 16.9.4:

16.9.5.1 Hydrogen-3 (tritium) sources;

16.9.5.2 Sources of radioactive material with a half-life of 30 days or less;

16.9.5.3 Sealed sources of radioactive material in gaseous form;

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

16.9.5.5 Sources of alpha-emitting radioactive material with an activity of 0.37 MBq (10 microcurie) or less.

16.10 Quarterly Inventory.

16.10.1 Each licensee or registrant shall conduct a quarterly physical inventory to account for all sources of radiation.

16.10.2 Records of inventories shall be maintained for 2 years from the date of the inventory for inspection by the Department and shall include the quantities and kinds of sources of radiation, the location where sources of radiation are assigned, the date of the inventory, and the name of the individual conducting the inventory.

16.11 Utilization Records.

16.11.1 Each licensee or registrant shall maintain current records, which shall be kept available for inspection by the Department for 2 years from the date of the recorded event.

16.11.2 The records shall show the following information for each source of radiation:

16.11.2.1 Make, model number, and a serial number or a description of each source of radiation used;

16.11.2.2 The identity of the well-logging supervisor or field unit to whom assigned; and

16.11.2.3 Locations where used and dates of use.

16.11.3 In the case of tracer materials and radioactive markers, the utilization record shall indicate the radionuclide and activity used in a particular well.

16.12 Design, Performance, and Certification Criteria for Sealed Sources Used in Downhole Operations.

16.12.1 Each sealed source, except energy compensation sources (ECS) and those containing radioactive material in gaseous form, used in downhole operations and manufactured after December 30, 1986, shall be certified by the manufacturer, or other testing organization acceptable to the Department, to meet the following minimum criteria:

16.12.1.1 Be of doubly encapsulated construction;

16.12.1.2 Contain radioactive material whose chemical and physical forms are as insoluble and non-dispersible as practical; and

16.12.1.3 Satisfies the requirements of 16.12.3.1, 16.12.3.2, or 16.12.3.3, as appropriate.

16.12.2 For sealed sources, except those containing radioactive material in gaseous form, acquired after December 30, 1986, in the absence of a certificate from a transferor certifying that an individual sealed source meets the requirements of 16.12.1, the sealed source shall not be put into use until such determinations and testing have been performed.

16.12.3 Each sealed source, except energy compensation sources (ECS) and those containing radioactive material in gaseous form, used in downhole operations after December 30, 1986, shall be certified by the manufacturer, or other testing organization acceptable to the Department, as meeting the sealed source performance requirements for oil well-logging:

16.12.3.1 For a sealed source manufactured on or before July 14, 1989, a licensee may use the sealed source, for use in well logging applications, if it meets the requirements of United States Of America Standards Institute (USASI) N5.10-1968, “Classification of Sealed Radioactive Sources” (1968), or the requirements in 16.12.3.2 or 16.12.3.3.

16.12.3.2 For a sealed source manufactured after July 14, 1989, a licensee may use the sealed source, for use in well logging applications, if it meets the oil well logging requirements of American National Standards Institute / Health Physics Society (ANSI/HPS) N43.6-1997, “Sealed Radioactive Sources Classification” (November 1997).

16.12.3.3 For a sealed source manufactured after July 14, 1989, a licensee may use the sealed source, for use in well logging applications, if the sealed source's prototype has been tested and found to maintain its integrity after each of the following tests:

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

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

(3) Vibration test. The test source must be subject to a vibration from 25 Hz to 500 Hz at 5 g amplitude for 30 minutes.

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

(5) Pressure test. The test source must be subject to an external pressure of 1.695 x 10^7 pascal [24,600 pounds per square inch absolute].

16.12.4 Certification documents shall be maintained for inspection by the Department for a period of 2 years after source disposal. If the source is abandoned downhole, the certification documents shall be maintained until the Department authorizes disposition.

16.12.5 Use of an energy compensation source (ECS) is subject to this part, except that if the ECS is contained within a logging tool, or other tool components, and contains quantities of licensed material not exceeding 3.7 MBq (100 microcurie), the ECS is only subject to the requirements:

16.12.5.1 Of 16.9, 16.10 and 16.11 for well logging applications with a surface casing for protecting fresh water aquifers; or

16.12.5.2 Of 16.9, 16.10, 16.11, 16.12 and 16.25 for well logging applications without a surface casing for protecting fresh water aquifers.

16.12.6 Use of a tritium neutron generation target source is subject to this part, except the requirements:

16.12.6.1 Of 16.12 and 16.25 do not apply for use of a tritium neutron generation target source containing quantities not exceeding 1,110 MBq (30 curie) and in a well with a surface casing for protecting fresh water aquifers; and

16.12.6.2 Of 16.12 do not apply for use of a tritium neutron generation target source containing quantities exceeding 1,110 MBq (30 curie) or in a well without a surface casing for protecting fresh water aquifers.

16.13 Labeling.

16.13.1 Each source, source holder, or logging tool containing radioactive material shall bear a durable, legible, and clearly visible marking or label, which has, as a minimum, the standard radiation caution symbol, without the conventional color requirement, and the following wording:

DANGER* – RADIOACTIVE

*or “CAUTION”

This labeling shall be on the smallest component transported as a separate piece of equipment.

16.13.2 Each transport container shall have permanently attached to it a durable, legible, and clearly visible label which has, as a minimum, the standard radiation caution symbol and the following wording:

DANGER*- RADIOACTIVE

NOTIFY CIVIL AUTHORITIES [OR NAME OF COMPANY]

*or “CAUTION”

16.13.3 The licensee may use a uranium sinker bar in well logging applications only if it is legibly impressed with the following wording:

CAUTION--RADIOACTIVE--DEPLETED URANIUM

and

NOTIFY CIVIL AUTHORITIES [OR COMPANY NAME] IF FOUND

16.14 Inspection and Maintenance.

16.14.1 Each licensee or registrant shall conduct, at intervals not to exceed 6 months, a program of inspection and maintenance of source holders, logging tools, source handling tools, storage containers, transport containers, and injection tools to assure proper labeling and physical condition.

16.14.2 If any inspection conducted pursuant to 16.14.1 reveals damage to labeling or components critical to radiation safety, the device shall be removed from service until repairs have been made.

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

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

16.14.5 Records of inspection and maintenance shall be maintained for a period of 2 years for inspection by the Department.

REQUIREMENTS FOR PERSONNEL SAFETY

16.15 Training Requirements.

16.15.1 No licensee or registrant shall permit any individual to act as a logging supervisor as defined in this part until such individual has:

16.15.1.1 Received, in a course recognized by the Department, the U.S. Nuclear Regulatory Commission, an Agreement State, or a Licensing State, instruction in the subjects outlined in Appendix 16A and demonstrated an understanding thereof;

16.15.1.2 Read and received instruction in the regulations contained in this part and the applicable sections of Parts 1, 4, and 10 of these regulations or their equivalent, conditions of appropriate license or certificate of registration, and the licensee's or registrant's operating and emergency procedures, and demonstrated an understanding thereof; and

16.15.1.3 Demonstrated competence to use sources of radiation, related handling tools, and radiation survey instruments which will be used on the job.

16.15.2 No licensee or registrant shall permit any individual to assist in the handling of sources of radiation until such individual has:

16.15.2.1 Read or received instruction in the licensee's or registrant's operating and emergency procedures and demonstrated an understanding thereof; and

16.15.2.2 Demonstrated competence to use, under the personal supervision of the logging supervisor, the sources of radiation, related handling tools, and radiation survey instruments which will be used on the job.

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

16.15.4 The licensee or registrant shall maintain employee training records for inspection by the Department for 2 years following termination of the individual's employment.

16.16 Operating and Emergency Procedures.

The licensee's or registrant's operating and emergency procedures shall include instructions in at least the following:

16.16.1 Handling and use of sources of radiation to be employed so that no individual is likely to be exposed to radiation doses in excess of the standards established in Part 4 of these regulations;

16.16.2 Methods and occasions for conducting radiation surveys;

16.16.3 Methods and occasions for locking and securing sources of radiation;

16.16.4 Personnel monitoring and the use of personnel monitoring equipment;

16.16.5 Transportation to temporary jobsites and field stations, including the packaging and placing of sources of radiation in vehicles, placarding of vehicles, and securing sources of radiation during transportation;

16.16.6 Minimizing exposure of individuals in the event of an accident;

16.16.7 Procedure for notifying proper personnel in the event of an accident;

16.16.8 Maintenance of records;

16.16.9 Use, inspection and maintenance of source holders, logging tools, source handling tools, storage containers, transport containers, and injection tools;

16.16.10 Procedure to be followed in the event a sealed source is lodged downhole;

16.16.11 Procedures to be used for picking up, receiving, and opening packages containing radioactive material;

16.16.12 For the use of tracers, decontamination of the environment, equipment, and personnel;

16.16.13 Maintenance of records generated by logging personnel at temporary jobsites;

16.16.14 Notifying proper persons in the event of an accident; and

16.16.15 Actions to be taken if a sealed source is ruptured, including actions to prevent the spread of contamination and minimize inhalation and ingestion of radioactive material and actions to obtain suitable radiation survey instruments as required by 16.8.

16.17 Personnel Monitoring.

16.17.1 No licensee or registrant shall permit any individual to act as a logging supervisor or to assist in the handling of sources of radiation unless each such individual wears, at all times during the handling of such sources, a personnel dosimeter that is processed and evaluated by an accredited National Voluntary Laboratory Accreditation Program (NVLAP) processor.

16.7.1.1 Each personnel dosimeter shall be assigned to and worn by only one individual.

16.7.1.2 Film badges must be replaced at least monthly. Other types of personnel dosimeter must be replaced at least quarterly.

16.7.1.3 After replacement, each personnel dosimeter must be promptly processed.

16.17.2 Personnel monitoring records shall be maintained for inspection until the Department authorizes disposition.

PRECAUTIONARY PROCEDURES IN LOGGING AND SUBSURFACE TRACER OPERATIONS

16.18 Security.

During each logging or tracer application, the logging supervisor or other designated employee shall maintain direct surveillance of the operation to protect against unauthorized or unnecessary entry into a restricted area, as defined in Part 1 of these regulations.

16.19 Handling Tools.

The licensee shall provide and require the use of tools that will assure remote handling of sealed sources other than low-activity calibration sources.

16.20 Subsurface Tracer Studies.

16.20.1 Protective gloves and other appropriate protective clothing and equipment shall be used by all personnel handling radioactive tracer material. Precautions shall be taken to avoid ingestion or inhalation of radioactive material.

16.20.2 No licensee shall cause the injection of radioactive material into potable aquifers without prior written authorization from the Department and any other appropriate State agency.

16.21 Particle Accelerators.

No licensee or registrant shall permit aboveground testing of particle accelerators, designed for use in well-logging, which results in the production of radiation, except in areas or facilities controlled or shielded so that the requirements of 4.6 and 4.14 of these regulations, as applicable, are met.

RADIATION SURVEYS AND RECORDS

16.22 Radiation Surveys.

16.22.1 Radiation surveys or calculations shall be made and recorded for each area where radioactive materials are stored.

16.22.2 Radiation surveys or calculations shall be made and recorded for the radiation levels in occupied positions and on the exterior of each vehicle used to transport radioactive material. Such surveys and calculations shall include each source of radiation or combination of sources to be transported in the vehicle.

16.22.3 If the sealed source assembly is removed from the logging tool before departing the jobsite, the logging tool detector shall be energized, or a survey meter used, to assure that the logging tool is free of contamination.

16.22.4 Radiation surveys shall be made and recorded at the jobsite or wellhead for each tracer operation, except those using hydrogen-3, carbon-14, and sulfur-35. These surveys shall include measurements of radiation levels before and after the operation.

16.22.5 Records required pursuant to 16.22.1 through 16.22.4 shall include the dates, the identification of individual(s) making the survey, the identification of survey instrument(s) used, and an exact description of the location of the survey. Records of these surveys shall be maintained for inspection by the Department for 2 years after completion of the survey.

16.23 Documents and Records Required at Field Stations.

Each licensee or registrant shall maintain, for inspection by the Department, the following documents and records for the specific devices and sources used at the field station:

16.23.1 Appropriate license, certificate of registration, or equivalent document(s);

16.23.2 Operating and emergency procedures;

16.23.3 Applicable regulations;

16.23.4 Records of the latest survey instrument calibrations pursuant to 16.8;

16.23.5 Records of the latest leak test results pursuant to 16.9;

16.23.6 Records of quarterly inventories required pursuant to 16.10;

16.23.7 Utilization records required pursuant to 16.11;

16.23.8 Records of inspection and maintenance required pursuant to 16.14;

16.23.9 Survey records required pursuant to 16.22; and

16.23.10 Training records required pursuant to 16.15.

16.24 Documents and Records Required at Temporary Jobsites.

Each licensee or registrant conducting operations at a temporary jobsite shall have the following documents and records available at that site for inspection by the Department:

16.24.1 Operating and emergency procedures;

16.24.2 Survey records required pursuant to 16.22 for the period of operation at the site;

16.24.3 Evidence of current calibration for the radiation survey instruments in use at the site;

16.24.4 When operating in the State under reciprocity, a copy of the appropriate license, certificate of registration, or equivalent document(s); and

16.24.5 Shipping papers for the transportation of radioactive material.

NOTIFICATION

16.25 Notification of Incidents, Abandonment, and Lost Sources.

16.25.1 Notification of incidents and sources lost in other than downhole logging operations shall be made in accordance with appropriate provisions of 4.52 of these regulations.

16.25.2 Whenever a sealed source or device containing radioactive material is lodged downhole, the licensee shall:

16.25.2.1 Monitor at the surface for the presence of radioactive contamination with a radiation survey instrument or logging tool during logging tool recovery operations; and

16.25.2.2 Notify the Department immediately by telephone and subsequently within 30 days by confirmatory letter if the licensee knows or has reason to believe that a sealed source has been ruptured. This letter shall identify the well or other location, describe the magnitude and extent of the escape of radioactive material, assess the consequences of the rupture, and explain efforts being planned or taken to mitigate these consequences.

16.25.3 When it becomes apparent that efforts to recover the radioactive source will not be successful, the licensee shall:

16.25.3.1 Advise the well operator of the regulations of the Department regarding abandonment and an appropriate method of abandonment, which shall include:

(1) The immobilization and sealing in place of the radioactive source with a cement plug;

(2) The setting of a whipstock or other deflection device; and

(3) The mounting of a permanent identification plaque at the surface of the well, containing the appropriate information required by 16.25.4;

16.25.3.2 Notify the Department by telephone, giving the circumstances that resulted in the inability to retrieve the source; and

(1) Obtain department approval to implement abandonment procedures; or

(2) Notify the department that the licensee implemented abandonment before receiving department approval because the licensee believed there was an immediate threat to public health and safety; and

16.25.3.3 File a written report with the Department within 30 days of the abandonment. The licensee shall send a copy of the report to the appropriate State agency that issued permits or otherwise approved of the drilling operation. The report shall contain the following information:

(1) Date of occurrence;

(2) A description of the well-logging source involved, including the radionuclide and its quantity, chemical, and physical form;

(3) Surface location and identification of the well;

(4) Results of efforts to immobilize and seal the source in place;

(5) A brief description of the attempted recovery effort;

(6) Depth of the source;

(7) Depth of the top of the cement plug;

(8) Depth of the well;

(9) The immediate threat to public health and safety justification for implementing abandonment if prior Department approval was not obtained in accordance with 16.25.3.2(1);

(10) Any other information, such as a warning statement, contained on the permanent identification plaque; and

(11) The names of State Agencies receiving a copy of this report.

16.25.4 Whenever a sealed source containing radioactive material is abandoned downhole, the licensee shall provide a means to prevent inadvertent intrusion on the source, unless the source is not accessible to any subsequent drilling operations, and shall provide a permanent plaque [1] for posting the well or well-bore. This plaque shall:

1 An example of a suggested plaque is shown in Appendix 16B.

16.25.4.1 Be constructed of long-lasting material, such as stainless steel, brass, bronze, or monel;

16.25.4.2 Be mounted at the surface of the well, unless the mounting of the plaque is not practical;

16.25.4.3 Be at least 17 cm (7 inches) square and 3 mm (1/8 th inch) thick; and

16.25.4.4 Contain the following information engraved on its face:

(1) The word “CAUTION” ;

(2) The radiation symbol prescribed in 4.27 without the conventional color requirement;

(3) The date of abandonment;

(4) The name of the well-operator or well-owner;

(5) The well name and well identification number(s) or other designation;

(6) The sealed source(s) by radionuclide and activity;

(7) The source depth and the depth to the top of the plug; and

(8) An appropriate warning, depending on the specific circumstances of each abandonment. [2]

2 Appropriate warnings may include: (a) "Do not drill below plug-back depth"; (b) "Do not enlarge casing"; or (c) "Do not re-enter the hole", followed by the words, "before contacting the Colorado Department of Public Health and Environment, Hazardous Materials And Waste Management Division.”

16.25.5 The licensee shall immediately notify the Department by telephone and subsequently by confirming letter if the licensee knows or has reason to believe that radioactive material has been lost in or to an underground potable aquifer. Such notice shall designate the well location and shall describe the magnitude and extent of loss of radioactive material, assess the consequences of such loss, and explain efforts planned or being taken to mitigate these consequences.

PART 16, APPENDIX 16A:

SUBJECTS TO BE INCLUDED IN TRAINING COURSES FOR LOGGING SUPERVISORS

16A.1 Fundamentals of Radiation Safety

16A.1.1 Characteristics of radiation

16A.1.2 Units of radiation dose and quantity of radioactivity

16A.1.3 Significance of radiation dose

(1) Radiation protection standards

(2) Biological effects of radiation dose

16A.1.4 Levels of radiation from sources of radiation

16A.1.5 Methods of minimizing radiation dose

(1) Working time

(2) Working distances

(3) Shielding

16A.1.6 Radiation safety practices including prevention of contamination and methods of decontamination

16A.2 Radiation Detection Instrumentation To Be Used

16A.2.1 Use of radiation survey instruments

(1) Operation

(2) Calibration

(3) Limitations

16A.2.2 Survey techniques

16A.2.3 Use of personnel monitoring equipment

16A.3 Equipment To Be Used

16A.3.1 Handling equipment

16A.3.2 Sources of radiation

16A.3.3 Storage and control of equipment

16A.3.4 Operation and control of equipment

16A.4 The Requirements of Pertinent Federal and State Regulations

16A.5 The Licensee's or Registrant's Written Operating and Emergency Procedures

16A.6 The Licensee's or Registrant's Record Keeping Procedures

PART 16, APPENDIX 16B:

EXAMPLE OF PLAQUE FOR IDENTIFYING WELLS CONTAINING SEALED SOURCES CONTAINING RADIOACTIVE MATERIAL ABANDONED DOWNHOLE

[COMPANY NAME]

[WELL IDENTIFICATION]

ONE 2 CURIE CS-137 RADIOACTIVE SOURCE

ABANDONED 3-3-75 AT 8400 FT. PLUG BACK DEPTH 8200 FT.

DO NOT RE-ENTER THIS WELL BEFORE CONTACTING

COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

The size of the plaque should be convenient for use on active or inactive wells, for example, a 7-inch square. Letter size of the word “CAUTION” should be approximately twice the letter size of the rest of the information, for example, 1/2-inch and 1/4-inch letter size, respectively.

PART 17: TRANSPORTATION OF RADIOACTIVE MATERIAL

GENERAL PROVISIONS

17.1 Purpose and Scope.

17.1.1 Authority.

Rules and regulations set forth herein are adopted pursuant to the provisions of sections 25-1-108, 25-1.5-101(1)(l), and 25-11-104, CRS.

17.1.2 Basis and Purpose.

A statement of basis and purpose accompanies this part and changes to this part. A copy may be obtained from the Department.

17.1.3 Scope.

This part establishes requirements for packaging, preparation for shipment, and transportation of radioactive material.

17.1.4 Applicability.

17.1.4.1 This part applies to any person who transports radioactive material or delivers radioactive material to a carrier for transport.

(1) This part applies in particular to any licensee authorized by specific or general license to receive, possess, use, or transfer licensed material, if the licensee delivers that material to a carrier for transport, transports the material outside the site of usage as specified in the license, or transports that material on a public highway.

(2) The transport of licensed material or delivery of licensed material to a carrier for transport is subject to the:

(a) General provisions of 17.1 through 17.5, including referenced DOT regulations;

(b) Quality assurance requirements of 17.10; and

(c) Operating controls and procedures requirements of 17.11 through 17.17.

(3) No provision of this part authorizes possession of licensed material.

(4) Exemptions from the requirement in 17.3 for a license are specified in 17.4.

(5) The general license under 17.7 requires that a NRC certificate of compliance or other package approval be issued for the package to be used under the general license.

(6) General licenses for which no package approval is required are issued in 17.8 and 17.9.

(7) These rules apply to any person required to obtain a certificate of compliance or an approved compliance plan from the NRC pursuant to 10 CFR 71 if the person delivers radioactive material to a common or contract carrier for transport or transports the material outside the confines of the person's plant or other authorized place of use.

17.1.4.2 The packaging and transport of radioactive material are also subject to other parts of these regulations and to the regulations of other agencies (such as the DOT, the United States Postal Service and the NRC) having jurisdiction over means of transport.

17.1.4.3 The requirements of this part are in addition to, and not in substitution for, other requirements.

17.1.5 Published Material Incorporated by Reference.

Published material incorporated in Part 17 by reference is available in accord with Part 1, Section 1.4.

17.2 Definitions.

17.2.1 Definitions of general applicability to these regulations are in Part 1, Section 1.2.2.

17.2.2 Terms used in Part 17 have the definitions set forth as follows.

"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 has been issued a certificate of compliance or other package approval by the NRC.

"Certificate of Compliance" (COC) means the certificate issued by the NRC under subpart D of 10 CFR 71 (January 1, 2007) which approves the design of a package for the transportation of radioactive material.

"Closed transport vehicle" means a transport vehicle equipped with a securely attached exterior enclosure that during normal transportation restricts the access of unauthorized persons to the cargo space containing the radioactive material. The enclosure may be either temporary or permanent but shall limit access from top, sides, and ends. In the case of packaged materials, it may be of the "see-through" type.

"Consignment" means each shipment of a package or groups of packages or load of radioactive material offered by a shipper for transport.

"Containment system" means the assembly of components of the packaging intended to retain the radioactive material during transport.

"Conveyance" means:

(1) For transport by public highway or rail any transport vehicle or large freight container;

(2) For transport by water any vessel, or any hold, compartment, or defined deck area of a vessel including any transport vehicle on board the vessel; and

(3) For transport by any aircraft.

"Criticality Safety Index (CSI)" means the dimensionless number (rounded up to the next tenth) assigned to and placed on the label of a fissile material package, to designate the degree of control of accumulation of packages containing fissile material during transportation. Determination of the criticality safety index is described in 10 CFR 71.22, 71.23, and 71.59.

"Deuterium" means, for the purposes of Part 17, deuterium and any deuterium compound, including heavy water, in which the ratio of deuterium atoms to hydrogen atoms exceeds 1:5000.

"Exclusive use" means the sole use by a single consignor of a conveyance for which all initial, intermediate, and final loading and unloading are carried out in accordance with the direction of the consignor or consignee. The consignor and the carrier must ensure that any loading or unloading is performed by personnel having radiological training and resources appropriate for safe handling of the consignment. The consignor must issue specific instructions, in writing, for maintenance of exclusive use shipment controls, and include them with the shipping paper information provided to the carrier by the consignor.

"Fissile material package" means a fissile material packaging together with its fissile material contents.

"Graphite" means, for the purposes of Part 17, graphite with a boron equivalent content less than 5 parts per million and density greater than 1.5 grams per cubic centimeter.

"Low specific activity material" (LSA material) means radioactive material with limited specific activity which is nonfissile or except under Part 17 and which satisfies the descriptions and limits set forth below. Shielding materials surrounding the LSA material may not be considered in determining the estimated average specific activity of the package contents. LSA material must be in one of three groups:

(1) LSA-I .

(a) Uranium and thorium ores, concentrates of uranium and thorium ores, and other ores containing naturally occurring radionuclides which are not intended to be processed for the use of these radionuclides; or

(b) Radioactive material, other than fissile material, for which the A_2 value in Appendix 17A is unlimited; or

(c) Other radioactive material in which the activity is distributed throughout and the estimated average specific activity does not exceed 30 times the value for exempt material activity concentration determined in accordance with Appendix 17A.

(2) LSA-II .

(a) Water with tritium concentration up to 0.8 TBq/liter (20.0 Ci/liter); or

(b) Other radioactive material in which the activity is distributed throughout, and the average specific activity does not exceed $10^{-4} \times A_2$ /g for solids and gases, and $10^{-5} \times A_2$ /g for liquids.

(3) LSA-III . Solids in and for which:

(a) The radioactive material is distributed throughout a solid or a collection of solid objects, or is essentially uniformly distributed in a solid compact binding agent (such as concrete, bitumen, or ceramic); and

(b) The radioactive material is relatively insoluble, or it is intrinsically contained in a relatively insoluble material, so that, even under loss of packaging, the loss of radioactive material per package by leaching, when placed in water for 7 days, would not exceed $0.1 \times A_2$;

(c) The estimated average specific activity of the solid does not exceed 2×10^{-3} A_2 /g; and

(d) A specimen of the material has passed a leaching test, provided also that any differences between the specimen tested and the material to be transported were taken into account in determining whether the test requirements have been met.

(i) The specimen, representing no less than the entire contents of the package, must be immersed for 7 days in water at ambient temperature;

(ii) The volume of water to be used in the test must be sufficient to ensure that at the end of the test period the free volume of the unabsorbed and unreacted water remaining will be at least 10% of the volume of the specimen itself;

(iii) The water must have an initial pH of 6-8 and a maximum conductivity 10 micromho/cm at 20°C (68°F); and

(iv) The total activity of the free volume of water must be measured following the 7-day immersion test and must not exceed 0.1x A_2 .

“Low toxicity alpha emitters” means natural uranium, depleted uranium, natural thorium; uranium-235, uranium-238, thorium-232, thorium-228 or thorium-230 when contained in ores or physical or chemical concentrates or tailings; or alpha emitters with a half-life of less than 10 days.

“Nuclear waste” means, for the purposes of Part 17, a quantity of source, byproduct or special nuclear material required to be in NRC-approved specification packaging while transported to, through or across a state boundary to a disposal site, or to a collection point for transport to a disposal site.

“Packaging” means the assembly of components necessary to ensure compliance with the packaging requirements of 10 CFR 71. It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, and devices for cooling or absorbing mechanical shocks. The vehicle, tie-down system, and auxiliary equipment may be designated as part of the packaging.

"Quality assurance", for the purposes of Part 17, comprises all those planned and systematic actions necessary to provide adequate confidence that a system or component will perform satisfactorily in service.

“Quality control” , for the purposes of Part 17, comprises those quality assurance actions that relate to control of the physical characteristics and quality of the material or component to predetermined requirements.

“Regulations of the DOT” means the regulations in 49 CFR Parts 100-189 and Parts 390-397 (October 1, 2006).

“Regulations of the NRC” means the regulations in 10 CFR 71 (January 1, 2007) for purposes of Part 17.

“Surface contaminated object” (SCO) means a solid object that is not itself classed as radioactive material, but which has radioactive material distributed on any of its surfaces. The SCO must be in one of two groups with surface activity not exceeding the following limits:

(1) SCO-I: a solid object on which:

(a) The non-fixed contamination on the accessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 4 Bq/cm^2 (10^{-4} microcurie/cm^2) for beta, gamma and low toxicity alpha emitters, or 0.4 Bq/cm^2 (10^{-5} microcurie/cm^2) for all other alpha emitters;

(b) The fixed contamination on the accessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 4 x 10^4 Bq/cm^2 (1.0 microcurie/cm^2) for beta, gamma and low toxicity alpha emitters, or 4 x 10^3 Bq/cm^2 (0.1 microcurie/cm^2) for all other alpha emitters; and

(c) The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 4 x 10^4 Bq/cm^2 (1 microcurie/cm^2) for beta, gamma and low toxicity alpha emitters, or 4 x 10^3 Bq/cm^2 (0.1 microcurie/cm^2) for all other alpha emitters.

(2) SCO-II: a solid object on which the limits for SCO-I are exceeded and on which:

(a) The non-fixed contamination on the accessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 400 Bq/cm^2 (10^{-2} microcurie/cm^2) for beta, gamma and low toxicity alpha emitters or 40 Bq/cm^2 (10^{-3} microcurie/cm^2) for all other alpha emitters;

(b) The fixed contamination on the accessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 8 x 10^5 Bq/cm^2 (20 microcuries/cm^2) for beta, gamma and low toxicity alpha emitters, or 8 x 10^4 Bq/cm^2 (2 microcuries/cm^2) for all other alpha emitters; and

(c) The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over 300 cm^2 (or the area of the surface if less than 300 cm^2) does not exceed 8 x 10^5 Bq/cm^2 (20 microcuries/cm^2) for beta, gamma and low toxicity alpha emitters, or 8 x 10^4 Bq/cm^2 (2 microcuries/cm^2) for all other alpha emitters.

“Transport index” (TI) means the dimensionless number, rounded up the next tenth, placed on the label of a package to designate the degree of control to be exercised by the carrier during transportation. The transport index is the number determined by multiplying the maximum radiation level in millisievert (mSv) per hour at 1 meter (3.3 feet) from the external surface of the package by 100 (equivalent to the maximum radiation level in millirem per hour at 1 meter).

“Type A package” means a Type A packaging that, together with its radioactive contents limited to A1 or A2 as appropriate, meets the requirements of 49 CFR 173.410 and 173.412 and is designed to retain the integrity of containment and shielding required by Part 17 under normal conditions of transport as demonstrated by the tests set forth in 49 CFR 173.465 or 173.466, as appropriate.

“Type A packaging” means a packaging designed for a Type A package.

“Type AF package” , “Type BF package” , “Type B(U)F package” , and “Type B(M)F package” each means a fissile material packaging together with its fissile material contents.

“Type A quantity” means a quantity of radioactive material, the aggregate radioactivity of which does not exceed A1 for special form radioactive material or A2 for normal form radioactive material, where A1 and A2 are given in Appendix 17A or may be determined by procedures described in Appendix 17A.

“Type B package” means a Type B packaging together with its radioactive contents.2

2 A Type B package design is designated as B(U) or B(M). 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 700kPa (100 lb/in2) gauge or a pressure relief device that would allow the release of radioactive material to the environment under the tests specified in 10 CFR 71.73 (hypothetical accident conditions), in which case it will receive a designation B(M). B(U) refers to the need for unilateral approval of international shipments; B(M) refers to the need for multilateral approval of international shipments. No distinction is made in how packages with these designations may be used in domestic transportation. To determine their distinction for international transportation, refer to 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 17.8.

"Type B packaging" means a packaging designed to retain the integrity of containment and shielding when subjected to the normal conditions of transport and hypothetical accident test conditions set forth 10 CFR Part 71.

"Type B quantity" means a quantity of radioactive material greater than a Type A quantity.

LICENSE-RELATED REGULATORY REQUIREMENTS

17.3 Requirement for License.

No person shall transport radioactive material or deliver radioactive material to a carrier for transport except as authorized in a general or specific license issued by the Department, an Agreement State, a Licensing State, or NRC, or as exempted in 17.4

17.4 Exemptions.

17.4.1 Common and contract carriers, freight forwarders, and warehouse workers which are subject to the requirements of the DOT in 49 CFR 170 through 189, or the U.S. Postal Service in the Postal Service Manual (Domestic Mail Manual), are exempt from the requirements of Part 17 to the extent that they transport or store radioactive material in the regular course of their carriage for others or storage incident thereto. Common and contract carriers who are not subject to the requirements of the DOT or U.S. Postal Service are subject to 17.3 and other applicable requirements of these regulations.

17.4.2 Any licensee is exempt from the requirements of Part 17 with respect to shipment or carriage of the following low-level materials:

17.4.2.1 Natural material and ores containing naturally occurring radionuclides that are not intended to be processed for use of these radionuclides, provided the activity concentration of the material does not exceed 10 times the values specified in Appendix 17A, Table 17A2.

17.4.2.2 Materials for which the activity concentration is not greater than the activity concentration values specified in Appendix 17A, Table 17A2, or for which the consignment activity is not greater than the limit for an exempt consignment found in Appendix 17A, Table 17A2.

17.4.3 Fissile materials meeting the requirements of one of the paragraphs (a) through (f) in 10 CFR 71.15 are exempt from classification as fissile material, and from the fissile material package standards of 10 CFR 71.55 and 10 CFR 71.59, but are subject to all other requirements of 10 CFR 71, except as noted in paragraphs (a) through (f) in 10 CFR 71.15.

17.5 Transportation of Licensed Material.

17.5.1 Each licensee who transports licensed material outside the site of usage, as specified in the Department license, or where transport is on public highways, or who delivers licensed material to a carrier for transport, shall:

17.5.1.1 Comply with the applicable requirements, appropriate to the mode of transport, of the regulations of the DOT, particularly the regulations of the DOT in the following areas:

(1) Packaging - 49 CFR Part 173: Subparts A and B and I.

(2) Marking and labeling - 49 CFR Part 172: Subpart D, § § 172.400 through 172.407, § § 172.436 through 172.441, and Subpart E.

(3) Placarding - 49 CFR Part 172: Subpart F, especially § § 172.500 through 172.519, 172.556, and Appendices B and C.

(4) Accident reporting - 49 CFR Part 171: § § 171.15 and 171.16.

(5) Shipping papers and emergency information - 49 CFR Part 172: Subparts C and G.

(6) Hazardous material employee training - 49 CFR Part 172: Subpart H.

(7) Security plans - 49 CFR Part 172: Subpart I.

(8) Hazardous material shipper/carrier registration - 49 CFR Part 107: Subpart G.

17.5.1.2 The licensee shall also comply with applicable regulations of the DOT pertaining to the following modes of transportation:

(1) Rail - 49 CFR Part 174: Subparts A through D, and K.

(2) Air - 49 CFR Part 175.

(3) Vessel - 49 CFR Part 176: Subparts A through F, and M.

(4) Public highway - 49 CFR Part 177 and Parts 390 through 397.

17.5.1.3 Assure that any special instructions needed to safely open the package are sent to or have been made available to the consignee in accordance with 4.32.5.2.

17.5.2 If, for any reason, the regulations of the DOT are not applicable to a shipment of licensed material, the licensee shall conform to the standards and requirements of 49 CFR Parts 170 through 189 appropriate to the mode of transport to the same extent as if the shipment was subject to these regulations.

GENERAL LICENSES

17.6 General Licenses for Carriers.

17.6.1 A general license is hereby issued to any common or contract carrier not exempt under 17.4 to receive, possess, transport, and store radioactive material in the regular course of their carriage for others or storage incident thereto, provided the transportation and storage is in accordance with the applicable requirements, appropriate to the mode of transport, of the DOT insofar as such requirements relate to the loading and storage of packages, placarding of the transporting vehicle, and incident reporting. [3]

3 Notification of an incident shall be filed with, or made to, the Department as prescribed in 49 CFR, regardless of and in addition to the notification made to the DOT or other agencies.

17.6.2 A general license is hereby issued to any private carrier to transport radioactive material, provided the transportation is in accordance with the applicable requirements, appropriate to the mode of transport, of the DOT insofar as such requirements relate to the loading and storage of packages, placarding of the transporting vehicle, and incident reporting. [3]

17.6.3 Persons who transport radioactive material pursuant to the general licenses in 17.6.1 and 17.6.2 are exempt from the requirements of Parts 4 and 10 of these regulations to the extent that they transport radioactive material.

17.7 General License: NRC-Approved Packages.

17.7.1 A general license is hereby issued to any licensee of the Department to transport, or to deliver to a carrier for transport, licensed material in a package for which a license, certificate of compliance, or other approval has been issued by the NRC.

17.7.2 This general license applies only to a licensee who:

17.7.2.1 Has a quality assurance program approved by NRC as satisfying 10 CFR 71 Subpart H.

17.7.2.2 Has a copy of the specific license, certificate of compliance, or other approval by the NRC 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 action(s) to be taken prior to shipment;

17.7.2.3 Complies with the terms and conditions of the license, certificate, or other approval by the NRC, as applicable, and the applicable requirements of Part 17;

17.7.2.4 Prior to the licensee's first use of the package, has submitted to the NRC in writing in accordance with 10 CFR 71.1:

(1) The licensee’s name and license number; and

(2) The package identification number specified in the package approval; and

17.7.3 The general license in 17.7.1 applies only when the package approval authorizes use of the package under this general license.

17.7.4 For a Type B or fissile material package, the design of which was approved by NRC before April 1, 1996, the general license in 17.7.1 is subject to additional restrictions of 10 CFR 71.19.

17.8 General Licenses: Use of Foreign-Approved and Other Approved Packages

17.8.1 A general license is issued to any licensee of the Department to transport, or to deliver to a carrier for transport, licensed material in a package the design of which has been approved in a foreign national competent authority certificate and revalidated by the DOT as meeting the applicable requirements of 49 CFR 171.12. This general license applies only to:

17.8.1.1 Shipments made to or from locations outside the United States; and

17.8.1.2 A licensee who:

(1) Has a quality assurance program approved by NRC;

(2) 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;

(3) Complies with the terms and conditions of the certificate and revalidation; and

(4) Complies with each applicable requirement of Part 17.

17.8.2 A general license is issued to any licensee of the Department 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 49 CFR Parts 173 and 178. This general license, which expires October 1, 2008:

17.8.2.1 Is subject to the limitation that the specification container may not be used for a shipment to a location outside the United States except by multilateral approval as defined in 49 CFR 173.403;

17.8.2.2 Applies only to a licensee who:

(1) Has a quality assurance program approved by NRC as satisfying 10 CFR 71 Subpart H or equivalent approval satisfying the requirements of 17.10;

(2) Has a copy of the specification;

(3) Complies with the terms and conditions of the certificate and revalidation; and

(4) Complies with each applicable requirement of Part 17.

17.9 General Licenses: Fissile Material Transport

17.9.1 A general license is hereby issued to any licensee to transport fissile material, or to deliver fissile material to a carrier for transport, if the licensee meets the requirements of 10 CFR 71.22 and the material is shipped in accordance with 10 CFR 71.22 and each applicable requirement of Part 17.

17.9.2 A general license is hereby issued to any licensee to transport fissile material in the form of plutonium-beryllium (Pu-Be) special form sealed sources, or to deliver fissile material in the form of plutonium-beryllium (Pu-Be) special form sealed sources to a carrier for transport, if the licensee meets the requirements of 10 CFR 71.23 and the material is shipped in accordance with 10 CFR 71.23 and each applicable requirement of Part 17.

QUALITY ASSURANCE

17.10 Quality Assurance Requirements.

17.10.1 Quality assurance requirements apply to design, purchase, fabrication, handling, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair, and modification of components of packaging that are important to safety.

17.10.1.1 The licensee, certificate holder, and applicant for a COC are responsible for complying with the quality assurance requirements which apply to design, fabrication, testing, and modification of packaging.

17.10.1.2 Each licensee is responsible for complying with each quality assurance provision which applies to the licensee's use of a packaging for the shipment of licensed material subject to the requirements of 10 CFR 71 and Part 17.

17.10.2 Each licensee, certificate holder, and applicant for a COC shall:

17.10.2.1 Be responsible to establish, maintain, and execute a quality assurance program that, using a graded approach to an extent that is commensurate with each quality assurance requirement's importance to safety, satisfies

(1) Each applicable criterion of 10 CFR 71.101 through 71.137; and

(2) Any specific provision that is applicable to the licensee's activities including procurement of packaging.

17.10.2.2 Be subject to each requirement that is applicable, whether the term “licensee” is or is not used in the requirement, for whatever design, fabrication, assembly, and testing of the package is accomplished with respect to a package before the time a package approval is issued.

17.10.3 Before the use of any package for the shipment of licensed material subject Part 17, each licensee shall obtain NRC approval of its quality assurance program.

17.10.4 A program for transport container inspection and maintenance limited to radiographic exposure devices, source changers, or packages transporting these devices and meeting the requirements of 10 CFR 34.31(b), or equivalent Agreement State requirements, is deemed to satisfy the requirements of 17.7 and 17.10.2.

17.10.5 The licensee, certificate holder, and applicant for a COC shall be responsible for the establishment and execution of the quality assurance program.

17.10.5.1 The licensee, certificate holder, and applicant for a COC 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.

17.10.5.2 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, including performing the functions associated with attaining quality objectives and the quality assurance functions.

17.10.6 The quality assurance functions are:

17.10.6.1 Assuring that an appropriate quality assurance program is established and effectively executed; and

17.10.6.2 Verifying, by procedures such as checking, auditing, and inspection, that activities affecting the safety-related functions have been performed correctly.

17.10.7 The persons and organizations performing quality assurance functions must have sufficient authority and organizational freedom to:

17.10.7.1 Identify quality problems;

17.10.7.2 Initiate, recommend, or provide solutions; and

17.10.7.3 Verify implementation of solutions.

17.11 Advance Notification of Transport of Nuclear Waste.

17.11.1 Prior to the transport of any nuclear waste outside of the confines of the licensee's facility or other place of use or storage, or prior to the delivery of any nuclear waste to a carrier for transport, each licensee shall provide advance notification of such transport to the governor, or governor's designee [6] , of each state through which the waste will be transported.

6 A list of the mailing addresses of the governors and governors' designees is available upon request from the Director, Office of State Programs, NRC, Washington, DC 20555. The list will be published annually in the Federal Register on or about June 30 to reflect any changes in information.

17.11.2 Advance notification is required only when:

17.11.2.1 The nuclear waste is required to be in Type B packaging for transportation;

17.11.2.2 The nuclear waste is being transported into, within, or through, a state enroute to a disposal facility or to a collection point for transport to a disposal facility; and

17.11.2.3 The quantity of licensed material in a single package exceeds any one of the following:

(1) 3000 times the A1 value of the radionuclides as specified in Appendix 17A for special form radioactive material; or

(2) 3000 times the A [2] value of the radionuclides as specified in Appendix 17A for normal form radioactive material; or

(3) 1000 TBq (27,000 Ci);

17.11.3 Each advance notification required by 17.11.1 shall contain the following information:

17.11.3.1 The name, address, and telephone number of the shipper, carrier, and receiver of the shipment;

17.11.3.2 A description of the nuclear waste contained in the shipment as required by 49 CFR 172.202 and 172.203(d);

17.11.3.3 The point of origin of the shipment and the 7-day period during which departure of the shipment is estimated to occur;

17.11.3.4 The 7-day period during which arrival of the shipment at state boundaries is estimated to occur;

17.11.3.5 The destination of the shipment, and the 7-day period during which arrival of the shipment is estimated to occur; and

17.11.3.6 A point of contact with a telephone number for current shipment information.

17.11.4 The notification required by 17.11.1 shall be made in writing to the office of each appropriate governor, or governor's designee, and to the Department. A notification delivered by mail must be postmarked at least 7 days before the beginning of the 7-day period during which departure of the shipment is estimated to occur. A notification delivered by messenger must reach the office of the governor, or governor's designee, at least 4 days before the beginning of the 7-day period during which departure of the shipment is estimated to occur. A copy of the notification shall be retained by the licensee for 3 years.

17.11.5 The licensee shall notify each appropriate governor, or governor's designee, and the Department of any changes to schedule information provided pursuant to 17.11.1. Such notification shall be by telephone to a responsible individual in the office of the governor, or governor's designee, of

the appropriate state or states. The licensee shall maintain for 3 years a record of the name of the individual contacted.

17.11.6 Each licensee who cancels a nuclear waste shipment, for which advance notification has been sent, shall send a cancellation notice to the governor, or governor's designee, of each appropriate state and to the Department. A copy of the notice shall be retained by the licensee for 3 years.

17.12 Air Transport of Plutonium.

Notwithstanding the provisions of any general licenses and notwithstanding any exemptions stated directly in this part or included indirectly by citation of the regulations of the DOT, as may be applicable, the licensee shall assure that plutonium in any form is not transported by air, or delivered to a carrier for air transport, unless:

17.12.1 The plutonium is contained in a medical device designed for individual human application; or

17.12.2 The plutonium is contained in a material in which the specific activity is less than or equal to the activity concentration values for plutonium specified in Appendix 17A, Table 17A-1, and in which the radioactivity is essentially uniformly distributed; or

17.12.3 The plutonium is shipped in a single package containing no more than an A2 quantity of plutonium in any isotope or form and is shipped in accordance with 17.5; or

17.12.4 The plutonium is shipped in a package specifically authorized (in the certificate of compliance issued by the NRC for that package) for the shipment of plutonium by air and the licensee requires, through special arrangement with the carrier, compliance with 49 CFR 175.704, the regulations of the DOT applicable to the air transport of plutonium.

OPERATING CONTROLS AND PROCEDURES

17.13 Fissile Material: Assumptions as to Unknown Properties of Fissile Material.

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 had credible values that would cause the maximum neutron multiplication.

17.14 Preliminary Determinations.

Prior to the first use of any packaging for the shipment of radioactive material:

17.14.1 The licensee shall ascertain that there are no defects which could significantly reduce the effectiveness of the packaging;

17.14.2 Where the maximum normal operating pressure will exceed 35 kilopascal (5 pounds per square inch) gauge, the licensee shall test the containment systems at an internal pressure at least 50 percent higher than the maximum normal operating pressure to verify the capability of that system to maintain its structural integrity at that pressure;

17.14.3 The licensee shall determine that the packaging has been fabricated in accordance with the design approved by the NRC; and

17.14.4 The licensee shall conspicuously and durably mark the packaging with its model number, serial number, gross weight, and a package identification number as assigned by the NRC.

17.15 Routine Determinations.

Prior to each shipment of licensed material, the licensee shall determine that:

17.15.1 The package is proper for the contents to be shipped;

17.15.2 The package is in unimpaired physical condition except for superficial defects such as marks or dents;

17.15.3 Each closure device of the packaging, including any required gasket, is properly installed and secured and free of defects;

17.15.4 Any system for containing liquid is adequately sealed and has adequate space or other specified provision for expansion of the liquid;

17.15.5 Any pressure relief device is operable and set in accordance with written procedures;

17.15.6 The package has been loaded and closed in accordance with written procedures;

17.15.7 Any structural part of the package which could be used to lift or tie down the package during transport is rendered inoperable for the purpose unless it satisfies design requirements specified in 10 CFR 71.45;

17.15.8 The level of non-fixed (removable) radioactive contamination on the external surfaces of each package offered for shipment is as low as reasonably achievable and within the limits specified in 49 CFR 173.443.

17.15.8.1 Determination of the level of non-fixed (removable) contamination shall be based upon 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.

(1) The number and location of measurements shall be sufficient to yield a representative assessment of the removable contamination levels.

(2) Other methods of assessment of equal or greater detection efficiency may be used.

17.15.8.2 In the case of packages transported as exclusive use shipments by rail or highway only, the non-fixed (removable) radioactive contamination:

(1) At the beginning of transport shall not exceed the levels specified in 49 CFR 173.443; and

(2) At any time during transport shall not exceed 10 times the levels specified in 49 CFR 173.443.

17.15.9 External radiation levels around the package and around the vehicle, if applicable, shall not exceed:

17.15.9.1 2 mSv/h (200 millirem per hour) at any point on the external surface of the package at any time during transportation;

17.15.9.2 A transport index of 10.0.

17.15.10 For a package transported in exclusive use by rail, highway or water, radiation levels external to the package may exceed the limits specified in 17.15.9 but shall not exceed any of the following:

17.15.10.1 2 mSv/h (200 millirem per hour) on the accessible external surface of the package unless the following conditions are met, in which case the limit is 10 mSv/h (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) No loading or unloading operation occurs between the beginning and end of the transportation.

17.15.10.2 2 mSv/h (200 millirem per hour) at any point on the outer surface of the vehicle, including the upper and lower surfaces, or, in the case of a flat-bed style vehicle, with a personnel barrier, at any point on the vertical planes projected from the outer edges of the vehicle, on the upper surface of the load (or enclosure, if used), and on the lower external surface of the vehicle;

(1) A flat bed style vehicle with a personnel barrier shall have radiation levels determined at vertical planes.

(2) If no personnel barrier is in place, the package cannot exceed 2 mSv/h (200 millirem per hour) at any accessible surface.

17.15.10.3 0.1 mSv/h (10 millirem per hour) at any point 2 meters from the vertical planes represented by the outer lateral surfaces of the vehicle, or, in the case of a flat-bed style vehicle, at any point 2 meters from the vertical planes projected from the outer edges of the vehicle; and

17.15.10.4 0.02 mSv/h (2 millirem per 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 10.3; and

17.15.11 A package must be prepared for transport so that in still air at 100 degrees Fahrenheit (38 degrees Celsius) and in the shade, no accessible surface of a package would have a temperature exceeding 50 degrees Celsius (122 degrees Fahrenheit) in a nonexclusive use shipment or 82 degrees Celsius (185 degrees Fahrenheit) in an exclusive use shipment. Accessible package surface temperatures shall not exceed these limits at any time during transportation.

17.15.12 A package may not incorporate a feature intended to allow continuous venting during transport.

17.15.13 Before delivery of a package to a carrier for transport, the licensee shall ensure that any special instructions needed to safely open the package have been sent to the consignee, or otherwise made available to the consignee, for the consignee's use in accordance with 4.32.5.2.

REPORTS AND RECORDS

17.16 Reports.

The licensee shall report to the Department within 30 days:

17.16.1 Any instance in which there is significant reduction in the effectiveness of any packaging during use; and

17.16.2 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; and

17.16.3 Instances in which the conditions of approval in the certificate of compliance were not observed in making a shipment.

17.17 Shipment Records.

Each licensee shall maintain, for a period of 3 years after shipment, a record of each shipment of licensed material not exempt under 17.4 showing, where applicable:

17.17.1 Identification of the packaging by model number and serial number;

17.17.2 Verification that the packaging, as shipped, had no significant defect;

17.17.3 Volume and identification of coolant;

17.17.4 Type and quantity of licensed material in each package, and the total quantity of each shipment;

17.17.5 Date of the shipment;

17.17.6 Name and address of the transferee;

17.17.7 Address to which the shipment was made; and

17.17.8 Results of the determinations required by 17.15 and by the conditions of the package approval.

Appendix 17A - Determination of A_1 and A_2

17A1 Values of A_1 and A_2 for individual radionuclides, which are the bases for many activity limits elsewhere in these regulations are given in Table 17A1. The curie (Ci) values specified are obtained by converting from the Terabecquerel (TBq) figure. The Terabecquerel values are the regulatory standard. The curie values are for information only and are not intended to be the regulatory standard. The curie values are expressed to three significant figures to assure that the difference in the TBq and Ci quantities is one tenth of one percent or less. Where values of A_1 or A_2 are unlimited, it is for radiation control purposes only. For nuclear criticality safety, some materials are subject to controls placed on fissile material.

17A2 For individual radionuclides whose identities are known, but which are:

17A2.1 Not listed in Table 17A1:

(1) The A_1 and A_2 values Table 17A3 may be used.

(2) Otherwise, the licensee shall obtain prior NRC approval of the A_1 and A_2 values for radionuclides not listed in Table 17A1, before shipping the material. The licensee shall submit such request for prior approval to NRC in accordance with 10 CFR 71.1.

17A2.2 Not listed in Table 17A2:

(1) The exempt material activity concentration and exempt consignment activity values contained in Table 17A3 may be used.

(2) Otherwise, the licensee shall obtain prior NRC approval of the exempt material activity concentration and exempt consignment activity values for radionuclides not listed in Table 17A2, before shipping the material. The licensee shall submit such request for prior approval to NRC in accordance with 10 CFR 71.1.

17A3 In the calculations of A_1 and A_2 for a radionuclide not in Table 17A1, a single radioactive decay chain, in which radionuclides are present in their naturally occurring proportions, and in which no radioactive decay product nuclide has a half-life either longer than 10 days, or longer than that of the parent nuclide, shall be considered as a single radionuclide, and the activity to be taken into account, and the A_1 or A_2 value to be applied shall be those corresponding to the parent nuclide of that chain. In the case of radioactive decay chains in which any radioactive decay product nuclide has a half-life either longer than 10 days, or greater than that of the parent nuclide, the parent and those radioactive decay product nuclides shall be considered as mixtures of different nuclides.

17A4 For mixtures of radionuclides whose identities and respective activities are known, the following conditions apply:

17A4.1 For special form radioactive material, the maximum quantity transported in a Type A package is as follows:

$$\sum_i \frac{B(i)}{A_1(i)} - 1$$

where B(i) is the activity of radionuclide i, and A_1 (i) is the A_1 value for radionuclide i.

17A4.2 For normal form radioactive material, the maximum quantity transported in a Type A package is as follows:

$$\sum_i \frac{B(i)}{A_2(i)} \leq 1$$

where B(i) is the activity of radionuclide i, and A_2 (i) is the A_2 value for radionuclide i.

17A4.3 Alternatively, an A_1 value for mixtures of special form material may be determined as follows:

$$A_1 \text{ for mixture } = \frac{1}{\sum_i \frac{f(i)}{A_1(i)}}$$

where f(i) is the fraction of activity of nuclide i in the mixture and A_1 (i) is the appropriate A_1 value for nuclide i.

17A4.4 Alternatively, the A_2 value for mixtures of normal form material may be determined as follows:

$$A_2 \text{ for mixture } = \frac{1}{\sum_i \frac{f(i)}{A_2(i)}}$$

where f(i) is the fraction of activity of nuclide I in the mixture and A_2 (i) is the appropriate A_2 value for nuclide I.

17A4.5 The exempt activity concentration for mixtures of nuclides may be determined as follows:

$$[A] = \frac{1}{\sum_i \frac{f(i)}{[A](i)}}$$

where f(i) is the fraction of activity concentration of radionuclide i in the mixture, and [A] is the activity concentration for exempt material containing radionuclide i.

17A4.6 The activity limit for an exempt consignment for mixtures of radionuclides may be determined as follows:

$$A = \frac{1}{\sum_i \frac{f(i)}{A(i)}}$$

where f(i) is the fraction of activity of radionuclide i in the mixture, and A is the activity limit for exempt consignments for radionuclide i.

17A5 When the identity of each radionuclide is known, but the individual activities of some of the radionuclides are not known, the radionuclides may be grouped and the lowest A_1 or A_2 value, as appropriate, for the radionuclides in each group may be used in applying the formulas in 17A4. Groups may be based on the total alpha activity and the total beta/gamma activity when these are known, using the lowest A_1 or A_2 values for the alpha emitters and beta/gamma emitters.

TABLE 17A1: A_1 AND A_2 VALUES FOR RADIONUCLIDES – Part 1 of 4

Symbol of radionuclide	Element and atomic number	A_1 (TBq)	A_1 (Ci)b	A_2 (Tab)	A_2 (Ci)b	Specific activity	Specific activity
.	.	.	.	.	.	(TBq/g)	(Ci/g)
Ac-225 (a)	Actinium (89)	$8.0X10^{-1}$	$2.2X10^{1}$	$6.0X10^{-3}$	$1.6X10^{-1}$	$2.1X10^{3}$	$5.8X10^{4}$
Ac-227 (a)	.	$9.0X10^{-1}$	$2.4X10^{1}$	$9.0X10^{-5}$	$2.4X10^{-3}$	2.7	$7.2X10^{1}$
Ac-228	.	$6.0X10^{-1}$	$1.6X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$8.4X10^{4}$	$2.2X10^{6}$
Ag-105	Silver (47)	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$1.1X10^{3}$	$3.0X10^{4}$
Ag-108m (a)	.	$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$9.7X10^{-1}$	$2.6X10^{1}$
Ag-110m (a)	.	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.8X10^{2}$	$4.7X10^{3}$
Ag-111	.	2.0	$5.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$5.8X10^{3}$	$1.6X10^{5}$
Al-26	Aluminum (13)	$1.0X10^{-1}$	2.7	$1.0X10^{-1}$	2.7	$7.0X10^{-4}$	$1.9X10^{-2}$
Am-241	Americium (95)	$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$1.3X10^{-1}$	3.4
Am-242m (a)	.	$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$3.6X10^{-1}$	$1.0X10^{1}$

Am-243 (a)	.	5.0	$1.4X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$7.4X10^{-3}$	$2.0X10^{-1}$
Ar-37	Argon (18)	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$3.7X10^{3}$	$9.9X10^{4}$
Ar-39	.	$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{1}$	$5.4X10^{2}$	1.3	$3.4X10^{1}$
Ar-41	.	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$1.5X10^{6}$	$4.2X10^{7}$
As-72	Arsenic (33)	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$6.2X10^{4}$	$1.7X10^{6}$
As-73	.	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$8.2X10^{2}$	$2.2X10^{4}$
As-74	.	1.0	$2.7X10^{1}$	$9.0X10^{-1}$	$2.4X10^{1}$	$3.7X10^{3}$	$9.9X10^{4}$
As-76	.	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$5.8X10^{4}$	$1.6X10^{6}$
As-77	.	$2.0X10^{1}$	$5.4X10^{2}$	$7.0X10^{-1}$	$1.9X10^{1}$	$3.9X10^{4}$	$1.0X10^{6}$
At-211 (a)	Astatine (85)	$2.0X10^{1}$	$5.4X10^{2}$	$5.0X10^{-1}$	$1.4X10^{1}$	$7.6X10^{4}$	$2.1X10^{6}$
Au-193	Gold (79)	7.0	$1.9X10^{2}$	2.0	$5.4X10^{1}$	$3.4X10^{4}$	$9.2X10^{5}$
Au-194	.	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$1.5X10^{4}$	$4.1X10^{5}$
Au-195	.	$1.0X10^{1}$	$2.7X10^{2}$	6.0	$1.6X10^{2}$	$1.4X10^{2}$	$3.7X10^{3}$
Au-198	.	1.0	$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$9.0X10^{3}$	$2.4X10^{5}$
Au-199	.	$1.0X10^{1}$	$2.7X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$7.7X10^{3}$	$2.1X10^{5}$
Ba-131 (a)	Barium (56)	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$3.1X10^{3}$	$8.4X10^{4}$
Ba-133	.	3.0	$8.1X10^{1}$	3.0	$8.1X10^{1}$	9.4	$2.6X10^{2}$
Ba-133m	.	$2.0X10^{1}$	$5.4X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.2X10^{4}$	$6.1X10^{5}$
Ba-140 (a)	.	$5.0X10^{-1}$	$1.4X10^{1}$	$3.0X10^{-1}$	8.1	$2.7X10^{3}$	$7.3X10^{4}$
Be-7	Beryllium (4)	$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{1}$	$5.4X10^{2}$	$1.3X10^{4}$	$3.5X10^{5}$
Be-10	.	$4.0X10^{1}$	$1.1X10^{3}$	$6.0X10^{-1}$	$1.6X10^{1}$	$8.3X10^{-4}$	$2.2X10^{-2}$
Bi-205	Bismuth (83)	$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$1.5X10^{3}$	$4.2X10^{4}$
Bi-206	.	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$3.8X10^{3}$	$1.0X10^{5}$
Bi-207	.	$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	1.9	$5.2X10^{1}$
Bi-210	.	1.0	$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$4.6X10^{3}$	$1.2X10^{5}$
Bi-210m (a)	.	$6.0X10^{-1}$	$1.6X10^{1}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$2.1X10^{-5}$	$5.7X10^{-4}$
Bi-212 (a)	.	$7.0X10^{-1}$	$1.9X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$5.4X10^{5}$	$1.5X10^{7}$
Bk-247	Berkelium (97)	8.0	$2.2X10^{2}$	$8.0X10^{-4}$	$2.2X10^{-2}$	$3.8X10^{-2}$	1.0
Bk-249 (a)	.	$4.0X10^{1}$	$1.1X10^{3}$	$3.0X10^{-1}$	8.1	$6.1X10^{1}$	$1.6X10^{3}$
Br-76	Bromine (35)	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$9.4X10^{4}$	$2.5X10^{6}$
Br-77	.	3.0	$8.1X10^{1}$	3.0	$8.1X10^{1}$	$2.6X10^{4}$	$7.1X10^{5}$
Br-82	.	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{4}$	$1.1X10^{6}$
C-11	Carbon (6)	1.0	$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.1X10^{7}$	$8.4X10^{8}$
C-14	.	$4.0X10^{1}$	$1.1X10^{3}$	3.0	$8.1X10^{1}$	$1.6X10^{-1}$	4.5
Ca-41	Calcium (20)	Unlimited	Unlimited	Unlimited	Unlimited	$3.1X10^{-3}$	$8.5X10^{-2}$
Ca-45	.	$4.0X10^{1}$	$1.1X10^{3}$	1.0	$2.7X10^{1}$	$6.6X10^{2}$	$1.8X10^{4}$
Ca-47 (a)	.	3.0	$8.1X10^{1}$	$3.0X10^{-1}$	8.1	$2.3X10^{4}$	$6.1X10^{5}$
Cd-109	Cadmium (48)	$3.0X10^{1}$	$8.1X10^{2}$	2.0	$5.4X10^{1}$	$9.6X10^{1}$	$2.6X10^{3}$
Cd-113m	.	$4.0X10^{1}$	$1.1X10^{3}$	$5.0X10^{-1}$	$1.4X10^{1}$	8.3	$2.2X10^{2}$
Cd-115 (a)	.	3.0	$8.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.9X10^{4}$	$5.1X10^{5}$
Cd-115m	.	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$9.4X10^{2}$	$2.5X10^{4}$
Ce-139	Cerium (58)	7.0	$1.9X10^{2}$	2.0	$5.4X10^{1}$	$2.5X10^{2}$	$6.8X10^{3}$
Ce-141	.	$2.0X10^{1}$	$5.4X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.1X10^{3}$	$2.8X10^{4}$
Ce-143	.	$9.0X10^{-1}$	$2.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.5X10^{4}$	$6.6X10^{5}$

Ce-144 (a)	.	$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$1.2X10^{2}$	$3.2X10^{3}$
Cf-248	Californium (98)	$4.0X10^{1}$	$1.1X10^{3}$	$6.0X10^{-3}$	$1.6X10^{-1}$	$5.8X10^{1}$	$1.6X10^{3}$
Cf-249	.	3.0	$8.1X10^{1}$	$8.0X10^{-4}$	$2.2X10^{-2}$	$1.5X10^{-1}$	4.1
Cf-250	.	$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{-3}$	$5.4X10^{-2}$	4.0	$1.1X10^{2}$
Cf-251	.	7.0	$1.9X10^{2}$	$7.0X10^{-4}$	$1.9X10^{-2}$	$5.9X10^{-2}$	1.6
Cf-252 (h)	.	$5.0X10^{-2}$	1.4	$3.0X10^{-3}$	$8.1X10^{-2}$	$2.0X10^{1}$	$5.4X10^{2}$
Cf-253 (a)	.	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{-2}$	1.1	$1.1X10^{3}$	$2.9X10^{4}$
Cf-254	.	$1.0X10^{-3}$	$2.7X10^{-2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$3.1X10^{2}$	$8.5X10^{3}$
Cl-36	Chlorine (17)	$1.0X10^{1}$	$2.7X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.2X10^{-3}$	$3.3X10^{-2}$
Cl-38	.	$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$4.9X10^{6}$	$1.3X10^{8}$
Cm-240	Curium (96)	$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$7.5X10^{2}$	$2.0X10^{4}$
Cm-241	.	2.0	$5.4X10^{1}$	1.0	$2.7X10^{1}$	$6.1X10^{2}$	$1.7X10^{4}$
Cm-242	.	$4.0X10^{1}$	$1.1X10^{3}$	$1.0X10^{-2}$	$2.7X10^{-1}$	$1.2X10^{2}$	$3.3X10^{3}$
Cm-243	.	9.0	$2.4X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$1.9X10^{-3}$	$5.2X10^{1}$
Cm-244	.	$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{-3}$	$5.4X10^{-2}$	3.0	$8.1X10^{1}$
Cm-245	.	9.0	$2.4X10^{2}$	$9.0X10^{-4}$	$2.4X10^{-2}$	$6.4X10^{-3}$	$1.7X10^{-1}$
Cm-246	.	9.0	$2.4X10^{2}$	$9.0X10^{-4}$	$2.4X10^{-2}$	$1.1X10^{-2}$	$3.1X10^{-1}$
Cm-247 (a)	.	3.0	$8.1X10^{1}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$3.4X10^{-6}$	$9.3X10^{-5}$
Cm-248	.	$2.0X10^{-2}$	$5.4X10^{-1}$	$3.0X10^{-4}$	$8.1X10^{-3}$	$1.6X10^{-4}$	$4.2X10^{-3}$
Co-55	Cobalt (27)	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$1.1X10^{5}$	$3.1X10^{6}$
Co-56	.	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$1.1X10^{3}$	$3.0X10^{4}$
Co-57	.	$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	$3.1X10^{2}$	$8.4X10^{3}$
Co-58	.	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$1.2X10^{3}$	$3.2X10^{4}$
Co-58m	.	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$2.2X10^{5}$	$5.9X10^{6}$
Co-60	.	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$4.2X10^{1}$	$1.1X10^{3}$
Cr-51	Chromium (24)	$3.0X10^{1}$	$8.1X10^{2}$	$3.0X10^{1}$	$8.1X10^{2}$	$3.4X10^{3}$	$9.2X10^{4}$
Cs-129	Cesium (55)	4.0	$1.1X10^{2}$	4.0	$1.1X10^{2}$	$2.8X10^{4}$	$7.6X10^{5}$
Cs-131	.	$3.0X10^{1}$	$8.1X10^{2}$	$3.0X10^{1}$	$8.1X10^{2}$	$3.8X10^{3}$	$1.0X10^{5}$
Cs-132	.	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$5.7X10^{3}$	$1.5X10^{5}$
Cs-134	.	$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$4.8X10^{1}$	$1.3X10^{3}$
Cs-134m	.	$4.0X10^{1}$	$1.1X10^{3}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.0X10^{5}$	$8.0X10^{6}$
Cs-135	.	$4.0X10^{1}$	$1.1X10^{3}$	1.0	$2.7X10^{1}$	$4.3X10^{-5}$	$1.2X10^{-3}$
Cs-136	.	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$2.7X10^{3}$	$7.3X10^{4}$
Cs-137 (a)	.	2.0	$5.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	3.2	$8.7X10^{1}$
Cu-64	Copper (29)	6.0	$1.6X10^{2}$	1.0	$2.7X10^{1}$	$1.4X10^{5}$	$3.9X10^{6}$
Cu-67	.	$1.0X10^{1}$	$2.7X10^{2}$	$7.0X10^{-1}$	$1.9X10^{1}$	$2.8X10^{4}$	$7.6X10^{5}$
Dy-159	Dysprosium (66)	$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{1}$	$5.4X10^{2}$	$2.1X10^{2}$	$5.7X10^{3}$
Dy-165	.	$9.0X10^{-1}$	$2.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.0X10^{5}$	$8.2X10^{6}$
Dy-166 (a)	.	$9.0X10^{-1}$	$2.4X10^{1}$	$3.0X10^{-1}$	8.1	$8.6X10^{3}$	$2.3X10^{5}$
Er-169	Erbium (68)	$4.0X10^{1}$	$1.1X10^{3}$	1.0	$2.7X10^{1}$	$3.1X10^{3}$	$8.3X10^{4}$
Er-171	.	$8.0X10^{-1}$	$2.2X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$9.0X10^{4}$	$2.4X10^{6}$
Eu-147	Europium (63)	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$1.4X10^{3}$	$3.7X10^{4}$

TABLE 17A1: A_1 AND A_2 VALUES FOR RADIONUCLIDES – Part 2 of 4

Symbol.of. radionuclide	Element.and. atomic.number	A_1 .(Tab)	A_1 (Ci)b	A_2 .(TBq)	A_2 (Ci)b	Specific. activity	Specific. activity
.	.	.	.	.	.	(TBq/g)	(Ci/g)
Eu-148	.	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$6.0X10^{2}$	$1.6X10^{4}$
Eu-149	.	$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{1}$	$5.4X10^{2}$	$3.5X10^{2}$	$9.4X10^{3}$
Eu-150. (short.lived)	.	2.0	$5.4X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$6.1X10^{4}$	$1.6X10^{6}$
Eu-150. (long.lived)	.	$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$6.1X10^{4}$	$1.6X10^{6}$
Eu-152	.	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	6.5	$1.8X10^{2}$
Eu-152m	.	$8.0X10^{-1}$	$2.2X10^{1}$	$8.0X10^{-1}$	$2.2X10^{1}$	$8.2X10^{4}$	$2.2X10^{6}$
Eu-154	.	$9.0X10^{-1}$	$2.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	9.8	$2.6X10^{2}$
Eu-155	.	$2.0X10^{1}$	$5.4X10^{2}$	3.0	$8.1X10^{1}$	$1.8X10^{1}$	$4.9X10^{2}$
Eu-156	.	$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$2.0X10^{3}$	$5.5X10^{4}$
F-18	Fluorine.(9)	1.0	$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.5X10^{6}$	$9.5X10^{7}$
Fe-52.(a)	Iron.(26)	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$2.7X10^{5}$	$7.3X10^{6}$
Fe-55	.	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$8.8X10^{1}$	$2.4X10^{3}$
Fe-59	.	$9.0X10^{-1}$	$2.4X10^{1}$	$9.0X10^{-1}$	$2.4X10^{1}$	$1.8X10^{3}$	$5.0X10^{4}$
Fe-60.(a)	.	$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{-1}$	5.4	$7.4X10^{-4}$	$2.0X10^{-2}$
Ga-67	Gallium.(31)	7.0	$1.9X10^{2}$	3.0	$8.1X10^{1}$	$2.2X10^{4}$	$6.0X10^{5}$
Ga-68	.	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$1.5X10^{6}$	$4.1X10^{7}$
Ga-72	.	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.1X10^{5}$	$3.1X10^{6}$
Gd-146.(a)	Gadolinium.(64)	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$6.9X10^{2}$	$1.9X10^{4}$
Gd-148	.	$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{-3}$	$5.4X10^{-2}$	1.2	$3.2X10^{1}$
Gd-153	.	$1.0X10^{1}$	$2.7X10^{2}$	9.0	$2.4X10^{2}$	$1.3X10^{2}$	$3.5X10^{3}$
Gd-159	.	3.0	$8.1X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.9X10^{4}$	$1.1X10^{6}$
Ge-68.(a)	Germanium.(32)	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$2.6X10^{2}$	$7.1X10^{3}$
Ge-71	.	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$5.8X10^{3}$	$1.6X10^{5}$
Ge-77	.	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$1.3X10^{5}$	$3.6X10^{6}$
Hf-172.(a)	Hafnium.(72)	$6.0X10^{-1}$	$1.6X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$4.1X10^{1}$	$1.1X10^{3}$
Hf-175	.	3.0	$8.1X10^{1}$	3.0	$8.1X10^{1}$	$3.9X10^{2}$	$1.1X10^{4}$
Hf-181	.	2.0	$5.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$6.3X10^{2}$	$1.7X10^{4}$
Hf-182	.	Unlimited	Unlimited	Unlimited	Unlimited	$8.1X10^{-6}$	$2.2X10^{-4}$
Hg-194.(a)	Mercury.(80)	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$1.3X10^{-1}$	3.5
Hg-195m.(a)	.	3.0	$8.1X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$1.5X10^{4}$	$4.0X10^{5}$
Hg-197	.	$2.0X10^{1}$	$5.4X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	$9.2X10^{3}$	$2.5X10^{5}$
Hg-197m	.	$1.0X10^{1}$	$2.7X10^{2}$	$4.0X10^{-1}$	$1.1X10^{1}$	$2.5X10^{4}$	$6.7X10^{5}$
Hg-203	.	5.0	$1.4X10^{2}$	1.0	$2.7X10^{1}$	$5.1X10^{2}$	$1.4X10^{4}$
Ho-166	Holmium.(67)	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$2.6X10^{4}$	$7.0X10^{5}$
Ho-166m	.	$6.0X10^{-1}$	$1.6X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$6.6X10^{-2}$	1.8
I-123	Iodine.(53)	6.0	$1.6X10^{2}$	3.0	$8.1X10^{1}$	$7.1X10^{4}$	$1.9X10^{6}$
I-124	.	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$9.3X10^{3}$	$2.5X10^{5}$
I-125	.	$2.0X10^{1}$	$5.4X10^{2}$	3.0	$8.1X10^{1}$	$6.4X10^{2}$	$1.7X10^{4}$
I-126	.	2.0	$5.4X10^{1}$	1.0	$2.7X10^{1}$	$2.9X10^{3}$	$8.0X10^{4}$
I-129	.	Unlimited	Unlimited	Unlimited	Unlimited	$6.5X10^{-6}$	$1.8X10^{-4}$

I-131	.	3.0	$8.1X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$4.6X10^{3}$	$1.2X10^{5}$
I-132	.	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$3.8X10^{5}$	$1.0X10^{7}$
I-133	.	$7.0X10^{-1}$	$1.9X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$4.2X10^{4}$	$1.1X10^{6}$
I-134	.	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$9.9X10^{5}$	$2.7X10^{7}$
I-135.(a)	.	$6.0X10^{-1}$	$1.6X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.3X10^{5}$	$3.5X10^{6}$
In-111	Indium.(49)	3.0	$8.1X10^{1}$	3.0	$8.1X10^{1}$	$1.5X10^{4}$	$4.2X10^{5}$
In-113m	.	4.0	$1.1X10^{2}$	2.0	$5.4X10^{1}$	$6.2X10^{5}$	$1.7X10^{7}$
In-114m.(a)	.	$1.0X10^{1}$	$2.7X10^{2}$	$5.0X10^{-1}$	$1.4X10^{1}$	$8.6X10^{2}$	$2.3X10^{4}$
In-115m	.	7.0	$1.9X10^{2}$	1.0	$2.7X10^{1}$	$2.2X10^{5}$	$6.1X10^{6}$
Ir-189.(a)	Iridium.(77)	$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	$1.9X10^{3}$	$5.2X10^{4}$
Ir-190	.	$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$2.3X10^{3}$	$6.2X10^{4}$
Ir-192.(c)	.	1.0	$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.4X10^{2}$	$9.2X10^{3}$
Ir-194	.	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$3.1X10^{4}$	$8.4X10^{5}$
K-40	Potassium.(19)	$9.0X10^{-1}$	$2.4X10^{1}$	$9.0X10^{-1}$	$2.4X10^{1}$	$2.4X10^{-7}$	$6.4X10^{-6}$
K-42	.	$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$2.2X10^{5}$	$6.0X10^{6}$
K-43	.	$7.0X10^{-1}$	$1.9X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.2X10^{5}$	$3.3X10^{6}$
Kr-81	Krypton.(36)	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$7.8X10^{-4}$	$2.1X10^{-2}$
Kr-85	.	$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	$1.5X10^{1}$	$3.9X10^{2}$
Kr-85m	.	8.0	$2.2X10^{2}$	3.0	$8.1X10^{1}$	$3.0X10^{5}$	$8.2X10^{6}$
Kr-87	.	$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$1.0X10^{6}$	$2.8X10^{7}$
La-137	Lanthanum.(57)	$3.0X10^{1}$	$8.1X10^{2}$	6.0	$1.6X10^{2}$	$1.6X10^{-3}$	$4.4X10^{-2}$
La-140	.	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$2.1X10^{4}$	$5.6X10^{5}$
Lu-172	Lutetium.(71)	$6.0X10^{-1}$	$1.6X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$4.2X10^{3}$	$1.1X10^{5}$
Lu-173	.	8.0	$2.2X10^{2}$	8.0	$2.2X10^{2}$	$5.6X10^{1}$	$1.5X10^{3}$
Lu-174	.	9.0	$2.4X10^{2}$	9.0	$2.4X10^{2}$	$2.3X10^{1}$	$6.2X10^{2}$
Lu-174m	.	$2.0X10^{1}$	$5.4X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	$2.0X10^{2}$	$5.3X10^{3}$
Lu-177	.	$3.0X10^{1}$	$8.1X10^{2}$	$7.0X10^{-1}$	$1.9X10^{1}$	$4.1X10^{3}$	$1.1X10^{5}$
Mg-28.(a)	Magnesium.(12)	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$2.0X10^{5}$	$5.4X10^{6}$
Mn-52	Manganese.(25)	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$1.6X10^{4}$	$4.4X10^{5}$
Mn-53	.	Unlimited	Unlimited	Unlimited	Unlimited	$6.8X10^{-5}$	$1.8X10^{-3}$
Mn-54	.	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$2.9X10^{2}$	$7.7X10^{3}$
Mn-56	.	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$8.0X10^{5}$	$2.2X10^{7}$
Mo-93	Molybdenum.(42)	$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{1}$	$5.4X10^{2}$	$4.1X10^{-2}$	1.1
Mo-99.(a).(i)	.	1.0	$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.8X10^{4}$	$4.8X10^{5}$
N-13	Nitrogen.(7)	$9.0X10^{-1}$	$2.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$5.4X10^{7}$	$1.5X10^{9}$
Na-22	Sodium.(11)	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$2.3X10^{2}$	$6.3X10^{3}$
Na-24	.	$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$3.2X10^{5}$	$8.7X10^{6}$
Nb-93m	Niobium.(41)	$4.0X10^{1}$	$1.1X10^{3}$	$3.0X10^{1}$	$8.1X10^{2}$	8.8	$2.4X10^{2}$
Nb-94	.	$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$6.9X10^{-3}$	$1.9X10^{-1}$
Nb-95	.	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$1.5X10^{3}$	$3.9X10^{4}$
Nb-97	.	$9.0X10^{-1}$	$2.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$9.9X10^{5}$	$2.7X10^{7}$
Nd-147	Neodymium.(60)	6.0	$1.6X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.0X10^{3}$	$8.1X10^{4}$
Nd-149	.	$6.0X10^{-1}$	$1.6X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$4.5X10^{5}$	$1.2X10^{7}$
Ni-59	Nickel.(28)	Unlimited	Unlimited	Unlimited	Unlimited	$3.0X10^{-3}$	$8.0X10^{-2}$

Ni-63	.	$4.0X10^{1}$	$1.1X10^{3}$	$3.0X10^{1}$	$8.1X10^{2}$	2.1	$5.7X10^{1}$
Ni-65	.	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$7.1X10^{5}$	$1.9X10^{7}$
Np-235	Neptunium.(93)	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$5.2X10^{1}$	$1.4X10^{3}$
Np-236. (short-lived)	.	$2.0X10^{1}$	$5.4X10^{2}$	2.0	$5.4X10^{1}$	$4.7X10^{-4}$	$1.3X10^{-2}$
Np-236. (long-lived)	.	$9.0X10^{0}$	$2.4X10^{2}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$4.7X10^{-4}$	$1.3X10^{-2}$
Np-237	.	$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{-3}$	$5.4X10^{-2}$	$2.6X10^{-5}$	$7.1X10^{-4}$
Np-239	.	7.0	$1.9X10^{2}$	$4.0X10^{-1}$	$1.1X10^{1}$	$8.6X10^{3}$	$2.3X10^{5}$
Os-185	Osmium.(76)	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$2.8X10^{2}$	$7.5X10^{3}$
Os-191	.	$1.0X10^{1}$	$2.7X10^{2}$	2.0	$5.4X10^{1}$	$1.6X10^{3}$	$4.4X10^{4}$
Os-191m	.	$4.0X10^{1}$	$1.1X10^{3}$	$3.0X10^{1}$	$8.1X10^{2}$	$4.6X10^{4}$	$1.3X10^{6}$
Os-193	.	2.0	$5.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.0X10^{4}$	$5.3X10^{5}$
Os-194.(a)	.	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$1.1X10^{1}$	$3.1X10^{2}$

TABLE 17A1: A_1 AND A_2 VALUES FOR RADIONUCLIDES – Part 3 of 4

Symbol.of .radionuclide	Element.and. atomic.number	A_1 . (TBq)	A_1 (Ci)b	A_2 . (Tab)	A_2 (Ci)b	Specific. activity	Specific. activity
.	.	.	.	.	.	(TBq/g)	(Ci/g)
P-32	Phosphorus . (15)	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$1.1X10^{4}$	$2.9X10^{5}$
P-33	.	$4.0X10^{1}$	$1.1X10^{3}$	1.0	$2.7X10^{1}$	$5.8X10^{3}$	$1.6X10^{5}$
Pa-230 . (a)	Protactinium . (91)	2.0	$5.4X10^{1}$	$7.0X10^{-2}$	1.9	$1.2X10^{3}$	$3.3X10^{4}$
Pa-231	.	4.0	$1.1X10^{2}$	$4.0X10^{-4}$	$1.1X10^{-2}$	$1.7X10^{-3}$	$4.7X10^{-2}$
Pa-233	.	5.0	$1.4X10^{2}$	$7.0X10^{-1}$	$1.9X10^{1}$	$7.7X10^{2}$	$2.1X10^{4}$
Pb-201	Lead . (82)	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$6.2X10^{4}$	$1.7X10^{6}$
Pb-202	.	$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{1}$	$5.4X10^{2}$	$1.2X10^{-4}$	$3.4X10^{-3}$
Pb-203	.	4.0	$1.1X10^{2}$	3.0	$8.1X10^{1}$	$1.1X10^{4}$	$3.0X10^{5}$
Pb-205	.	Unlimited	Unlimited	Unlimited	Unlimited	$4.5X10^{-6}$	$1.2X10^{-4}$
Pb-210 . (a)	.	1.0	$2.7X10^{1}$	$5.0X10^{-2}$	1.4	2.8	$7.6X10^{1}$
Pb-212 . (a)	.	$7.0X10^{-1}$	$1.9X10^{1}$	$2.0X10^{-1}$	5.4	$5.1X10^{4}$	$1.4X10^{6}$
Pd-103 . (a)	Palladium . (46)	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$2.8X10^{3}$	$7.5X10^{4}$
Pd-107	.	Unlimited	Unlimited	Unlimited	Unlimited	$1.9X10^{-5}$	$5.1X10^{-4}$
Pd-109	.	2.0	$5.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$7.9X10^{4}$	$2.1X10^{6}$
Pm-143	Promethium . (61)	3.0	$8.1X10^{1}$	3.0	$8.1X10^{1}$	$1.3X10^{2}$	$3.4X10^{3}$
Pm-144	.	$7.0X10^{-1}$	$1.9X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$9.2X10^{1}$	$2.5X10^{3}$
Pm-145	.	$3.0X10^{1}$	$8.1X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	5.2	$1.4X10^{2}$
Pm-147	.	$4.0X10^{1}$	$1.1X10^{3}$	2.0	$5.4X10^{1}$	$3.4X10^{1}$	$9.3X10^{2}$
Pm-148m . (a)	.	$8.0X10^{-1}$	$2.2X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$7.9X10^{2}$	$2.1X10^{4}$
Pm-149	.	2.0	$5.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.5X10^{4}$	$4.0X10^{5}$
Pm-151	.	2.0	$5.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.7X10^{4}$	$7.3X10^{5}$
Po-210	Polonium . (84)	$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$1.7X10^{2}$	$4.5X10^{3}$
Pr-142	Praseodymium . (59)	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$4.3X10^{4}$	$1.2X10^{6}$
Pr-143	.	3.0	$8.1X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.5X10^{3}$	$6.7X10^{4}$

Pt-188 . (a)	Platinum . (78)	1.0	$2.7X10^{1}$	$8.0X10^{-1}$	$2.2X10^{1}$	$2.5X10^{3}$	$6.8X10^{4}$
Pt-191	.	4.0	$1.1X10^{2}$	3.0	$8.1X10^{1}$	$8.7X10^{3}$	$2.4X10^{5}$
Pt-193	.	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	1.4	$3.7X10^{1}$
Pt-193m	.	$4.0X10^{1}$	$1.1X10^{3}$	$5.0X10^{-1}$	$1.4X10^{1}$	$5.8X10^{3}$	$1.6X10^{5}$
Pt-195m	.	$1.0X10^{1}$	$2.7X10^{2}$	$5.0X10^{-1}$	$1.4X10^{1}$	$6.2X10^{3}$	$1.7X10^{5}$
Pt-197	.	$2.0X10^{1}$	$5.4X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.2X10^{4}$	$8.7X10^{5}$
Pt-197m	.	$1.0X10^{1}$	$2.7X10^{2}$	$6.0X10^{-1}$	$1.6X10^{1}$	$3.7X10^{5}$	$1.0X10^{7}$
Pu-236	Plutonium . (94)	$3.0X10^{1}$	$8.1X10^{2}$	$3.0X10^{-3}$	$8.1X10^{-2}$	$2.0X10^{1}$	$5.3X10^{2}$
Pu-237	.	$2.0X10^{1}$	$5.4X10^{2}$	$2.0X10^{1}$	$5.4X10^{2}$	$4.5X10^{2}$	$1.2X10^{4}$
Pu-238	.	$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$6.3X10^{-1}$	$1.7X10^{1}$
Pu-239	.	$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$2.3X10^{-3}$	$6.2X10^{-2}$
Pu-240	.	$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$8.4X10^{-3}$	$2.3X10^{-1}$
Pu-241 . (a)	.	$4.0X10^{1}$	$1.1X10^{3}$	$6.0X10^{-2}$	1.6	3.8	$1.0X10^{2}$
Pu-242	.	$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$1.5X10^{-4}$	$3.9X10^{-3}$
Pu-244 . (a)	.	$4.0X10^{-1}$	$1.1X10^{1}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$6.7X10^{-7}$	$1.8X10^{-5}$
Ra-223 . (a)	Radium . (88)	$4.0X10^{-1}$	$1.1X10^{1}$	$7.0X10^{-3}$	$1.9X10^{-1}$	$1.9X10^{3}$	$5.1X10^{4}$
Ra-224 . (a)	.	$4.0X10^{-1}$	$1.1X10^{1}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$5.9X10^{3}$	$1.6X10^{5}$
Ra-225 . (a)	.	$2.0X10^{-1}$	5.4	$4.0X10^{-3}$	$1.1X10^{-1}$	$1.5X10^{3}$	$3.9X10^{4}$
Ra-226 . (a)	.	$2.0X10^{-1}$	5.4	$3.0X10^{-3}$	$8.1X10^{-2}$	$3.7X10^{-2}$	1.0
Ra-228 . (a)	.	$6.0X10^{-1}$	$1.6X10^{1}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$1.0X10^{1}$	$2.7X10^{2}$
Rb-81	Rubidium . (37)	2.0	$5.4X10^{1}$	$8.0X10^{-1}$	$2.2X10^{1}$	$3.1X10^{5}$	$8.4X10^{6}$
Rb-83 . (a)	.	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$6.8X10^{2}$	$1.8X10^{4}$
Rb-84	.	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$1.8X10^{3}$	$4.7X10^{4}$
Rb-86	.	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$3.0X10^{3}$	$8.1X10^{4}$
Rb-87	.	Unlimited	Unlimited	Unlimited	Unlimited	$3.2X10^{-9}$	$8.6X10^{-8}$
Rb(nat)	.	Unlimited	Unlimited	Unlimited	Unlimited	$6.7X10^{6}$	$1.8X10^{8}$
Re-184	Rhenium . (75)	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$6.9X10^{2}$	$1.9X10^{4}$
Re-184m	.	3.0	$8.1X10^{1}$	1.0	$2.7X10^{1}$	$1.6X10^{2}$	$4.3X10^{3}$
Re-186	.	2.0	$5.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$6.9X10^{3}$	$1.9X10^{5}$
Re-187	.	Unlimited	Unlimited	Unlimited	Unlimited	$1.4X10^{-9}$	$3.8X10^{-8}$
Re-188	.	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$3.6X10^{4}$	$9.8X10^{5}$
Re-189 . (a)	.	3.0	$8.1X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.5X10^{4}$	$6.8X10^{5}$
Re(nat)	.	Unlimited	Unlimited	Unlimited	Unlimited	0.0	$2.4X10^{-8}$
Rh-99	Rhodium . (45)	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$3.0X10^{3}$	$8.2X10^{4}$
Rh-101	.	4.0	$1.1X10^{2}$	3.0	$8.1X10^{1}$	$4.1X10^{1}$	$1.1X10^{3}$
Rh-102	.	$5.0X10^{-1}$	$1.4X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$4.5X10^{1}$	$1.2X10^{3}$
Rh-102m	.	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$2.3X10^{2}$	$6.2X10^{3}$
Rh-103m	.	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$1.2X10^{6}$	$3.3X10^{7}$
Rh-105	.	$1.0X10^{1}$	$2.7X10^{2}$	$8.0X10^{-1}$	$2.2X10^{1}$	$3.1X10^{4}$	$8.4X10^{5}$
Rn-222 . (a)	Radon . (86)	$3.0X10^{-1}$	8.1	$4.0X10^{-3}$	$1.1X10^{-1}$	$5.7X10^{3}$	$1.5X10^{5}$
Ru-97	Ruthenium . (44)	5.0	$1.4X10^{2}$	5.0	$1.4X10^{2}$	$1.7X10^{4}$	$4.6X10^{5}$
Ru-103 . (a)	.	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$1.2X10^{3}$	$3.2X10^{4}$
Ru-105	.	1.0	$2.7X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.5X10^{5}$	$6.7X10^{6}$
Ru-106 . (a)	.	$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$1.2X10^{2}$	$3.3X10^{3}$

S-35	Sulphur . (16)	4.0X10 1	1.1X10 3	3.0	8.1X10 1	1.6X10 3	4.3X10 4
Sb-122	Antimony . (51)	4.0X10 -1	1.1X10 1	4.0X10 -1	1.1X10 1	1.5X10 4	4.0X10 5
Sb-124	.	6.0X10 -1	1.6X10 1	6.0X10 -1	1.6X10 1	6.5X10 2	1.7X10 4
Sb-125	.	2.0	5.4X10 1	1.0	2.7X10 1	3.9X10 1	1.0X10 3
Sb-126	.	4.0X10 -1	1.1X10 1	4.0X10 -1	1.1X10 1	3.1X10 3	8.4X10 4
Sc-44	Scandium . (21)	5.0X10 -1	1.4X10 1	5.0X10 -1	1.4X10 1	6.7X10 5	1.8X10 7
Sc-46	.	5.0X10 -1	1.4X10 1	5.0X10 -1	1.4X10 1	1.3X10 3	3.4X10 4
Sc-47	.	1.0X10 1	2.7X10 2	7.0X10 -1	1.9X10 1	3.1X10 4	8.3X10 5
Sc-48	.	3.0X10 -1	8.1	3.0X10 -1	8.1	5.5X10 4	1.5X10 6
Se-75	Selenium . (34)	3.0	8.1X10 1	3.0	8.1X10 1	5.4X10 2	1.5X10 4
Se-79	.	4.0X10 1	1.1X10 3	2.0	5.4X10 1	2.6X10 -3	7.0X10 -2
Si-31	Silicon . (14)	6.0X10 -1	1.6X10 1	6.0X10 -1	1.6X10 1	1.4X10 6	3.9X10 7
Si-32	.	4.0X10 1	1.1X10 3	5.0X10 -1	1.4X10 1	3.9	1.1X10 2
Sm-145	Samarium . (62)	1.0X10 1	2.7X10 2	1.0X10 1	2.7X10 2	9.8X10 1	2.6X10 3
Sm-147	.	Unlimited	Unlimited	Unlimited	Unlimited	8.5X10 -1	2.3X10 -8
Sm-151	.	4.0X10 1	1.1X10 3	1.0X10 1	2.7X10 2	9.7X10 -1	2.6X10 1
Sm-153	.	9.0	2.4X10 2	6.0X10 -1	1.6X10 1	1.6X10 4	4.4X10 5
Sn-113 . (a)	Tin . (50)	4.0	1.1X10 2	2.0	5.4X10 1	3.7X10 2	1.0X10 4
Sn-117m	.	7.0	1.9X10 2	4.0X10 -1	1.1X10 1	3.0X10 3	8.2X10 4
Sn-119m	.	4.0X10 1	1.1X10 3	3.0X10 1	8.1X10 2	1.4X10 2	3.7X10 3
Sn-121m . (a)	.	4.0X10 1	1.1X10 3	9.0X10 -1	2.4X10 1	2.0	5.4X10 1
Sn-123	.	8.0X10 -1	2.2X10 1	6.0X10 -1	1.6X10 1	3.0X10 2	8.2X10 3
Sn-125	.	4.0X10 -1	1.1X10 1	4.0X10 -1	1.1X10 1	4.0X10 3	1.1X10 5
Sn-126 . (a)	.	6.0X10 -1	1.6X10 1	4.0X10 -1	1.1X10 1	1.0X10 -3	2.8X10 -2
Sr-82 . (a)	Strontium . (38)	2.0X10 -1	5.4	2.0X10 -1	5.4	2.3X10 3	6.2X10 4
Sr-85	.	2.0	5.4X10 1	2.0	5.4X10 1	8.8X10 2	2.4X10 4
Sr-85m	.	5.0	1.4X10 2	5.0	1.4X10 2	1.2X10 6	3.3X10 7
Sr-87m	.	3.0	8.1X10 1	3.0	8.1X10 1	4.8X10 5	1.3X10 7

TABLE 17A1: A_1 AND A_2 VALUES FOR RADIONUCLIDES – Part 4 of 4

Symbol.of. radionuclide	Element.and. atomic.number	A_1 .(TBq)	A_1 (Ci)b	A_2 .(Tab)	A_2 (Ci)b	Specific. activity	Specific. activity
.	.	.	.	.	.	(TBq/g)	(Ci/g)
Sr-89	.	6.0X10 -1	1.6X10 1	6.0X10 -1	1.6X10 1	1.1X10 3	2.9X10 4
Sr-90 . (a)	.	3.0X10 -1	8.1	3.0X10 -1	8.1	5.1	1.4X10 2
Sr-91 . (a)	.	3.0X10 -1	8.1	3.0X10 -1	8.1	1.3X10 5	3.6X10 6
Sr-92 . (a)	.	1.0	2.7X10 1	3.0X10 -1	8.1	4.7X10 5	1.3X10 7
T(H-3)	Tritium . (1)	4.0X10 1	1.1X10 3	4.0X10 1	1.1X10 3	3.6X10 2	9.7X10 3
Ta-178 . (long	Tantalum . (73)	1.0	2.7X10 1	8.0X10 -1	2.2X10 1	4.2X10 6	1.1X10 8
Ta-179	.	3.0X10 1	8.1X10 2	3.0X10 1	8.1X10 2	4.1X10 1	1.1X10 3
Ta-182	.	9.0X10 -1	2.4X10 1	5.0X10 -1	1.4X10 1	2.3X10 2	6.2X10 3
Tb-157	Terbium . (65)	4.0X10 1	1.1X10 3	4.0X10 1	1.1X10 3	5.6X10 -1	1.5X10 1
Tb-158	.	1.0	2.7X10 1	1.0	2.7X10 1	5.6X10 -1	1.5X10 1
Tb-160	.	1.0	2.7X10 1	6.0X10 -1	1.6X10 1	4.2X10 2	1.1X10 4

Tc-95m . (a)	Technetium . (43)	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$8.3X10^{2}$	$2.2X10^{4}$
Tc-96	.	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.2X10^{4}$	$3.2X10^{5}$
Tc-96m . (a)	.	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.4X10^{6}$	$3.8X10^{7}$
Tc-97	.	Unlimited	Unlimited	Unlimited	Unlimited	$5.2X10^{-5}$	$1.4X10^{-3}$
Tc-97m	.	$4.0X10^{1}$	$1.1X10^{3}$	1.0	$2.7X10^{1}$	$5.6X10^{2}$	$1.5X10^{4}$
Tc-98	.	$8.0X10^{-1}$	$2.2X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$3.2X10^{-5}$	$8.7X10^{-4}$
Tc-99	.	$4.0X10^{1}$	$1.1X10^{3}$	$9.0X10^{-1}$	$2.4X10^{1}$	$6.3X10^{-4}$	$1.7X10^{-2}$
Tc-99m	.	$1.0X10^{1}$	$2.7X10^{2}$	4.0	$1.1X10^{2}$	$1.9X10^{5}$	$5.3X10^{6}$
Te-121	Tellurium . (52)	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$2.4X10^{3}$	$6.4X10^{4}$
Te-121m	.	5.0	$1.4X10^{2}$	3.0	$8.1X10^{1}$	$2.6X10^{2}$	$7.0X10^{3}$
Te-123m	.	8.0	$2.2X10^{2}$	1.0	$2.7X10^{1}$	$3.3X10^{2}$	$8.9X10^{3}$
Te-125m	.	$2.0X10^{1}$	$5.4X10^{2}$	$9.0X10^{-1}$	$2.4X10^{1}$	$6.7X10^{2}$	$1.8X10^{4}$
Te-127	.	$2.0X10^{1}$	$5.4X10^{2}$	$7.0X10^{-1}$	$1.9X10^{1}$	$9.8X10^{4}$	$2.6X10^{6}$
Te-127m . (a)	.	$2.0X10^{1}$	$5.4X10^{2}$	$5.0X10^{-1}$	$1.4X10^{1}$	$3.5X10^{2}$	$9.4X10^{3}$
Te-129	.	$7.0X10^{-1}$	$1.9X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$7.7X10^{5}$	$2.1X10^{7}$
Te-129m . (a)	.	$8.0X10^{-1}$	$2.2X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$1.1X10^{3}$	$3.0X10^{4}$
Te-131m . (a)	.	$7.0X10^{-1}$	$1.9X10^{1}$	$5.0X10^{-1}$	$1.4X10^{1}$	$3.0X10^{4}$	$8.0X10^{5}$
Te-132 . (a)	.	$5.0X10^{-1}$	$1.4X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$3.1X10^{4}$	$3.0X10^{5}$
Th-227	Thorium . (90)	$1.0X10^{1}$	$2.7X10^{2}$	$5.0X10^{-3}$	$1.4X10^{-1}$	$1.1X10^{3}$	$3.1X10^{4}$
Th-228 . (a)	.	$5.0X10^{-1}$	$1.4X10^{1}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$3.0X10^{1}$	$8.2X10^{2}$
Th-229	.	5.0	$1.4X10^{2}$	$5.0X10^{-4}$	$1.4X10^{-2}$	$7.9X10^{-3}$	$2.1X10^{-1}$
Th-230	.	$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$7.6X10^{-4}$	$2.1X10^{-2}$
Th-231	.	$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$2.0X10^{4}$	$5.3X10^{5}$
Th-232	.	Unlimited	Unlimited	Unlimited	Unlimited	$4.0X10^{-9}$	$1.1X10^{-7}$
Th-234 . (a)	.	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$8.6X10^{2}$	$2.3X10^{4}$
Th(nat)	.	Unlimited	Unlimited	Unlimited	Unlimited	$8.1X10^{-9}$	$2.2X10^{-7}$
Ti-44 . (a)	Titanium . (22)	$5.0X10^{-1}$	$1.4X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	6.4	$1.7X10^{2}$
Tl-200	Thallium . (81)	$9.0X10^{-1}$	$2.4X10^{1}$	$9.0X10^{-1}$	$2.4X10^{1}$	$2.2X10^{4}$	$6.0X10^{5}$
Tl-201	.	$1.0X10^{1}$	$2.7X10^{2}$	4.0	$1.1X10^{2}$	$7.9X10^{3}$	$2.1X10^{5}$
Tl-202	.	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$2.0X10^{3}$	$5.3X10^{4}$
Tl-204	.	$1.0X10^{1}$	$2.7X10^{2}$	$7.0X10^{-1}$	$1.9X10^{1}$	$1.7X10^{1}$	$4.6X10^{2}$
Tm-167	Thulium . (69)	7.0	$1.9X10^{2}$	$8.0X10^{-1}$	$2.2X10^{1}$	$3.1X10^{3}$	$8.5X10^{4}$
Tm-170	.	3.0	$8.1X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.2X10^{2}$	$6.0X10^{3}$
Tm-171	.	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$
U-230 . (fast . lung . absorption) . (a)(d)	Uranium . (92)	$4.0X10^{1}$	$1.1X10^{3}$	$1.0X10^{-1}$	2.7	$1.0X10^{3}$	$2.7X10^{4}$
U-230 . (medium . lung . absorption) . (a)(e)	.	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{-3}$	$1.1X10^{-1}$	$1.0X10^{3}$	$2.7X10^{4}$
U-230 . (slow . lung . absorption) .	.	$3.0X10^{1}$	$8.1X10^{2}$	$3.0X10^{-3}$	$8.1X10^{-2}$	$1.0X10^{3}$	$2.7X10^{4}$

(a)(f)							
U-232 . (fast . lung . absorption) . (d)	.	$4.0X10^{1}$	$1.1X10^{3}$	$1.0X10^{-2}$	$2.7X10^{-1}$	$8.3X10^{-1}$	$2.2X10^{1}$
U-232 . (medium . lung . absorption) . (e)	.	$4.0X10^{1}$	$1.1X10^{3}$	$7.0X10^{-3}$	$1.9X10^{-1}$	$8.3X10^{-1}$	$2.2X10^{1}$
U-232 . (slow . lung . absorption) . (f)	.	$1.0X10^{1}$	$2.7X10^{2}$	$1.0X10^{-3}$	$2.7X10^{-2}$	$8.3X10^{-1}$	$2.2X10^{1}$
U-233 . (fast . lung . absorption) . (d)	.	$4.0X10^{1}$	$1.1X10^{3}$	$9.0X10^{-2}$	2.4	$3.6X10^{-4}$	$9.7X10^{-3}$
U-233 . (medium . lung . absorption) . (e)	.	$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$3.6X10^{-4}$	$9.7X10^{-3}$
U-233 . (slow . lung . absorption) . (f)	.	$4.0X10^{1}$	$1.1X10^{3}$	$6.0X10^{-3}$	$1.6X10^{-1}$	$3.6X10^{-4}$	$9.7X10^{-3}$
U-234 . (fast . lung . absorption) . (d)	.	$4.0X10^{1}$	$1.1X10^{3}$	$9.0X10^{-2}$	2.4	$2.3X10^{-4}$	$6.2X10^{-3}$
U-234 . (medium . lung . absorption) . (e)	.	$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$2.3X10^{-4}$	$6.2X10^{-3}$
U-234 . (slow . lung . absorption) . (f)	.	$4.0X10^{1}$	$1.1X10^{3}$	$6.0X10^{-3}$	$1.6X10^{-1}$	$2.3X10^{-4}$	$6.2X10^{-3}$
U-235 . (all . lung . absorption . types) . (a),(d),(e),(f)	.	Unlimited	Unlimited	Unlimited	Unlimited	$8.0X10^{-8}$	$2.2X10^{-6}$
U-236 . (fast . lung . absorption) . (d)	.	Unlimited	Unlimited	Unlimited	Unlimited	$2.4X10^{-6}$	$6.5X10^{-5}$
U-236 . (medium . lung . absorption) . (e)	.	$4.0X10^{1}$	$1.1X10^{3}$	$2.0X10^{-2}$	$5.4X10^{-1}$	$2.4X10^{-6}$	$6.5X10^{-5}$
U-236 . (slow . lung . absorption) . (f)	.	$4.0X10^{1}$	$1.1X10^{3}$	$6.0X10^{-3}$	$1.6X10^{-1}$	$2.4X10^{-6}$	$6.5X10^{-5}$
U-238 . (all . lung . absorption .	.	Unlimited	Unlimited	Unlimited	Unlimited	$1.2X10^{-8}$	$3.4X10^{-7}$

types) . (d),(e),(f)							
U . (nat)	.	Unlimited	Unlimited	Unlimited	Unlimited	$2.6X10^{-8}$	$7.1X10^{-7}$
U . (enriched . to . 20% . or . less) . (g)	.	Unlimited	Unlimited	Unlimited	Unlimited	See . Table . A-4	See . Table . A-4
U . (dep)	.	Unlimited	Unlimited	Unlimited	Unlimited	See . Table . A-4	(See . Table . A-3)
V-48	Vanadium . (23)	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$6.3X10^{3}$	$1.7X10^{5}$
V-49	.	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$3.0X10^{2}$	$8.1X10^{3}$
W-178 . (a)	Tungsten . (74)	9.0	$2.4X10^{2}$	5.0	$1.4X10^{2}$	$1.3X10^{3}$	$3.4X10^{4}$
W-181	.	$3.0X10^{1}$	$8.1X10^{2}$	$3.0X10^{1}$	$8.1X10^{2}$	$2.2X10^{2}$	$6.0X10^{3}$
W-185	.	$4.0X10^{1}$	$1.1X10^{3}$	$8.0X10^{-1}$	$2.2X10^{1}$	$3.5X10^{2}$	$9.4X10^{3}$
W-187	.	2.0	$5.4X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$2.6X10^{4}$	$7.0X10^{5}$
W-188 . (a)	.	$4.0X10^{-1}$	$1.1X10^{1}$	$3.0X10^{-1}$	8.1	$3.7X10^{2}$	$1.0X10^{4}$
Xe-122 . (a)	Xenon . (54)	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$4.8X10^{4}$	$1.3X10^{6}$
Xe-123	.	2.0	$5.4X10^{1}$	$7.0X10^{-1}$	$1.9X10^{1}$	$4.4X10^{5}$	$1.2X10^{7}$
Xe-127	.	4.0	$1.1X10^{2}$	2.0	$5.4X10^{1}$	$1.0X10^{3}$	$2.8X10^{4}$
Xe-131m	.	$4.0X10^{1}$	$1.1X10^{3}$	$4.0X10^{1}$	$1.1X10^{3}$	$3.1X10^{3}$	$8.4X10^{4}$
Xe-133	.	$2.0X10^{1}$	$5.4X10^{2}$	$1.0X10^{1}$	$2.7X10^{2}$	$6.9X10^{3}$	$1.9X10^{5}$
Xe-135	.	3.0	$8.1X10^{1}$	2.0	$5.4X10^{1}$	$9.5X10^{4}$	$2.6X10^{6}$
Y-87 . (a)	Yttrium . (39)	1.0	$2.7X10^{1}$	1.0	$2.7X10^{1}$	$1.7X10^{4}$	$4.5X10^{5}$
Y-88	.	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$5.2X10^{2}$	$1.4X10^{4}$
Y-90	.	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$2.0X10^{4}$	$5.4X10^{5}$
Y-91	.	$6.0X10^{-1}$	$1.6X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$9.1X10^{2}$	$2.5X10^{4}$
Y-91m	.	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$1.5X10^{6}$	$4.2X10^{7}$
Y-92	.	$2.0X10^{-1}$	5.4	$2.0X10^{-1}$	5.4	$3.6X10^{5}$	$9.6X10^{6}$
Y-93	.	$3.0X10^{-1}$	8.1	$3.0X10^{-1}$	8.1	$1.2X10^{5}$	$3.3X10^{6}$
Yb-169	Ytterbium . (70)	4.0	$1.1X10^{2}$	1.0	$2.7X10^{1}$	$8.9X10^{2}$	$2.4X10^{4}$
Yb-175	.	$3.0X10^{1}$	$8.1X10^{2}$	$9.0X10^{-1}$	$2.4X10^{1}$	$6.6X10^{3}$	$1.8X10^{5}$
Zn-65	Zinc . (30)	2.0	$5.4X10^{1}$	2.0	$5.4X10^{1}$	$3.0X10^{2}$	$8.2X10^{3}$
Zn-69	.	3.0	$8.1X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.8X10^{6}$	$4.9X10^{7}$
Zn-69m . (a)	.	3.0	$8.1X10^{1}$	$6.0X10^{-1}$	$1.6X10^{1}$	$1.2X10^{5}$	$3.3X10^{6}$
Zr-88	Zirconium . (40)	3.0	$8.1X10^{1}$	3.0	$8.1X10^{1}$	$6.6X10^{2}$	$1.8X10^{4}$
Zr-93	.	Unlimited	Unlimited	Unlimited	Unlimited	$9.3X10^{-5}$	$2.5X10^{-3}$
Zr-95 . (a)	.	2.0	$5.4X10^{1}$	$8.0X10^{-1}$	$2.2X10^{1}$	$7.9X10^{2}$	$2.1X10^{4}$
Zr-97 . (a)	.	$4.0X10^{-1}$	$1.1X10^{1}$	$4.0X10^{-1}$	$1.1X10^{1}$	$7.1X10^{4}$	$1.9X10^{6}$

Notes:

a A1 and/or A2 values include contributions from daughter nuclides with half-lives less than 10 days.

b Parent nuclides and their progeny included in secular equilibrium are listed in the following:

Sr-90 Y-90

Zr-93 Nb-93m

Zr-97 Nb-97

Ru-106 Rh-106

Cs-137 Ba-137m

Ce-134 La-134

Ce-144 Pr-144

Ba-140 La-140

Bi-212 Tl-208 0.36 , Po-212 0.64

Pb-210 Bi-210, Po-210

Pb-212 Bi-212, Tl-208 0.36 , Po-212 0.64

Rn-220 Po-216

Rn-222 Po-218, Pb-214, Bi-214, Po-214

Ra-223 Rn-219, Po-215, Pb-211, Bi-211, Tl-207

Ra-224 Rn-220, Po-216, Pb-212, Bi-212, Tl-208 0.36 , Po-212 0.64

Ra-226 Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210

Ra-228 Ac-228

Th-226 Ra-222, Rn-218, Po-214

Th-228 Ra-224, Rn-220, Po-216, Pb212, Bi-212, Tl208 0.36 , Po-212 0.64

Th-229 Ra-225, Ac-225, Fr-221, At-217, Bi-213, Po-213, Pb-209

Th-nat Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 0.36 , Po-12 0.64

Th-234 Pa-234m

U-230 Th-226, Ra-222, Rn-218, Po-214

U-232 Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 0.36 , Po-212 0.64

U-235 Th-231

U-238 Th-234, Pa-234m

U-nat Th-234, Pa-234m, U-234, Th-230, Ra-226, Rn-222, Po-218, Pb-214, Bi-214, Po-214,

U-240 Np-240m

Np-237 Pa-233

Am-242m Am-242

Am-243 Np-239

c The quantity may be determined from a measurement of the rate of decay or a measurement of the radiation level at a prescribed distance from the source.

d These values apply only to compounds of uranium that take the chemical form of UF6, UO2F2 and UO2(NO3)2 in both normal and accident conditions of transport.

e These values apply only to compounds of uranium that take the chemical form of UO3, UF4, UCl4, and hexavalent compounds in both normal and accident conditions of transport.

f These values apply to all compounds of uranium other than those specified in d and e, above.

g These values apply to unirradiated uranium only.

h These values apply to domestic transport only. For international transport, use the values in the table below.

TABLE 17A1 (SUPPLEMENT): A 1 AND A 2 VALUES FOR RADIONUCLIDES FOR INTERNATIONAL SHIPMENTS

Symbol of radionuclide	Element and atomic number	A_1 (TBq)	A_1 (Ci)	A_2 (TBq)	A_2 (Ci)	Specific activity (TBq/g)	Specific activity (Ci/g)
Cf-252	Californium (98)	5.0×10^{-2}	1.4	3.0×10^{-3}	8.1×10^{-2}	2.0×10^{1}	5.4×10^{2}
Mo-99 [c]	Molybdenum (42)	1.0	2.7×10^{1}	6.0×10^{-1}	1.6×10^{1}	1.8×10^{4}	4.8×10^{5}

TABLE 17A2: EXEMPT MATERIAL ACTIVITY CONCENTRATIONS AND EXEMPT CONSIGNMENT ACTIVITY LIMITS FOR RADIONUCLIDES Part 1 of 4

Symbol of radionuclide	Element and atomic number	Activity concentration for exempt material (Bq/g)	Activity concentration for exempt material (Ci/g)	Activity limit for exempt consignment (Bq)	Activity limit for exempt consignment (Ci)
Ac-225 (a)	Actinium (89)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Ac-227 (a)	.	1.0×10^{-1}	2.7×10^{-12}	1.0×10^{3}	2.7×10^{-8}
Ac-228	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ag-105	Silver (47)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ag-108m (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ag-110m (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ag-111	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Al-26	Aluminum (13)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Am-241	Americium (95)	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Am-242m (a)	.	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Am-243 (a)	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Ar-37	Argon (18)	1.0×10^{6}	2.7×10^{-5}	1.0×10^{8}	2.7×10^{-3}
Ar-39	.	1.0×10^{7}	2.7×10^{-4}	1.0×10^{4}	2.7×10^{-7}
Ar-41	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{9}	2.7×10^{-2}
As-72	Arsenic (33)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
As-73	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
As-74	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
As-76	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
As-77	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
At-211 (a)	Astatine (85)	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Au-193	Gold (79)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Au-194	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Au-195	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Au-198	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Au-199	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ba-131 (a)	Barium (56)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ba-133	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ba-133m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ba-140 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Be-7	Beryllium (4)	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Be-10	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{6}	2.7×10^{-5}
Bi-205	Bismuth (83)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Bi-206	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Bi-207	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Bi-210	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Bi-210m (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Bi-212 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Bk-247	Berkelium	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}

	(97)				
Bk-249 [5]	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Br-76	Bromine (35)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Br-77	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Br-82	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
C-11	Carbon (6)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
C-14	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Ca-41	Calcium (20)	1.0×10^{5}	2.7×10^{-6}	1.0×10^{7}	2.7×10^{-4}
Ca-45	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Ca-47 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Cd-109	Cadmium (48)	1.0×10^{4}	2.7×10^{-7}	1.0×10^{6}	2.7×10^{-5}
Cd-113m	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Cd-115 (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Cd-115m	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Ce-139	Cerium (58)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ce-141	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Ce-143	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ce-144 (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Cf-248	Californium (98)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Cf-249	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Cf-250	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Cf-251	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Cf-252	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Cf-253 (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Cf-254	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Cl-36	Chlorine (17)	1.0×10^{4}	2.7×10^{-7}	1.0×10^{6}	2.7×10^{-5}
Cl-38	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Cm-240	Curium (96)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Cm-241	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Cm-242	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Cm-243	.	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Cm-244	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Cm-245	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Cm-246	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Cm-247 (a)	.	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Cm-248	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Co-55	Cobalt (27)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Co-56	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Co-57	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Co-58	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Co-58m	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Co-60	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Cr-51	Chromium (24)	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Cs-129	Cesium (55)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Cs-131	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}

Cs-132	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Cs-134	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Cs-134m	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{5}	2.7×10^{-6}
Cs-135	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Cs-136	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Cs-137 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Cu-64	Copper (29)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Cu-67	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Dy-159	Dysprosium (66)	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Dy-165	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Dy-166 (a)	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Er-169	Erbium (68)	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Er-171	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}

TABLE 17A2: EXEMPT MATERIAL ACTIVITY CONCENTRATIONS AND EXEMPT CONSIGNMENT ACTIVITY LIMITS FOR RADIONUCLIDES Part 2 of 4

Symbol of radionuclide	Element and atomic number	Activity concentration for exempt material (Bq/g)	Activity concentration for exempt material (Ci/g)	Activity limit for exempt consignment (Bq)	Activity limit for exempt consignment (Ci)
Eu-147	Europium (63)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Eu-148	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Eu-149	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Eu-150 (short-lived)	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Eu-150 (long-lived)	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Eu-152	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Eu-152 m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Eu-154	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Eu-155	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Eu-156	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
F-18	Fluorine (9)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Fe-52 (a)	Iron (26)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Fe-55	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{6}	2.7×10^{-5}
Fe-59	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Fe-60 (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Ga-67	Gallium (31)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ga-68	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Ga-72	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Gd-146 (a)	Gadolinium (64)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Gd-148	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Gd-153	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Gd-159	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Ge-68 (a)	Germanium (32)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Ge-71	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{8}	2.7×10^{-3}
Ge-77	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}

Hf-172 (a)	Hafnium (72)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Hf-175	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Hf-181	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Hf-182	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Hg-194 (a)	Mercury (80)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Hg-195m (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Hg-197	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Hg-197m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Hg-203	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Ho-166	Holmium (67)	1.0×10^{3}	2.7×10^{-8}	1.0×10^{5}	2.7×10^{-6}
Ho-166m	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
I-123	Iodine (53)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
I-124	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
I-125	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
I-126	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
I-129	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
I-131	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
I-132	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
I-133	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
I-134	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
I-135 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
In-111	Indium (49)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
In-113m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
In-114m (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
In-115m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ir-189 (a)	Iridium (77)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Ir-190	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ir-192	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Ir-194	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
K-40	Potassium (19)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
K-42	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
K-43	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Kr-81	Krypton (36)	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Kr-85	.	1.0×10^{5}	2.7×10^{-6}	1.0×10^{4}	2.7×10^{-7}
Kr-85m	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{10}	2.7×10^{-1}
Kr-87	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{9}	2.7×10^{-2}
La-137	Lanthanum (57)	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
La-140	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Lu-172	Lutetium (71)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Lu-173	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Lu-174	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Lu-174m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Lu-177	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Mg-28 (a)	Magnesium (12)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Mn-52	Manganese (25)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}

Mn-53	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{9}	2.7×10^{-2}
Mn-54	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Mn-56	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Mo-93	Molybdenum (42)	1.0×10^{3}	2.7×10^{-8}	1.0×10^{8}	2.7×10^{-3}
Mo-99 (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
N-13	Nitrogen (7)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{9}	2.7×10^{-2}
Na-22	Sodium (11)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Na-24	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Nb-93m	Niobium (41)	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Nb-94	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Nb-95	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Nb-97	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Nd-147	Neodymium (60)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Nd-149	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ni-59	Nickel (28)	1.0×10^{4}	2.7×10^{-7}	1.0×10^{8}	2.7×10^{-3}
Ni-63	.	1.0×10^{5}	2.7×10^{-6}	1.0×10^{8}	2.7×10^{-3}
Ni-65	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Np-235	Neptunium (93)	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Np-236 (short-lived)	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Np-236 (long-lived)	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Np-237	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Np-239	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Os-185	Osmium (76)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Os-191	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Os-191m	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Os-193	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}

TABLE 17A2: EXEMPT MATERIAL ACTIVITY CONCENTRATIONS AND EXEMPT CONSIGNMENT ACTIVITY LIMITS FOR RADIONUCLIDES Part 3 of 4

Symbol of radionuclide	Element and atomic number	Activity concentration for exempt material (Bq/g)	Activity concentration for exempt material (Ci/g)	Activity limit for exempt consignment (Bq)	Activity limit for exempt consignment (Ci)
Os-194 (a)	Osmium (76)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
P-32	Phosphorus (15)	1.0×10^{3}	2.7×10^{-8}	1.0×10^{5}	2.7×10^{-6}
P-33	.	1.0×10^{5}	2.7×10^{-6}	1.0×10^{8}	2.7×10^{-3}
Pa-230(a)	Protactinium (91)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Pa-231	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Pa-233	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Pb-201	Lead (82)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Pb-202	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Pb-203	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Pb-205	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Pb-210 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}

Pb-212 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Pd-103 (a)	Palladium (46)	1.0×10^{3}	2.7×10^{-8}	1.0×10^{8}	2.7×10^{-3}
Pd-107	.	1.0×10^{5}	2.7×10^{-6}	1.0×10^{8}	2.7×10^{-3}
Pd-109	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Pm-143	Promethium (61)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Pm-144	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Pm-145	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Pm-147	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Pm-148m (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Pm-149	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Pm-151	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Po-210	Polonium (84)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Pr-142	Praseodymium (59)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Pr-143	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{6}	2.7×10^{-5}
Pt-188 (a)	Platinum (78)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Pt-191	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Pt-193	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Pt-193m	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Pt-195m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Pt-197	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Pt-197m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Pu-236	Plutonium (94)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Pu-237	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Pu-238	.	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Pu-239	.	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Pu-240	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Pu-241 (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Pu-242	.	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Pu-244 (a)	.	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Ra-223 (a)	Radium (88)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Ra-224 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Ra-225 (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Ra-226 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Ra-228 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Rb-81	Rubidium (37)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Rb-83 (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Rb-84	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Rb-86	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Rb-87	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Rb (natural)	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Re-184	Rhenium (75)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Re-184m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Re-186	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Re-187	.	1.0×10^{6}	2.7×10^{-5}	1.0×10^{9}	2.7×10^{-2}
Re-188	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Re-189 (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Re (natural)	.	1.0×10^{6}	2.7×10^{-5}	1.0×10^{9}	2.7×10^{-2}

Rh-99	Rhodium (45)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Rh-101	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Rh-102	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Rh-102m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Rh-103m	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{8}	2.7×10^{-3}
Rh-105	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Rn-222 (a)	Radon (86)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{8}	2.7×10^{-3}
Ru-97	Ruthenium (44)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Ru-103 (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Ru-105	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ru-106 (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
S-35	Sulphur (16)	1.0×10^{5}	2.7×10^{-6}	1.0×10^{8}	2.7×10^{-3}
Sb-122	Antimony (51)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{4}	2.7×10^{-7}
Sb-124	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Sb-125	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Sb-126	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Sc-44	Scandium (21)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Sc-46	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Sc-47	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Sc-48	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Se-75	Selenium (34)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Se-79	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Si-31	Silicon (14)	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Si-32	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Sm-145	Samarium (62)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Sm-147	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Sm-151	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{8}	2.7×10^{-3}
Sm-153	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Sn-113 (a)	Tin (50)	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Sn-117m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Sn-119m	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Sn-121m (a)	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Sn-123	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Sn-125	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Sn-126 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Sr-82 (a)	Strontium (38)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Sr-85	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Sr-85m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}

TABLE 17A2: EXEMPT MATERIAL ACTIVITY CONCENTRATIONS AND EXEMPT CONSIGNMENT ACTIVITY LIMITS FOR RADIONUCLIDES Part 4 of 4

Symbol of radionuclide	Element and atomic number	Activity concentration for exempt material (Bq/g)	Activity concentration for exempt material (Ci/g)	Activity limit for exempt consignment (Bq)	Activity limit for exempt consignment (Ci)
Sr-87m	Strontium (38)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Sr-89	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Sr-90 (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{4}	2.7×10^{-7}
Sr-91 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
Sr-92 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
T(H-3)	Tritium (1)	1.0×10^{6}	2.7×10^{-5}	1.0×10^{9}	2.7×10^{-2}
Ta-178 (long-lived)	Tantalum (73)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Ta-179	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Ta-182	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Tb-157	Terbium (65)	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Tb-158	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Tb-160	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Tc-95m (a)	Technetium (43)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Tc-96	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Tc-96m (a)	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Tc-97	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{8}	2.7×10^{-3}
Tc-97m	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Tc-98	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Tc-99	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
Tc-99m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Te-121	Tellurium (52)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Te-121m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Te-123m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Te-125m	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Te-127	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Te-127m (a)	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Te-129	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Te-129m (a)	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Te-131m (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Te-132 (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Th-227	Thorium (90)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Th-228 (a)	.	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Th-229	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Th-230	.	1.0	2.7×10^{-11}	1.0×10^{4}	2.7×10^{-7}
Th-231	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Th-232	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
Th-234 (a)	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{5}	2.7×10^{-6}
Th (natural)	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
Ti-44 (a)	Titanium (22)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}

Tl-200	Thallium (81)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Tl-201	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Tl-202	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Tl-204	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{4}	2.7×10^{-7}
Tm-167	Thulium (69)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Tm-170	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Tm-171	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{8}	2.7×10^{-3}
U-230 (fast lung absorption) (a),(d)	Uranium (92)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
U-230 (medium lung absorption) (a),(e)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
U-230 (slow lung absorption) (a),(f)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
U-232 (fast lung absorption) (d)	Uranium (92)	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
U-232 (medium lung absorption) (e)	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
U-232 (slow lung absorption) (f)	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
U-233 (fast lung absorption) (d)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-233 (medium lung absorption) (e)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-233 (slow lung absorption) (f)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-234 (fast lung absorption) (d)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-234 (medium lung absorption) (e)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-234 (slow lung absorption) (f)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-235 (all lung absorption types) (a),(d),(e),(f)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-236 (fast lung	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}

absorption) (d)					
U-236 (medium lung absorption) (e)	Uranium (92)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-236 (slow lung absorption) (f)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U-238 (all lung absorption types) (d),(e),(f)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{4}	2.7×10^{-7}
U (natural)	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
U (enriched to 20% or less) (g)	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
U (depleted)	.	1.0	2.7×10^{-11}	1.0×10^{3}	2.7×10^{-8}
V-48	Vanadium (23)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}
V-49	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
W-178 (a)	Tungsten (74)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
W-181	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
W-185	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{7}	2.7×10^{-4}
W-187	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
W-188 (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Xe-122 (a)	Xenon (54)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{9}	2.7×10^{-2}
Xe-123	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{9}	2.7×10^{-2}
Xe-127	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{5}	2.7×10^{-6}
Xe-131m	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{4}	2.7×10^{-7}
Xe-133	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{4}	2.7×10^{-7}
Xe-135	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{10}	2.7×10^{-1}
Y-87 (a)	Yttrium (39)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Y-88	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Y-90	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{5}	2.7×10^{-6}
Y-91	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{6}	2.7×10^{-5}
Y-91m	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Y-92	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Y-93	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{5}	2.7×10^{-6}
Yb-169	Ytterbium (79)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{7}	2.7×10^{-4}
Yb-175	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Zn-65	Zinc (30)	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Zn-69	.	1.0×10^{4}	2.7×10^{-7}	1.0×10^{6}	2.7×10^{-5}
Zn-69m (a)	.	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Zr-88	Zirconium (40)	1.0×10^{2}	2.7×10^{-9}	1.0×10^{6}	2.7×10^{-5}
Zr-93	.	1.0×10^{3}	2.7×10^{-8}	1.0×10^{7}	2.7×10^{-4}
Zr-95 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{6}	2.7×10^{-5}
Zr-97 (a)	.	1.0×10^{1}	2.7×10^{-10}	1.0×10^{5}	2.7×10^{-6}

TABLE 17A3: GENERAL VALUES FOR A 1 AND A 2

Contents	A_1 (TBq)	A_1 (Ci)	A_2 (TBq)	A_2 (Ci)	Activity concen-tration for exempt material (Bq/g)	Activity concen-tration for exempt material(Ci/g)	Activity limits for exempt consign-ments (Bq)	Activity limits for exempt consign-ments (Ci)
Only beta or gamma emitting radionuclides are known to be present	1×10^{-1}	2.7×10^{0}	2×10^{-2}	5.4×10^{-1}	1×10^{1}	2.7×10^{-10}	1×10^{4}	2.7×10^{-7}
Only alpha emitting radionuclides are known to be present	2×10^{-1}	5.4×10^{0}	9×10^{-5}	2.4×10^{-3}	1×10^{-1}	2.7×10^{-12}	1×10^{3}	2.7×10^{-8}
No relevant data are available	1×10^{-3}	2.7×10^{-2}	9×10^{-5}	2.4×10^{-3}	1×10^{-1}	2.7×10^{-12}	1×10^{3}	2.7×10^{-8}

TABLE 17A4: ACTIVITY-MASS RELATIONSHIPS FOR URANIUM

Uranium Enrichment (i) weight % U-235 present	Specific Activity	Specific Activity
.	TBq/g	Ci/g
0.45	1.8×10^{-8}	5.0×10^{-7}
0.72	2.6×10^{-8}	7.1×10^{-7}
1.0	2.8×10^{-8}	7.6×10^{-7}
1.5	3.7×10^{-8}	1.0×10^{-6}
5.0	1.0×10^{-7}	2.7×10^{-6}
10.0	1.8×10^{-7}	4.8×10^{-6}
20.0	3.7×10^{-7}	1.0×10^{-5}
35.0	7.4×10^{-7}	2.0×10^{-5}
50.0	9.3×10^{-7}	2.5×10^{-5}
90.0	2.2×10^{-6}	5.8×10^{-5}
93.0	2.6×10^{-6}	7.0×10^{-5}
95.0	3.4×10^{-6}	9.1×10^{-5}

I The figures for uranium include representative values for the activity of the uranium-235 that is concentrated during the enrichment process.

PART 18: LICENSING REQUIREMENTS FOR URANIUM AND THORIUM PROCESSING

LICENSING REQUIREMENTS FOR URANIUM AND THORIUM PROCESSING

18.1 Purpose and Scope.

18.1.1 The regulations in this part establish criteria, terms and conditions upon which the Department issues licenses to receive title to, receive, possess, use, transfer, or deliver source and byproduct materials, to operate uranium and thorium processing facilities and for the disposition of the resulting byproduct material. The requirements of this part are in addition to, and not in substitution for, other applicable requirements of these regulations.

18.1.2 This part establishes performance objectives and procedural requirements applicable to any uranium or thorium material processing operation, to waste systems for byproduct material as in definition (2) of 1.2.2, and to related activities concerning uranium-bearing and thorium-bearing materials. It establishes specific technical and financial requirements for sitting, construction, operation, and decontamination, reclamation and ultimate stabilization, as well as requirements for license transfer and termination, long-term site monitoring and surveillance, and ownership and ultimate custody of source material milling facilities and byproduct material impoundments.

18.1.3 The requirements of this part apply to byproduct material that is located at a site where milling operations are no longer active, if such site is not covered by the remedial action program of Title I of the Uranium Mill Tailings Radiation Control Act (UMTRCA) OF 1978 (92 STAT. 3021; 42 U.S.C. 7901). The regulations in this part do not establish procedures and criteria for the issuance of licenses for materials covered under Title I of the Uranium Mill Tailings Radiation Control Act of 1978 (92 Stat. 3021) unless that program fails to accomplish remedial action. Disposal at a uranium or thorium processing site of radioactive material which is not type 2 byproduct material must not inhibit reclamation of the tailings impoundment or the ability of the U.S. Government to take title to the impoundment as long-term custodian.

18.1.4 Nothing in this Part shall apply to the following naturally occurring radioactive materials (NORM) or technologically enhanced naturally occurring radioactive materials (TENORM):

18.1.4.1 Residuals or sludges from the treatment of drinking water by aluminum, ferric chloride, or similar processes; except that the material may not contain hazardous substances that otherwise would preclude receipt;

18.1.4.2 Sludges, soils, or pipe scale in or on equipment from oil and gas exploration, production, or development operations or drinking water or wastewater treatment operations; except that the material may not contain hazardous substances that otherwise would preclude receipt;

18.1.4.3 Materials from or activities related to construction material mining regulated under article 32.5 of title 34, CRS.

18.1.4.4 The treatment, storage, management, processing, or disposal of solid waste, which may include NORM and TENORM, either pursuant to issuance of a certificate of designation or considered approved or otherwise deemed to satisfy the requirement for a certificate of designation.

18.1.5 The regulation of uranium in situ leach mining (in situ recovery), as defined in Section 34-32-103, CRS., involves the Department of Natural Resources, Division of Reclamation, Mining and Safety or their successor. The requirements of that agency may, due to the use of terms-of-art and other technical words, phrases and definitions, be interpreted inconsistently or be held in conflict with the Department's requirements. The Department will coordinate with that agency to the maximum extent practicable to resolve any such conflicts or inconsistencies. An applicant or licensee that identifies such inconsistency or conflict shall provide that information to both agencies for resolution.

18.1.6 License amendments for the receipt of classified material at a facility are subject to sections 18.3 and 18.4 except when the material is from an approved source and such amendment would not result in a change in ownership, design, or operation of the facility. License amendments not subject to 18.3 and 18.4 of this part are subject to 18.5 of this section.

18.2 As used in this regulation:

"Active maintenance" means any significant activity needed during the period of long term care including ongoing activities such as the pumping and treatment of water from a site or one-time measures such as replacement of a disposal site's cover. Active maintenance does not include custodial activities such as repair of fencing, repair or replacement of monitoring equipment, revegetation, minor additions to soil cover, minor repair of disposal site cover, and general disposal site upkeep such as mowing grass.

"Aquifer" means a geologic formation, group of formations, or part of a formation capable of yielding a significant amount of ground water to wells or springs. Any saturated zone created by uranium or thorium operations would not be considered an aquifer unless the zone is or potentially is:

(1) hydraulically interconnected to a natural aquifer;

(2) capable of discharge to surface water; or

(3) reasonably accessible because of migration beyond the vertical projection of the boundary of the land transferred for long-term government ownership and care in accordance with Criterion 9 of Appendix A to this Part 18.

"As expeditiously as practicable considering technological feasibility", for the purposes of Criterion 6A, means as quickly as possible considering: the physical characteristics of the tailings and the site; the limits of available technology; the need for consistency with mandatory requirements of other regulatory programs; and factors beyond the control of the licensee. The phrase permits consideration of the cost of compliance only to the extent specifically provided for by use of the term available technology.

"Available radon barrier technology" means technologies and methods for emplacing a final radon barrier on uranium mill tailings piles or impoundments. This term shall not be construed to include extraordinary measures or techniques that would impose costs that are grossly excessive as measured by practice within the industry (or one that is reasonably analogous), (such as, by way of illustration only, unreasonable overtime, staffing, or transportation requirements, etc., considering normal practice in the industry; laser fusion of soils, etc.), provided there is reasonable progress toward emplacement of the final radon barrier. To determine grossly excessive costs, the relevant baseline against which cost shall be compared is the cost estimate for tailings impoundment closure contained in the licensee's approved reclamation plan, but costs beyond these estimates shall not automatically be considered grossly excessive.

"Certificate of designation" means the approval pursuant to article 20 of title 30, CRS., or section 25-15-204 (6).

"Closure" means the activities following operations to decontaminate and decommission the buildings and site used to produce byproduct materials and reclaim the tailings and/or waste disposal area.

"Closure plan" means the Department approved plan to accomplish closure.

"Compliance period" begins when the Department sets secondary ground-water protection standards and ends when the owner or operator's license is terminated and the site is transferred to the State or Federal agency for long-term care.

"Dike" means an embankment or ridge of either natural or man-made materials used to prevent the movement of liquids, sludges, solids, or other materials.

"Disposal area" means the area containing byproduct materials to which the requirements of Criterion 6 of Appendix A to this Part 18 apply.

"Disposal site" means all land that is subject to transfer to a government agency after termination of the license.

"Existing portion" means that land surface area of an existing surface impoundment on which significant quantities of uranium or thorium byproduct materials had been placed prior to September 30, 1983.

"Facility" in this part means the physical location at one site or address and under the same administrative control at which:

(1) the possession, use, processing or storage of uranium-bearing and thorium-bearing radioactive material is or was authorized by license pursuant to this part; or

(2) uranium and thorium is milled, or otherwise processed and the resulting byproduct material is dispositioned.

"Factors beyond the control of the licensee" means factors proximately causing delay in meeting the schedule in the applicable reclamation plan for the timely emplacement of the final radon barrier notwithstanding the good faith efforts of the licensee to complete the barrier in compliance with paragraph (1) of Criterion 6A. These factors may include, but are not limited to:

(1) physical conditions at the site;

(2) inclement weather or climatic conditions;

(3) an act of god;

(4) an act of war;

(5) a judicial or administrative order or decision, or change to the statutory, regulatory, or other legal requirements applicable to the licensee's facility that would preclude or delay the performance of activities required for compliance;

(6) labor disturbances;

(7) any modifications, cessation or delay ordered by state, federal, or local agencies;

(8) delays beyond the time reasonably required in obtaining necessary government permits, licenses, approvals, or consent for activities described in the reclamation plan proposed by the licensee that result from agency failure to take final action after the licensee has made a good faith, timely effort to submit legally sufficient applications, responses to requests (including relevant data requested by the agencies), or other information, including approval of the reclamation plan; and

(9) an act or omission of any third party over whom the licensee has no control.

"Final radon barrier" means the earthen cover (or approved alternative cover) over tailings or waste constructed to comply with Criterion 6 of this Appendix (excluding erosion protection features).

"Ground water" means water below the land surface in a zone of saturation. For purposes of Appendix A to this Part 18, ground water is the water contained within an aquifer as defined above.

"Leachate" means any liquid, including any suspended or dissolved components in the liquid that has percolated through or drained from the byproduct material.

"Licensed site" means the area contained within the boundary of a location under the control of persons generating or storing radioactive materials under a Department license.

"Liner" means a continuous layer of natural or man-made materials, beneath or on the sides of a surface impoundment, which restricts the downward or lateral escape of byproduct material, hazardous constituents, or leachate.

"Long term care" means the observation and maintenance of a site following the post closure period and termination of the license.

"Milestone" means an action or event that is required to occur by an enforceable date.

"Monitoring" means observing and making measurements to provide data to evaluate the performance and characteristics of a site.

"Operation" means that a uranium or thorium mill tailings pile or impoundment is being used for the continued placement of byproduct material or is in standby status for such placement. A pile or impoundment is in operation from the day that byproduct material is first placed in the pile or impoundment until the day final closure begins.

"Point of compliance" is the site specific location in the uppermost aquifer where the ground-water protection standard must be met.

"Post closure" means the period of time from completion of the site closure plan for decontamination, reclamation, and stabilization of the site and disposal area and prior to the termination of the license.

"Reclamation plan", for the purposes of Criterion 6A of Appendix A of this Part 18, means the plan detailing activities to accomplish reclamation of the tailings or waste disposal area in accordance with the technical criteria of Appendix A of this Part. The reclamation plan must include a schedule for reclamation milestones that are key to the completion of the final radon barrier including as appropriate, but not limited to, windblown tailings retrieval and placement on the pile, interim stabilization (including dewatering or the removal of freestanding liquids and recontouring), and final radon barrier construction. (Reclamation of tailings must also be addressed in the closure plan; the detailed reclamation plan may be incorporated into the closure plan.)

"Surface impoundment" means a natural topographic depression, man-made excavation, or diked area, which is designed to hold an accumulation of liquid wastes or wastes containing free liquids, and which is not an injection well.

"Surveillance" means the observation of the site for the purposes of visual detection of the need for maintenance, custodial care, evidence of unauthorized access, and compliance with other license and regulatory requirements.

"Third-party contractor" or "Third-party agreement" means a legal or contractual mechanism whereby an applicant or licensee voluntarily agrees to pay for the services, solely selected and supervised by the Department, of qualified persons not Department staff nor under contract directly to the Department.

"Uppermost aquifer" means the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility's property boundary.

18.3 Special Requirements for Issuance of Specific Licenses For Source Material Milling.

In addition to the requirements set forth in 3.8 and 3.9, a specific license for source material milling will be issued if the applicant submits to the Department a complete and accurate application that clearly demonstrates how objectives and requirements of this Part are met. Failure to clearly so demonstrate shall be grounds for refusing to accept an application. Any person desiring to have a facility or site referred to in this Part shall apply to the Department for approval of such facility or site. The application shall contain such information as the Department requires and shall be accompanied by an application fee determined by the Board pursuant to the provisions of Part 12 of these regulations.

18.3.1 An application for a license or to amend or renew an existing license to receive, possess, and use source material for milling or byproduct material as in definition (2) of 1.2.2 shall include all information required under these regulations and such other information as the Department may deem necessary, and shall address the following:

18.3.1.1 Description of the proposed project or action;

18.3.1.2 Area/site characteristics including geology, topography, hydrology and meteorology;

18.3.1.3 Radiological and nonradiological impacts of the proposed project or action, including waterway and groundwater impacts;

18.3.1.4 Environmental effects of accidents;

18.3.1.5 Tailings disposal and decommissioning;

18.3.1.6 Site and project alternatives.

18.3.2 The applicant shall provide procedures describing the means employed to meet the following requirements during the operational phase of any project.

18.3.2.1 Milling operations shall be conducted so that all releases are reduced to as low as is reasonably achievable below the limits of Part 4.

18.3.2.2 The mill operator shall conduct at least daily inspection of any tailings or waste retention systems. The inspection shall be performed by a person who is qualified and approved by the Department. Records of such inspections shall be maintained for review by the Department.

18.3.2.3 The mill operator shall immediately notify the Department of the following:

18.3.2.3.1 Any failure in a tailings or waste retention system which results in a release of tailings or waste into uncontrolled areas; and

18.3.2.3.2 Any unusual conditions which are not contemplated in the design of the retention system and which if not corrected could lead to failure of the system and result in a release of tailings or waste into uncontrolled areas.

18.3.3 During any one full year prior to submittal of a new application or amendment expanding the facility the applicant/licensee shall conduct a preoperational monitoring program to provide complete baseline data on a milling site and its environs. Throughout the construction and operating phases of the mill, the applicant/licensee shall conduct an operational monitoring program to measure or evaluate compliance with applicable standards and regulations, to evaluate performance of control systems and procedures, to evaluate environmental impacts of operation, and to detect potential long-term effects.

18.3.4 The environmental report required by 3.8.8 shall contain all information deemed necessary by the agency to assist the agency in the evaluation of the short-term and long-range environmental impact of the project and activity so that the agency may weigh environmental, economic, technical, and other benefits against environmental costs, while considering available alternatives. The environmental report shall be submitted with the license application or amendment request, unless an exemption as provided by 3.8.7.1 has been obtained from the Department.

18.3.5 The following types of actions require an applicant's environmental report:

18.3.5.1 Issuance or renewal of a source material milling license;

18.3.5.2 Issuance of an amendment that would authorize or result in:

(1) A significant expansion of a site;

(2) A significant change in the types of releases;

(3) A significant increase in the amounts of releases;

(4) A significant increase in individual or cumulative occupational radiation exposure; or

(5) A significant increase in the potential for or consequences from radiological accidents.

18.3.5.3. the environmental assessment shall contain all information deemed necessary by the department, and shall include, at a minimum:

(1) The identification of the types of classified material to be received, stored, processed, or disposed of;

(2) A representative presentation of the physical, chemical, and radiological properties of the type of classified material to be received, stored, processed, or disposed of;

(3) An evaluation of the short-term and long-range environmental impacts of such receipt, storage, processing, or disposal;

(4) An assessment of the radiological and nonradiological impacts to the public health from the proposed activities;

(5) Any facility-related impact on any waterway and ground water from the proposed activities;

(6) An analysis of the environmental, economic, social, technical, and other benefits of the proposed activities against environmental costs and social effects while considering available alternatives;

(7) a list of all material violations of local, state, or federal law at the facility since the submittal date of the previous license application or license renewal application;

(8) for an application for a license or license amendment pertaining to the facility's receipt of classified material for storage, processing, or disposal at the facility, a demonstration that:

(a) there are no outstanding material violations of any state or federal statutes, compliance orders, or court orders applicable to the facility, and any releases giving rise to any such violation have been remediated;

(b) the operator, after a good faith review of the facility and its operations, is not aware of any current license violation at the facility;

(c) there are no current releases to the air, ground, surface water, or groundwater that exceed permitted limits; and

(d) no conditions exist at the facility that would prevent the Department of Energy's receipt of title to the facility pursuant to the federal "Atomic Energy Act of 1954",42U.S.C. sec. 2113;

(9) a list of all necessary permits and any changes to local land use ordinances that are needed to construct or operate the facility; and

(10) for sites or facilities placed on the National Priority List pursuant to the federal "Comprehensive Environmental Response, Compensation, and Liability Act", 42 U.S.C. sec. 9605, a copy of the most recent five-year review and any associated updates that have been issued by the United States Environmental Protection Agency.

18.3.6 An application for a license to receive, possess and use source material for milling or byproduct material as in definition (2) of 1.2.2 shall contain proposed specifications relating to the milling operations and the disposition of tailings or wastes resulting from such milling activities to achieve the requirements and objectives set forth in the criteria listed in Appendix A to this Part 18. Each application for a new license or for license renewal must clearly demonstrate how the requirements and objectives set forth in Appendix A to this Part 18 have been addressed. Failure to clearly demonstrate how the requirements and objectives in Appendix A to this Part 18 have been addressed shall be grounds for refusing to accept an application.

18.3.7 Nothing in 18.3 shall apply to a contract for the storage, processing, or disposal of less than the sum of one hundred ten tons of classified material per source or to a contract for a bench-scale or a pilot-scale testing project or a contract for less than a de minimis amount of classified material as determined by the department for storage, processing, or disposal.

18.3.8 Upon receipt of an application or notice as provided in this section, the Department shall notify the public and forward a copy of the application or notice to the Governor and the General Assembly, as appropriate.

18.3.8.1 the Department shall publish a determination as to whether an application submitted pursuant to paragraph (b) of subsection (2) of this section is substantially complete within forty-five days after receipt of the application.

18.3.8.2 an initial public meeting or hearing shall be convened within forty-five days after publication of the determination that the application is substantially complete. A second such public meeting shall be convened within thirty days after the first public meeting.

18.3.8.3 the Department shall approve, approve with conditions, or deny the application within three hundred sixty days after the second public meeting.

18.3.9 In addition to the requirements of section 18.3 and 18.4, each new, renewal or amendment application pertaining to the facility's receipt of classified material shall include a written application to the Department and information relevant to the pending application, including:

18.3.9.1 transcripts of two public meetings hosted and presided over by a person selected upon agreement by the Department, the local Board of County Commissioners, and the applicant. One or both of the meetings shall be a hearing conducted to comply with section 24-4-104 or 24-4-105, CRS. The expense of the meetings or hearing shall be paid by the facility. Such meetings shall not be held until the Department determines that the application is substantially complete. The facility shall provide the public with:

(1) at least two weeks' written notice before the first meeting and an additional two weeks' written notice before the second meeting;

(2) At both meetings, summaries of the facility's license to receive, store, process, or dispose of classified material and the nature of the classified material, and an opportunity to be heard; and

(3) access to make copies of a transcript of the meetings, and shall provide an electronic copy to the Department in a manner that allows posting on the department's web site within ten days after receipt from the transcription service.

18.3.9.2 an environmental assessment as defined in 18.3.5;

18.3.9.3 a response, if any, to the environmental assessment written by the Board of County Commissioners provided to the facility within ninety days after the first public meeting. Upon request of and documentation of the expenditure by such Board, the applicant shall provide the Board with up to fifty thousand dollars, which shall be available to assist the Board in responding to the application, including an independent environmental analysis and identification of any substantial adverse impact upon the safety or maintenance of transportation infrastructure or transportation facilities within the county.

18.4 Environmental Impact Analysis

18.4.1 For each license application or application to amend or renew an existing license to receive, possess, or use source material for uranium or thorium milling or byproduct material as in definition (2) of 1.2.2 which will have a significant impact on the environment, the Department shall prepare a written analysis of the impact of the licensed activity on the environment, which shall be available to the public and for review by the NRC at the time of public notice of hearing, which analysis shall include:

18.4.1.1 An assessment of the radiological and nonradiological impacts to the public health;

18.4.1.2 An assessment of any impact on any waterway and ground water;

18.4.1.3 Consideration of alternatives to the activities to be conducted; and

18.4.1.4 Consideration of the long-term impacts of the licensed activities.

18.4.2 In preparing the environmental impact analysis, the Department may use and incorporate by reference the environmental report prepared by the applicant and environmental assessments prepared by Federal, State or local agencies.

18.4.3 The environmental impact analysis, or any part thereof, shall be prepared directly by the Department or the Department shall utilize the third party method set forth in 3.13.

18.5 Notices and Financial Assurance

18.5.1 At least ninety days before a facility proposes to receive, store, process, or dispose of classified material in a license application or amendment that is not subject to 18.3 and 18.4, the facility shall notify the Department, and the Department shall notify the public and the board of county commissioners of the county in which the facility is located, of the specific classified material to be received, stored, processed, or disposed of. The notice shall include:

18.5.1.1 a representative analysis of the physical, chemical, and radiological properties of the classified material;

18.5.1.2 the material acceptance report that demonstrates that the classified material does not contain hazardous waste characteristics not found in uranium ore;

18.5.1.3 a detailed plan for transport, acceptance, storage, handling, processing, and disposal of the material;

18.5.1.4 a demonstration that the material contains technically and economically recoverable uranium, without taking into account its value as disposal material;

18.5.1.5 the existing location of the classified material;

18.5.1.6 the history of the classified material;

18.5.1.7 a written statement by the applicant describing any pre-existing regulatory classification of the classified waste in the state of origin that describes all steps taken by the applicant to identify such classification;

18.5.1.8 a written statement from the United States Department of Energy or successor agency that the receipt, storage, processing, or disposal of the classified material at the facility will not adversely affect the Department of Energy's receipt of title to the facility pursuant to the federal "Atomic Energy Act of 1954", 42 U.S.C. Sec. 2113;

18.5.1.9 documentation showing any necessary approvals of the united states environmental protection agency; and

18.5.1.10 an environmental assessment as defined in section 18.4 and 18.5 of this section, which may incorporate by reference relevant information contained in an environmental assessment previously submitted for the facility.

18.5.2 Within thirty days after the department's receipt of notice pursuant to 18.5.1, the Department shall determine whether the notice is complete.

18.5.3 once the department determines that the notice pursuant to 18.5.1 is complete, the Department shall publish the notice on its web site and provide a sixty-day public comment period for the receipt of written comments concerning the notice. a public hearing may be held, at the Department's discretion, at the operator's expense.

18.5.4 within thirty days after the close of the written public comment period held pursuant to 18.5.3, the Department shall approve, approve with conditions, or deny the receipt, storage, processing, or disposal as described in the notice based on whether the material proposed for receipt, storage, processing, or disposal complies with the facility's license and:

18.5.4.1 Be conducted such that the exposures to workers and the public are within the dose limits of part 4 of the department's rules pertaining to radiation control for workers and the public;

18.5.4.2 Not cause releases to the air, ground, or surface or ground water that exceed permitted limits; and

18.5.4.3 Not prevent transfer of the facility to the United States in accordance with 42 U.S.C. sec. 2113 upon completion of decontamination, decommissioning, and reclamation of the facility.

18.5.5 Prior to issuance of the license, the applicant shall (1) establish financial assurance arrangements, as provided by 3.9.5, to ensure decontamination and decommissioning of the facility and (2) provide a fund adequate to cover the payment of the cost for long-term care and monitoring as provided by 3.9.5.10. Such fund shall be sufficient to meet the requirements of 3.9.5.10.4. The Department will consider proposals to combine the two types of financial assurance. Financial assurance shall be provided prior to commencement of construction or operation.

18.6 License Hearings

18.6.1 There shall be an opportunity for public hearings to be held in accordance with the procedures in 24-4-104 and 24-4-105, CRS., and 18.6, prior to the granting, denial or renewal of a specific license permitting the receipt, possession or use of source material for milling or byproduct material as in definition (2) of 1.2.2.

18.6.2 Notice of Hearing

18.6.2.1 All hearings shall be preceded by written notice containing:

18.6.2.1.1 The nature of the hearing and its time and place;

18.6.2.1.2 The legal authority and jurisdiction under which the hearing is to be held;

18.6.2.1.3 The matters of fact and law asserted or to be considered;

18.6.2.1.4 A description of the proposed licensing action and a statement of the availability of its text from the Department;

18.6.2.1.5 A description of the right of any interested person to make written comments to the Department or present oral comments at the hearing;

18.6.2.1.6 The procedure for applying to become a party to the hearing; and

18.6.2.1.7 A description of the procedures to be followed at the hearing and at a prehearing conference if required.

18.6.2.2 The notice of the hearing shall be mailed by the Department to the licensee or applicant and to each person who has filed a written request to receive notice of such proceedings. The licensee or applicant shall cause the notice to be published for three (3) days in a newspaper of statewide circulation and in local newspapers designated by the Department in the area to be affected by the proposed action. The notice shall be mailed and published not less than ninety (90) days prior to the hearing.

18.6.2.3 The time and place of hearing will be fixed with due regard for the convenience of the parties or their representatives, and the public interest. The hearing will be held in the locale of the site to be licensed.

18.6.2.4 The cost of any licensing action hearing shall be at the expense of the applicant. These costs shall include, but not be limited to, the hearing officer, the meeting room, the court reporter and transcript copies, and the required notices. The costs shall not include the expenses of other parties to the hearing.

18.6.3 Party Status

18.6.3.1 A person who may be affected or aggrieved by Department action may apply for party status not less than twenty (20) days prior to the hearing. Thereafter, application to be made a party shall not be considered except upon motion for good cause shown.

18.6.3.2 Application for party status must identify the individual or group applying, including the address or phone number where they may be contacted, state the nature of their interest in the hearing and the specific ground on which they claim to be affected or aggrieved, and the specific aspects of the hearing which they wish to address.

18.6.3.3 The Department, or the hearing officer, will grant or deny party status within five (5) days after receipt of the request for party status based on the nature and extent of the person's property, financial or other interest in the hearing and the possible effect of any order which may be entered as a result of the hearing on the person's interest. Any person applying for or granted party status may, by motion to the hearing officer or Department, as appropriate, challenge the right of any other person to be a party.

18.6.3.4 Parties shall have the right to initiate discovery. Parties shall have the right to make motions or objections, present evidence, cross-examine witnesses, and appeal from the decision of the hearing as provided by the Colorado Administrative Procedures Act, 24-4-101 et seq. , CRS.

18.6.3.5 A person who is not a party will be permitted to submit written comments to the Department and may be permitted to make an oral presentation at the hearing, but will not have the other rights of a party.

18.6.4 Prehearing Conference

18.6.4.1 The Department or hearing officer, on its own motion or at the request of any party or any person who has applied to become a party, may direct the parties to appear at a specific time and place for a conference to consider:

18.6.4.1.1 The simplification and clarification of the issues;

18.6.4.1.2 The obtaining of stipulations and admissions of fact and of the contents and authenticity of documents to avoid unnecessary proof;

18.6.4.1.3 Identification of witnesses and the limitation of the number of expert witnesses, and other steps to expedite the presentation of evidence;

18.6.4.1.4 The setting of a hearing schedule;

18.6.4.1.5 Granting or denying requests for party status, if such decisions have not previously been made;

18.6.4.1.6 Such other matters as may aid in the orderly disposition of the hearing.

18.6.4.2 At such conference each party or person who has applied to become a party shall present to every other person, party, and the Department a prehearing statement containing the following:

18.6.4.2.1 A brief summary of the nature of the claim of the party and the basis therefore;

18.6.4.2.2 A copy of all exhibits proposed to be introduced; and

18.6.4.2.3 A list of all witnesses who may be called and a brief description of their testimony.

18.6.4.3 Except for good cause shown or for evidence or testimony accepted as rebuttal, no witness may testify nor may any exhibits be introduced on behalf of a party who had notice of the prehearing conference unless such witness has been previously listed and/or his written testimony and related exhibits have been presented to opposing parties at the prehearing conference.

18.6.4.4 The Department or hearing officer shall issue a written summary of the action taken at the conference and agreements by the parties, which limits the issues or defines the matters in controversy to be determined in the hearing.

18.6.5 Discovery

18.6.5.1 Any party may initiate discovery in the form of interrogatories to another party, requests for admission to another party, requests for production of documents to another party, or depositions of any persons, or any combination thereof. The Colorado Rules of Civil Procedure, to the extent not inconsistent with the Colorado Administrative Procedure Act, shall apply. Such discovery may be modified by a motion for protective order filed with the Department or hearing officer within seven (7) days of receipt of the notice or request for discovery. Motions for protective order shall set forth the grounds in support thereof and shall be ruled upon immediately. Discovery shall be completed no later than ten (10) days preceding the hearing date, except as otherwise ordered by the Department or hearing officer.

18.6.6 Conduct of Hearings

18.6.6.1 Hearing presentations will proceed in the following order unless otherwise directed by the Department or hearing officer.

18.6.6.1.1 Call to order, introductory remarks, and action on applications for party status, if not already decided.

18.6.6.1.2 Presentation of any stipulations or agreements of the parties, and any other matters which were required to be dealt with at the prehearing conference, if held.

18.6.6.1.3 Opening statement by the party upon whom the burden of proof rests.

18.6.6.1.4 Opening statements by all other parties.

18.6.6.1.5 Presentation of case by party upon whom burden of proof rests.

18.6.6.1.6 Presentation by all other persons wishing to offer evidence in the order to be determined by the Department or hearing officer.

18.6.6.1.7 Rebuttal by the party upon whom the burden of proof rests, followed by rebuttal of other parties.

18.6.6.1.8 Closing statements by party upon whom the burden of proof rests, followed by closing statements of all other parties.

18.6.6.2 Public participation as provided for in these rules shall be allowed at that time or times during the hearing as determined by the Department or hearing officer in their discretion to be appropriate.

18.6.6.3 At the conclusion of any witness's testimony, or at the conclusion of the party's entire presentation, as may be determined by the Department or hearing officer, all parties may then cross-examine such witness or witnesses. The Department or hearing officer may examine and cross-examine any witness. A person who is not a party shall not have the right to cross-examine.

18.6.6.4 Any person, not a party to the proceeding, wishing to present testimony may do so by indicating his desire in writing. A form will be available prior to and during the hearing. This form will request the person's name, address, whom he represents, the general nature of his testimony, and the time required for his presentation. This form is to be presented to a representative of the Department during the hearing. Voluntary testimony not specifically requested on or by the written form may also be allowed. Any person presenting testimony shall be under oath and be subject to cross examination.

18.6.6.5 The proponent of any motion, order, or license issuance bears the burden of proof.

18.6.6.6 No interested person, party, or applicant for party status outside the Department will have any oral or written communication with any Department personnel or hearing officer relevant to the merits of a hearing pending before the Department unless reasonable prior notice is given to all participants in the hearing. This prohibition shall apply after the hearing is noticed. Any Department employee or hearing officer who is involved in such a prohibited communication shall make a written record of it and transmit it to all the parties to the hearing.

18.6.7 Department Decision

18.6.7.1 Any party to a hearing may, or if so directed by the Department or the hearing officer shall, file proposed findings of fact and conclusions of law and a proposed form of order or decision within twenty (20) days after the record is closed. A party who has the burden of proof may reply within ten (10) days after service of proposed findings of fact and conclusions of law.

18.6.7.2 After due consideration of the hearing record, the Department or hearing officer shall issue its findings of fact, conclusions of law, and decision and order.

18.7 Operational Requirements.

Each licensee authorized to receive, possess or use source material for milling or byproduct material as in definition (2) of 1.2.2 shall:

18.7.1 Operate in accordance with the requirements of this Part 18, in particular the procedures required by 18.3.2, monitoring required by 18.3.3, and the requirements and objectives of Appendix A to this Part 18.

18.7.2 Submit a report to the Department within 60 days after January 1 and July 1 of each year, specifying the quantity of each of the radioactive materials released to unrestricted areas in liquid and in gaseous effluents during the previous six months of operation, and such other information as the Department may require to estimate maximum potential annual radiation doses to the public resulting from effluent releases. If quantities of radioactive materials released during the reporting period are significantly above the licensee's design objectives previously reviewed as part of the licensing action, the report shall cover this specifically. On the basis of such reports and any additional information the Department may obtain from the licensee or others, the Department may from time to time require the licensee to take such action as the Department deems appropriate.

18.7.3 For any licensed site or facility determined by the Department to have caused a release to the groundwater that exceeds the basic standards for groundwater as established by the water quality control commission, until remediation has been completed, the licensee shall provide annual written notice of the status of the release and any remediation activities associated with the release, by certified or registered mail, return receipt requested, to the current address for each registered groundwater well within one mile of the release as identified in the corrective action monitoring program, unless the licensee demonstrates that a distance less than one mile is warranted. Documentation of this activity will be retained and made available to the Department upon request.

18.8 Decommissioning Requirements.

18.8.1 In addition to the information required under 3.16, each licensee authorized to receive, possess or use source material for milling or byproduct material as in definition (2) of 1.2.2 shall submit a plan for completion of decommissioning if the procedures necessary to carry out decommissioning:

18.8.1.1 Have not been previously approved by the Department; and

18.8.1.2 Could increase potential health and safety impacts to workers or to the public, such as in any of the following cases:

18.8.1.2.1 Procedures would involve techniques not applied routinely during cleanup or maintenance operations; or

18.8.1.2.2 Workers would be entering areas not normally occupied where surface contamination and radiation levels are significantly higher than routinely encountered; or

18.8.1.2.3 Procedures could result in significantly greater airborne concentrations of radioactive materials than are present during operation; or

18.8.1.2.4 Procedures could result in significantly greater releases of radioactive material to the environment than those associated with operation.

18.8.2 Procedures with potential health and safety impacts may not be carried out prior to approval of the decommissioning plan.

18.8.3 The proposed decommissioning plan, if required by 18.8.1 or by license condition, must include:

18.8.3.1 Description of planned decommissioning activities;

18.8.3.2 Description of methods used to assure protection of workers and the environment against radiation hazards during decommissioning;

18.8.3.3 A description of the planned final radiation survey; and

18.8.3.4 An updated detailed cost estimate for decommissioning, comparison of that estimate with present funds set aside for decommissioning, and plan for assuring the availability of adequate funds for completion of decommissioning.

18.8.4 The proposed decommissioning plan will be approved by the Department if the information therein demonstrates that the decommissioning will be completed as soon as is reasonable and that the health and safety of workers and the public will be adequately protected.

18.8.5 Upon approval of the decommissioning plan by the Department, the licensee shall complete decommissioning in accordance with the approved plan. As a final step in decommissioning, the licensee shall submit the information required in 3.16.4.1.5 and shall certify the disposition of accumulated wastes from decommissioning.

18.8.6 If the information submitted under 3.16.4.1.5 or 18.8 does not adequately demonstrate that the premises are suitable for release for unrestricted use, the Department will inform the licensee of the appropriate further actions required for termination of license.

PART 18, APPENDIX A CRITERIA RELATING TO THE OPERATION OF MILLS AND THE DISPOSITION OF THE TAILINGS OR WASTES FROM THESE OPERATIONS

Introduction: Every applicant for a license to possess and use radioactive material in conjunction with uranium or thorium milling, or byproduct material at sites formerly associated with such milling, is required by the provisions of 18.3 to include in a license application proposed specifications relating to milling operations and the disposition of tailings or wastes resulting from such milling activities. This appendix establishes technical, ownership, and long-term site surveillance criteria relating to the siting, operation, decontamination, decommissioning, and reclamation of mills and tailings or waste systems and sites at which such mills and systems are located.

As used in this appendix, the term "as low as is reasonably achievable" has the same meaning as in 1.2.2.

In many cases, flexibility is provided in the criteria to allow achieving an optimum tailings disposal program on a site-specific basis. However, in such cases the objectives, technical alternatives and concerns which must be taken into account in developing a tailings program are identified. As provided by the provisions of 18.3, applications for licenses must clearly demonstrate how the criteria have been addressed.

The specifications shall be developed considering the expected full capacity of tailings or waste systems and the lifetime of mill operations. Where later expansions of systems or operations may be likely (for example, where large quantities of ore now marginally uneconomical may be stockpiled), the amenability of the disposal system to accommodate increased capacities without degradation in long-term stability and other performance factors shall be evaluated.

Licensees or applicants may propose to the Department alternatives to meet the specific requirements in this Appendix. The alternative proposals may take into account local or regional conditions, including geology, topography, hydrology, and meteorology. The Department may find that the proposed alternatives meet the Department's requirements if the alternatives will achieve a level of stabilization and containment of the sites concerned and a level of protection for public health, safety, and the environment from radiological and nonradiological hazards associated with the site, which is equivalent to, to the extent practicable, or more stringent than the level which would be achieved by the requirements of this Appendix and the standards promulgated by the Environmental Protection Agency in 40 CFR Part 192, Subparts D and E. Proposed alternatives to specific regulations in this Part 18 require notice and opportunity for hearing before the NRC.

All site-specific licensing decisions based on the criteria in this Appendix or alternatives proposed by licensees or applicants will take into account the risk to the public health and safety and the environment with due consideration to the economic costs involved and any other factors the Department determines to be appropriate. In implementing this Appendix, the Department will consider "practicable" and "reasonably achievable" as equivalent terms. Decisions involving these terms will take 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.

Criterion 1.

Criterion 1A. The general goal or broad objective in sitting and design decisions is permanent isolation of tailings and associated contaminants by minimizing disturbance and dispersion by natural forces, and to do so without ongoing maintenance. For practical reasons, specific sitting decisions and design standards must involve finite times (e.g., the longevity design standard in Criterion 6). The following site features which will contribute to such a goal or objective must be considered in selecting among alternative tailings disposal sites or judging the adequacy of existing tailings sites:

(1) Remoteness from populated areas;

(2) Hydrologic and other natural conditions as they contribute to continued immobilization and isolation of contaminants from ground-water sources; and

(3) Potential for minimizing erosion, disturbance, and dispersion by natural forces over the long-term.

Criterion 1B. The site selection process must be an optimization to the maximum extent reasonably achievable in terms of the features in Criterion 1A.

Criterion 1C. In the selection of disposal sites, primary emphasis must be given to isolation of tailings or wastes, a matter having long-term impacts, as opposed to consideration only of short-term convenience or benefits, such as minimization of transportation or land acquisition costs. While isolation of tailings will be a function of both site and engineering design, overriding consideration must be given to sitting features given the long-term nature of the tailings hazards.

Criterion 1D. Tailings should be disposed of in a manner that no active maintenance is required to preserve conditions of the site.

Criterion 2.

To avoid proliferation of small waste disposal sites and thereby reduce perpetual surveillance obligations, byproduct material as in definition (2) of 1.2.2, from in situ extraction operations, such as residues from solution evaporation or contaminated control processes, and wastes from small remote above ground extraction operations shall be disposed of at existing large mill tailings disposal sites; unless considering the nature of the wastes, such as their volume and specific activity and the costs and environmental impacts of transporting the wastes to a large disposal site, such offsite disposal is demonstrated to be impracticable or the advantages of onsite burial clearly outweigh the benefits of reducing the perpetual surveillance obligations.

Criterion 3.

The "prime option" for disposal of tailings is placement below grade, either in mines or specially excavated pits (that is, where the need for any specially constructed retention structure is eliminated). The evaluation of alternative sites and disposal methods performed by mill operators in support of their proposed tailings disposal program (provided in applicants' environmental reports) must reflect serious consideration of this disposal mode. In some instances, below grade disposal may not be the most

environmentally sound approach, such as might be the case if a ground-water formation is relatively close to the surface or not very well isolated by overlying soils and rock. Also, geologic and topographic conditions might make full below grade burial impracticable: For example, bedrock may be sufficiently near the surface that blasting would be required to excavate a disposal pit at excessive cost, and more suitable alternative sites are not available. Where full below grade burial is not practicable, the size of retention structures, and size and steepness of slopes associated with exposed embankments must be minimized by excavation to the maximum extent reasonably achievable or appropriate given the geologic and hydrologic conditions at a site. In these cases, it must be demonstrated that an above grade disposal program will provide reasonably equivalent isolation of the tailings from natural erosional forces.

Criterion 4.

The following site and design criteria must be adhered to whether tailings or wastes are disposed of above or below grade.

Criterion 4A. Upstream rainfall catchment areas must be minimized to decrease erosion potential and the size of the floods, which could erode or wash out sections of the tailings disposal area.

Criterion 4B. Topographic features should provide good wind protection.

Criterion 4C. Embankment and cover slopes must be relatively flat after final stabilization to minimize erosion potential and to provide conservative factors of safety assuring long-term stability. The broad objective should be to contour final slopes to grades which are as close as possible to those which would be provided if tailings were disposed of below grade: this could, for example, lead to slopes of about 10 horizontal to 1 vertical (10h:1v) or less steep. In general, slopes should not be steeper than about 5h:1v. Where steeper slopes are proposed, reasons why a slope less steep than 5h:1v would be impracticable should be provided and compensating factors and conditions, which make such slopes acceptable, should be identified.

Criterion 4D. A full self-sustaining vegetative cover must be established or rock cover employed to reduce wind and water erosion to negligible levels.

(1) Where a full vegetative cover is not likely to be self-sustaining due to climatic or other conditions, such as in semi-arid and arid regions, rock cover must be employed on slopes of the impoundment system. The Department will consider relaxing this requirement for extremely gentle slopes such as those, which may exist on the top of the pile.

(2) The following factors must be considered in establishing the final rock cover design to avoid displacement of rock particles by human and animal traffic or by natural process, and to preclude undercutting and piping:

    (a) Shape, size, composition, and gradation of rock particles (excepting bedding material average particles size must be at least cobble size or greater);

    (b) Rock cover thickness and zoning of particles by size; and

    (c) Steepness of underlying slopes.

(3) Individual rock fragments must be dense, sound, and resistant to abrasion, and must be free from cracks, seams, and other defects that would tend to unduly increase their destruction by water and frost actions. Weak, friable, or laminated aggregate may not be used.

(4) Rock covering of slopes may be unnecessary where top covers are very thick (on the order of 10m or greater); impoundment slopes are very gentle (on the order of 10h:1v or less); bulk cover materials have inherently favorable erosion resistance characteristics; and, there is negligible drainage catchment area upstream of the pile and good wind protection as described in Criteria 4A and 4B.

(5) Furthermore, all impoundment surfaces must be contoured to avoid areas of concentrated surface runoff or abrupt or sharp changes in slope gradient. In addition to rock cover on slopes, areas toward which surface runoff might be directed must be well protected with substantial rock cover (rip rap). In addition to providing for stability of the impoundment system itself, overall stability, erosion potential, and geomorphology of surrounding terrain must be evaluated to assure that there are not ongoing or potential processes, such as gully erosion, which would lead to impoundment instability.

Criterion 4E. The impoundment may not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand. As used in this criterion, the term "capable fault" has the same meaning as defined in section III(g) of Appendix A of 10 CFR Part 100. The term "maximum credible earthquake" means that earthquake which would cause the maximum vibratory ground motion based upon an evaluation of earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material.

Criterion 4F. The impoundment, where feasible, should be designed to incorporate features, which will promote deposition. For example, design features, which promote deposition of sediment suspended in any runoff, which flows into the impoundment area, might be utilized; the object of such a design feature would be to enhance the thickness of cover over time.

Criterion 5.

Criteria 5A-5D and Criterion 10 incorporate the basic ground-water protection standards imposed by the Environmental Protection Agency in 40 CFR Part 192, Subparts D and E (48 FR 45926; October 7, 1983) which apply during operations and prior to the end of closure. Groundwater monitoring to comply with these standards is required by Criterion 7A.

Criterion 5A.

(1) The primary ground-water protection standard is a design standard for surface impoundments used to manage byproduct material. Unless exempted under paragraph 5A(3) of this criterion, surface impoundments (except for an existing portion) shall have a liner that is designed, constructed, and installed to prevent any migration of wastes out of the impoundment to the adjacent subsurface soil, ground water, or surface water at any time during the active life (including the closure period) of the impoundment. The liner may be constructed of materials that may allow wastes to migrate into the liner (but not into the adjacent subsurface soil, ground water, or surface water) during the active life of the facility, provided that impoundment closure includes removal or decontamination of all waste residues, contaminated containment system components (liners, etc.) contaminated subsoils, and structures and equipment contaminated with waste and leachate. For impoundments that will be closed with the liner material left in place, the liner must be constructed of materials that can prevent wastes from migrating into the liner during the active life of the facility.

(2) The liner required by paragraph 5A(1) above shall be:

(a) Constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the waste or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;

(b) Placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift; and

(c) Installed to cover all surrounding earth likely to be in contact with the wastes or leachate.

(3) The applicant or licensee will be exempted from the requirements of paragraph 5A(1) of this criterion if the Department finds, based on a demonstration by the applicant or licensee, that alternate design and operating practices, including the closure plan, together with site characteristics will prevent the migration of any hazardous constituents into ground water or surface water at any future time.

In deciding whether to grant an exemption, the Department will consider:

(a) The nature and quantity of the wastes;

(b) The proposed alternate design and operation;

(c) The hydrogeologic setting of the facility, including the attenuative capacity and thickness of the liners and soils present between the impoundment and ground water or surface water; and

(d) All other factors which would influence the quality and mobility of the leachate produced and the potential for it to migrate to ground water or surface water.

(4) A surface impoundment must be designed, constructed, maintained, and operated to prevent overtopping resulting from normal or abnormal operations, overfilling, wind and wave actions, rainfall, or run-on; from malfunctions of level controllers, alarms, and other equipment; and from human error.

(5) When dikes are used to form the surface impoundment, the dikes must be designed, constructed, and maintained with sufficient structural integrity to prevent massive failure of the dikes. In ensuring structural integrity, it must not be presumed that the liner system will function without leakage during the active life of the impoundment.

Criterion 5B.

(1) Uranium and thorium byproduct material in definition (2) of 1.2.2 shall be managed to conform to the following secondary ground-water protection standard: hazardous constituents entering the ground water from a licensed site must not exceed the specified concentration limits in the uppermost aquifer beyond the point of compliance during the compliance period. Hazardous constituents are those constituents identified by the Department pursuant to paragraph 5B(2) of this criterion. Specified concentration limits are those limits established by the Department as indicated in paragraph 5B(5) of this criterion. The Department will also establish the point of compliance and compliance period on a site-specific basis through license conditions and orders. The objective in selecting the point of compliance is to provide the earliest practicable warning that the impoundment is releasing hazardous constituents to the ground water. The point of compliance must be selected to provide prompt indication of ground-water contamination on the hydraulically downgradient edge of the disposal area. The Department shall identify hazardous

constituents, establish concentration limits, set the compliance period, and may adjust the point of compliance if needed to accord with developed data and site information as to the flow of ground water or contaminants, when the detection monitoring established under Criterion 7A indicates leakage of hazardous constituents from the disposal area.

(2) A constituent becomes a hazardous constituent subject to paragraph 5B(5) only when the constituent meets all three of the following tests:

(a) The constituent is reasonably expected to be in or derived from the uranium and thorium byproduct material in the disposal area;

(b) The constituent has been detected in the ground water in the uppermost aquifer; and

(c) The constituent is listed in Criterion 10 of this appendix.

(3) Even when constituents meet all three tests in paragraph 5B(2) of this criterion, the Department may exclude a detected constituent from the set of hazardous constituents on a site-specific basis if it finds that the constituent is not capable of posing a substantial present or potential hazard to human health or the environment. In deciding whether to exclude constituents, the Department will consider the following:

(a) Potential adverse effects on ground-water quality, considering

(i) The physical and chemical characteristics of the waste in the licensed site, including its potential for migration;

(ii) The hydrogeological characteristics of the facility and surrounding land;

(iii) The quantity of ground water and the direction of ground water flow;

(iv) The proximity and withdrawal rates of ground-water users;

(v) The current and future uses of ground water in the area;

(vi) The existing quality of ground water, including other sources of contamination and their cumulative impact on the ground water quality;

(vii) The potential for health risks caused by human exposure to waste constituents;

(viii) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents;

(ix) The persistence and permanence of the potential adverse effects.

(b) Potential adverse effects on hydraulically-connected surface water quality, considering

(i) The volume and physical and chemical characteristics of the waste in the licensed site;

(ii) The hydrogeological characteristics of the facility and surrounding land;

(iii) The quantity and quality of ground water and the direction of ground water flow;

(iv) The patterns of rainfall in the region;

(v) The proximity of the licensed site to surface waters;

(vi) The current and future uses of surface waters in the area and any water quality standards established for those surface waters;

(vii) The existing quality of surface water, including other sources of contamination and the cumulative impact on surface water quality;

(viii) The potential for health risks caused by human exposure to waste constituents;

(ix) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents; and

(x) The persistence and permanence of the potential adverse effects.

(4) In making any determinations under paragraphs 5B(3) and 5B(6) of this criterion about the use of ground water in the area around the facility, the Department will consider any identification of underground sources of drinking water and exempted aquifers made by the Colorado Water Quality Control Commission, as in 5 CCR 1002-8, or other agency having jurisdiction.

(5) At the point of compliance, the concentration of a hazardous constituent must not exceed:

(a) The Department-approved background concentration of that constituent in the ground water;

(b) The respective value given in the table in paragraph 5C if the constituent is listed in the table and if the background level of the constituent is below the value listed; or

(c) An alternate concentration limit established by the Department.

(6) Conceptually, background concentrations pose no incremental hazards and the drinking water limits in Criterion 5C state acceptable hazards but these two options may not be practically achievable at a specific site. Alternate concentration limits that present no significant hazard may be proposed by licensees for Department consideration. Licensees must provide the basis for any proposed limits including consideration of practicable corrective actions, that limits are as low as reasonably achievable, and information on the factors the Department must consider. The Department will establish a site specific alternate concentration limit for a hazardous constituent as provided in paragraph 5B(5) of this criterion if it finds that the proposed limit is as low as reasonably achievable after considering practicable corrective actions, and that the constituent will not pose a substantial present or potential hazard to human health or the environment as long as the alternate concentration limit is not exceeded. In making the present and potential hazard finding, the Department will consider the following factors:

(a) Potential adverse effects on ground water quality, considering:

(i) The physical and chemical characteristics of the waste in the licensed site including its potential for migration;

(ii) The hydrogeological characteristics of the facility and surrounding land;

(iii) The quantity of ground water and the direction of ground water flow;

(iv) The proximity and withdrawal rates of ground water users;

(v) The current and future uses of ground water in the area;

(vi) The existing quality of ground water, including other sources of contamination and their cumulative impact on the ground water quality;

(vii) The potential for health risks caused by human exposure to waste constituents;

(viii) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents;

(ix) The persistence and permanence of the potential adverse effects.

(b) Potential adverse effects on hydraulically-connected surface water quality, considering:

(i) The volume and physical and chemical characteristics of the waste in the licensed site;

(ii) The hydrogeological characteristics of the facility and surrounding land;

(iii) The quantity and quality of ground water, and the direction of ground water flow;

(iv) The patterns of rainfall in the region;

(v) The proximity of the licensed site to surface waters;

(vi) The current and future uses of surface waters in the area and any water quality standards established for those surface waters;

(vii) The existing quality of surface water including other sources of contamination and the cumulative impact on surface water quality;

(viii) The potential for health risks caused by human exposure to waste constituents;

(ix) The potential damage to wildlife, crops, vegetations, and physical structures caused by exposure to waste constituents; and

(x) The persistence and permanence of the potential adverse effects.

Criterion 5C.

Maximum Values for Ground Water Protection

Constituent or property	Maximum Concentration (Milligrams per liter):
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Selenium	0.01
Silver	0.05
Endrin (1,2,3,4,10, 10-hexachloro-1,7-expoxy-1,4,4a,5,6,7,8, 9a-octahydro-1, 4-endo, endo-5, 8-dimethano naphthalene)	0.0002
Lindane (1,2,3,4,5,6-hexachloro-cyclohexane, gamma isomer)	0.004
Methoxychlor (1,1,1-Trichloro-2, 2-bis, p-methoxyphenylethane)	0.1
Toxaphene (C 10 H 10 Cl 6 , Technical chlorinated camphene, 67–69 percent chlorine)	0.005
2,4-D (2,4-Dichlorophenoxyacetic acid)	0.1
2,4,5-TP Silvex (2,4,5-Trichloro-phenoxypropionic acid)	0.01

.	Becquerels per liter	PicoCuries per liter
Combined radium-226 and radium-228	0.185	5
Gross alpha-particle activity (excluding radon and uranium when producing uranium byproduct material or radon and thorium when producing thorium byproduct material)	0.555	15

Criterion 5D. If the ground water protection standards established under paragraph 5B(1) of this criterion are exceeded at a licensed site, a corrective action program must be put into operation as soon as is practicable, and in no event later than eighteen (18) months after the Department finds that the standards have been exceeded. The licensee shall submit the proposed corrective action program and supporting rationale for Department approval prior to putting the program into operation, unless otherwise directed by the Department. The objective of the program is to return hazardous constituent concentration levels in ground water to the concentration limits set as standards. The licensee's proposed program shall address removing the hazardous constituents that have entered the ground water at the point of compliance or treating then in place. The program shall also address removing or treating in place any hazardous constituents that exceed concentration limits in ground water between the point of compliance and the down gradient facility property boundary. The licensee shall continue corrective action measures to the extent necessary to achieve and maintain compliance with the ground water protection standard. The Department will determine when the licensee may terminate corrective action measures based on data from the ground water monitoring program and other information that provide reasonable assurance that the ground water protection standard will not be exceeded.

Criterion 5E. In developing and conducting ground water protection programs, applicants and licensees shall also consider the following:

(1) Installation of bottom liners (Where synthetic liners are used, a leakage detection system must be installed immediately below the liner to ensure major failures are detected if they occur. This is in addition to the ground water monitoring program conducted as provided in Criterion 7. Where clay liners are proposed or relatively thin, in situ clay soils are to be relied upon for seepage control, tests must be conducted with representative tailings solutions and clay materials to confirm that no significant deterioration of permeability or stability properties will occur with continuous exposure of clay to tailings solutions. Tests must be run for a sufficient period of time to reveal any effects if they are going to occur (in some cases deterioration has been observed to occur rather rapidly after about nine months of exposure)).

(2) Mill process designs which provide the maximum practicable recycle of solutions and conservation of water to reduce the net'input of liquid to the tailings impoundment.

(3) Dewatering of tailings by process devices and/or in situ drainage systems (At new sites, tailings must be dewatered by a drainage system installed at the bottom of the impoundment to lower the phreatic surface and reduce the driving head of seepage, unless tests show tailings are not amenable to such a system. Where in situ dewatering is to be conducted, the impoundment bottom must be graded to assure that the drains are at a low point. The drains must be protected by suitable filter materials to assure that drains remain free running. The drainage system must also be adequately sized to assure good drainage).

(4) Neutralization to promote immobilization of hazardous constituents.

Criterion 5F. Where ground water impacts are occurring at an existing site due to seepage, action must be taken to alleviate conditions that lead to excessive seepage impacts and restore ground water quality. The specific seepage control and ground water protection method, or combination of methods, to be used must be worked out on a site-specific basis. Technical specifications must be prepared to control installation of seepage control systems. A quality assurance, testing, and inspection program, which includes supervision by a qualified engineer or scientist, must be established to assure the specifications are met.

Criterion 5G. In support of a tailings disposal system proposal, the applicant/operator shall supply information concerning the following:

(1) The chemical and radioactive characteristics of the waste solutions.

(2) The characteristics of the underlying soil and geologic formations particularly as they will control transport of contaminants and solutions. This includes detailed information concerning extent, thickness, uniformity, shape, and orientation of underlying strata. Hydraulic gradients and conductivities of the various formations must be determined. This information must be gathered from borings and field survey methods taken within the proposed impoundment area and in surrounding areas where contaminants might migrate to ground water. The information gathered on boreholes must include both geological and geophysical logs in sufficient number and degree of sophistication to allow determining significant discontinuities, fractures, and channeled deposits of high hydraulic conductivity. If field survey methods are used, they should be in addition to and calibrated with borehole logging. Hydrologic parameters such as permeability may not be determined on the basis of laboratory analysis of samples alone; a sufficient amount of field testing (e.g., pump tests) must be conducted to assure actual field properties are adequately understood. Testing must be conducted to allow estimating chemi-sorption attenuation properties of underlying soil and rock.

(3) Location, extent, quality, capacity and current uses of any ground water at and near the site.

Criterion 5H. Steps must be taken during stockpiling of ore to minimize penetration of radionuclides into underlying soils; suitable methods include lining and/or compaction of ore storage areas.

Criterion 6.

(1) In disposing of waste byproduct material, licensees shall place an earthen cover (or approved alternative) over tailings or wastes at the end of milling operations and shall close the waste disposal area in accordance with a design [1] which provides reasonable assurance of control of radiological hazards to (i) be effective for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years, and (ii) limit releases of radon-222 from uranium byproduct materials, and radon-220 from thorium byproduct materials, to the atmosphere so as not to exceed an average [2] release rate of 0.74 Becquerel per square meter per second (Bq/m^2 s), or 20 picocuries per square meter per second (pCi/m^2 s), to the extent practicable throughout the effective design life determined pursuant to (1)(i) of this criterion. In computing required tailings cover thicknesses, moisture in soils in excess of amounts found normally in similar soils in similar circumstances may not be considered. Direct gamma exposure from the tailings or wastes should be reduced to background levels. The effects of any thin synthetic layer may not be taken into account in determining the calculated radon exhalation level. If non-soil materials are proposed as cover materials, it must be demonstrated that these materials will not crack or degrade by differential settlement, weathering, or other mechanism, over long-term intervals.

1 In the case of thorium byproduct materials, the standard applies only to design. Monitoring for radon emissions from thorium byproduct materials after installation of an appropriately designed cover is not required.

2 This average applies to the entire surface of each disposal area over a period of a least one year, but a period short compared to 100 years. Radon will come from both byproduct materials and from covering materials. Radon emissions from covering materials should be estimated as part of developing a closure plan for each site. The standard, however, applies only to the emissions from byproduct materials to the atmosphere.

(2) As soon as reasonably achievable after emplacement of the final cover to limit releases of radon-222 from uranium byproduct material and prior to placement of erosion protection barriers or other features necessary for long-term control of the tailings, the licensee shall verify through appropriate testing and analysis that the design and construction of the final radon barrier is effective in limiting releases of radon-222 to a level not exceeding 0.74 Bq/m^2 s (20 pCi/m^2 s) averaged over the entire pile or impoundment using the procedures described in 40 CFR Part 61, Appendix B, Method 115, or another method of verification approved by the Department as being at least as effective in demonstrating the effectiveness of the final radon barrier.

(3) When phased emplacement of the final radon barrier is included in the applicable reclamation plan, the verification of radon-222 release rates required in paragraph (2) of this Criterion must be conducted for each portion of the pile or impoundment as the final radon barrier for that portion is emplaced.

(4) Within ninety days of the completion of all testing and analysis relevant to the required verification in paragraphs (2) and (3) of this Criterion, the uranium mill licensee shall report to the Department the results detailing the actions taken to verify that levels of release of radon-222 do not exceed 0.74 Bq/m^2 s (20 pCi/m^2 s) when averaged over the entire pile or impoundment. The licensee shall maintain records until termination of the license documenting the source of input parameters including the results of all measurements on which they are based, the calculations and/or analytical methods used to derive values for input parameters, and the procedure used to determine compliance. These records shall be kept in a form suitable for transfer to the custodial agency at the time of transfer of the site to the U.S. Department of Energy or State for long-term care if requested.

(5) Near surface cover materials, i.e., within the top three meters (10 feet), may not include waste or rock that contains elevated levels of radium; soils used for near surface cover must be essentially the same, as far as radioactivity is concerned, as that of surrounding surface soils. This is to ensure that surface radon exhalation is not significantly above background because of the cover material itself.

(6) The design requirements in this Criterion for longevity and control of radon releases apply to any portion of a licensed and/or disposal site unless such portion contains a concentration of radium in land, averaged over areas of 100 square meters, which as a result of byproduct material, does not exceed the background level by more than: (i) 0.18 Becquerels (5 picocuries) per gram of radium-226, or, in the case of thorium byproduct material, radium-228, averaged over the first 15 centimeters (cm) below the surface, and (ii)0.56 Becquerels (15 pCi) of radium-226, or, in the case of thorium byproduct material, radium-228, averaged over 15-cm thick layers more than 15 cm below the surface.

Byproduct material containing concentrations of radionuclides other than radium in soil, and surface activity on remaining structures, must not result in a total effective dose equivalent (TEDE) exceeding the dose from cleanup of radium contaminated soil to the above standard (benchmark dose), and must be at levels which are as low is reasonably achievable. If more than one residual radionuclide is present in the same 100 square-meter area, the sum of the ratios for each radionuclide of concentration present to the concentration limit will not exceed "1" (unity). A calculation of the potential peak annual TEDE within 1000 years to the average member of the critical group that would result from applying the radium standard (not including radon) on the site must be submitted for approval. The use of decommissioning plans with benchmark doses which exceed 1 millisievert per year (100 mrem/year), before application of ALARA, requires the approval of the Department. This requirement for dose criteria does not apply to sites that have decommissioning plans for soil and structures approved before the effective date of this Criterion 6(6).

(7) The licensee shall also address the nonradiological hazards associated with the wastes in planning and implementing closure. The licensee shall ensure that disposal areas are closed in a manner that minimizes the need for further maintenance. To the extent necessary to prevent threats to human health and the environment, the licensee shall control minimize, or eliminate post-closure escape of nonradiological hazardous constituents, leachate, contaminated rainwater, or waste decomposition products to the ground or surface waters or to the atmosphere.

Criterion 6A.

(1) For impoundments containing uranium byproduct materials, the final radon barrier must be completed as expeditiously as practicable considering technological feasibility after the pile or impoundment ceases operation in accordance with a written, Department-approved reclamation plan. (The term as expeditiously as practicable considering technological feasibility as specifically defined in 18.2 includes factors beyond the control of the licensee). Deadlines for completion of the final radon barrier and, if applicable, the following interim milestones must be established as a condition of the individual license: windblown tailings retrieval and placement on the pile and interim stabilization including dewatering or the removal of freestanding liquids and recontouring. The placement of erosion protection barriers or other feature necessary for long-term control of the tailings must also be completed in a timely manner in accordance with a written, Department-approved reclamation plan.

(2) The Department may approve a licensee's request to extend the time for performance of milestones related to emplacement of the final radon barrier if, after providing an opportunity for public participation, the Department finds that the licensee has adequately demonstrated in the manner required in paragraph (2) of Criterion 6 that releases of radon-222 do not exceed an average of 0.74 Becquerel/m^2 s (20 pCi/m^2 s). If the delay is approved on the basis that the radon releases do not exceed 0.74 Becquerel/m^2 s (20 pCi/m^2 s), a verification of radon levels, as required by paragraph (2) of Criterion 6, must be made annually during the period of delay. In addition, once the Department has established the date in the reclamation plan for the milestone for completion of the final radon barrier, the Department may extend that date based on cost if after providing an opportunity for public participation, the Department finds that the licensee is making good faith efforts to emplace the final radon barrier, the delay is consistent with the definition of available technology, and the radon releases caused by the delay will not result in a significant incremental risk to the public health.

(3) The Department may authorize by license amendment, upon licensee report, a portion of the impoundment to accept uranium byproduct material or such materials that are similar in physical, chemical, and radiological characteristics to the uranium mill tailings and associated wastes already in the pile or impoundment from other sources, during the closure process. No such authorization will be made if it results in a delay or impediment to emplacement of the final radon barrier over the remainder of the impoundment in a manner that will achieve levels of radon-222 releases not exceeding 0.74 Becquerel/m^2 s (20 pCi/m^2 s) averaged over the entire impoundment. The verification required in paragraph (2) of Criterion 6 may be completed with a portion of the impoundment being used for further disposal if the Department makes a final finding that the impoundment will continue to achieve a level of radon-222 release not exceeding 0.74 Becquerel/m^2 s (20 pCi/m^2 s) averaged over the entire impoundment. In this case, after the final radon barrier is complete except for the continuing disposal area, (a) only byproduct material will be authorized for disposal, (b) the disposal will be limited to the specified existing disposal area, and (c) this authorization will only be made after providing opportunity for public participation. Reclamation of the disposal area, as appropriate, must be completed in a timely manner after disposal operations cease in accordance with paragraph (1) of Criterion 6; however, these actions are not required to be complete as part of meeting the deadline for final radon barrier construction.

Criterion 7.

The licensee shall establish a detection monitoring program needed for the Department to set the site-specific ground water protection standards in paragraph 5B(1) of this appendix. For all monitoring under this paragraph, the licensee or applicant will propose for Department approval as license conditions which constituents are to be monitored on a site-specific basis. A detection monitoring program has two purposes. The initial purpose of the program is to detect leakage of hazardous constituents from the disposal area so that the need to set ground water protection standards is monitored. If leakage is detected, the second purpose of the program is to generate data and information needed for the Department to establish the standards under Criterion 5B. The data and information must provide a sufficient basis to identify those hazardous constituents which require concentration limit standards and to enable the Department to set the limits for those constituents and the compliance period. They may also need to provide the basis for adjustments to the point of compliance. The detection monitoring programs must be in place when specified by the Department in orders or license conditions. Once ground water protection standards have been established pursuant to paragraph 5B(1), the licensee shall establish and implement a compliance monitoring program. The purpose of the compliance monitoring program is to determine that the hazardous constituent concentrations in ground water continue to comply with the standards set by the Department. In conjunction with a corrective action program, the licensee shall establish and implement a corrective action monitoring program. The purpose of the corrective action monitoring program is to demonstrate the effectiveness of the corrective actions. Any monitoring program required by this paragraph may be based on existing monitoring programs to the extent the existing programs can meet the stated objective for the program.

Criterion 8.

Milling operations must be conducted so that all airborne effluent releases are reduced to levels as low as is reasonably achievable. The primary means of accomplishing this must be by means of emission controls. Institutional controls, such as extending the site boundary and exclusion area, may be employed to ensure that offsite exposure limits are met, but only after all practicable measures have been taken to control emissions at the source. Notwithstanding the existence of individual dose standards, strict control of emissions is necessary to assure that population exposures are reduced to the maximum extent reasonably achievable and to avoid site contamination. The greatest potential sources of offsite radiation exposure (aside from radon exposure) are dusting from dry surfaces of the tailings disposal area not covered by tailings solution and emissions from yellowcake drying and packaging operations. During operations and prior to closure, radiation doses from radon emissions from surface impoundments of uranium or thorium byproduct materials must be kept as low as is reasonably achievable.

Checks must be made and logged hourly for all parameters (e.g., differential pressures and scrubber water flow rates) that determine the efficiency of yellowcake stack emission control equipment operation. The licensee shall retain each log as a record for three years after the last entry in the log is made. It must be determined whether or not conditions are within a range prescribed to ensure that the equipment is operating consistently near peak efficiency; corrective action must be taken when performance is outside of prescribed ranges. Effluent control devices must be operative at all times during drying and packaging operations and whenever air is exhausting from the yellowcake stack. Drying and packaging operations must terminate when controls are inoperative. When checks indicate the equipment is not operating within the range prescribed for peak efficiency, actions must be taken to restore parameters to the prescribed range. When this cannot be done without shutdown and repairs, drying and packaging operations must cease as soon as practicable. Operations may not be restarted after cessation due to off-normal performance until needed corrective actions have been identified and implemented. All these cessations, corrective actions, and restarts must be reported to the Department as indicated in Criterion 8A, in writing, within ten days of the subsequent restart.

To control dusting from tailings, that portion not covered by standing liquids must be wetted or chemically stabilized to prevent or minimize blowing and dusting to the maximum extent reasonably achievable. This requirement may be relaxed if tailings are effectively sheltered from wind, such as may be the case where they are disposed of below grade and the tailings surface is not exposed to wind. Consideration must be given in planning tailings disposal programs to methods which would allow phased covering and reclamation of tailings impoundments because this will help in controlling particulate and radon emissions during operation. To control dusting from diffuse sources, such as tailings and ore pads where automatic controls do not apply, operators shall develop written operating procedures specifying the methods of control which will be utilized.

Milling operations producing or involving uranium and thorium byproduct materials must be conducted in such a manner as to provide reasonable assurance that the annual dose equivalent does not exceed 0.25 millisievert (25 millirem) to the whole body, 0.75 millisievert (75 millirem) to the thyroid, and 0.25 millisievert (25 millirem) to any other organ of any member of the public as a result of exposures to the planned discharge of radioactive material, radon and its progeny excepted, to the general environment.

Uranium and thorium byproduct materials must be managed so as to conform to the applicable provisions of Title 40 of the *Code of Federal Regulations* , Part 440, "Ore Mining and Dressing Point Source Category: Effluent Limitations Guidelines and New Source Performance Standards, Subpart C, Uranium, Radium, and Vanadium Ores Subcategory" , as codified on January 1, 1983.

Criterion 8A. Inspections of tailings or waste retention systems must be conducted daily during operations, or at an alternate frequency approved by the Department for other conditions. Such inspections shall be conducted by, or under the supervision of, a qualified engineer or scientist, and documented. The licensee shall retain the documentation for each inspection as a record for three years after the documentation is made. The Department must be immediately notified of any failure in a tailings or waste retention system that results in a release of tailings or waste into unrestricted areas, or any unusual conditions (conditions not contemplated in the design of the retention system) that if not corrected could indicate the potential or lead to failure of the system and result in a release of tailings or waste into unrestricted areas.

Criterion 9.

Criterion 9A. These criteria relating to ownership of tailings and their disposal sites became effective on November 8, 1981, and apply to all licenses terminated, issued, or renewed after that date.

Criterion 9B. Any uranium or thorium milling license or tailings license must contain such terms and conditions as the NRC and Department determine necessary to assure that prior to termination of the license, the licensee will comply with ownership requirements of this criterion for sites used for tailings disposal.

Criterion 9C. Title to the byproduct material licensed under this Part 18 and land, including any interests therein (other than land owned by the United States or by the State), which is used for the disposal of any such byproduct material, or is essential to ensure the long-term stability of such disposal site, must be transferred to the United States or the State in which such land is located, at the option of such State. In view of the fact that physical isolation must be the primary means of long-term control, and Government land ownership is a desirable supplementary measure, ownership of certain severable subsurface interests (for example, mineral rights) may be determined to be unnecessary to protect the public health and safety and the environment. In any case, however, the applicant/operator must demonstrate a serious effort to obtain such subsurface rights, and must in the event that certain rights cannot be obtained, provide notification in local public land records of the fact that the land is being used for the disposal of radioactive material and is subject to either a NRC or Department general or specific license prohibiting the disruption and disturbance of the tailings. In some rare cases, such as may occur with deep burial where no ongoing site surveillance will be required, surface land ownership transfer requirements may be waived with the approval of the Department and NRC. For licenses issued before November 8, 1981, the Department and NRC may take into account the status of the ownership of such land, and interests therein, and the ability of a licensee to transfer title and custody thereof to the United States or the State.

Criterion 9D. If the NRC, or the Department if title is held by the State, subsequent to title transfer determines that use of the surface or subsurface estates, or both, of the land transferred to the United States or to a State will not endanger the public health, safety, welfare, or environment, the NRC, or the Department if title is held by the State, may permit the use of the surface or subsurface estates, or both, of such and in a manner consistent with the provisions provided in these criteria. If the NRC, or the Department if title is held by the state, permits such use of such land, it will provide the person who transferred such land with the right of first refusal with respect to such use of such land.

Criterion 9E. Material and land transferred to the United States or the State in accordance with this Criterion 9 must be transferred to the United States or the State without cost other than administrative or legal costs incurred in carrying out such transfer.

Criterion 9F. The provisions of this part respecting transfer of title and custody to land and tailings and wastes do not apply in the case of lands held in trust by the United States for any Indian tribe or lands owned by such Indian tribe subject to a restriction against alienation imposed by the United States. In the case of such lands which are used for the disposal of uranium or thorium byproduct material, as defined in Part 1, the licensee shall enter into arrangements with the NRC as may be appropriate to assure the long-term surveillance of such lands by the United States.

Criterion 10.

Secondary ground-water protection standards required by Criterion 5 of this Appendix are concentration limits for individual hazardous constituents. The following list of constituents identifies the constituents for which standards must be set and complied with if the specific constituent is reasonably expected to be in or derived from the radioactive material and has been detected in ground water. For purposes of this Appendix, the property of gross alpha activity will be treated as if it is a hazardous constituent. Thus, when setting standards under paragraph 5B(5) of Criterion 5, the Department will also set a limit for gross alpha activity. The Department does not consider the following list imposed by 40 CFR Part 192 to be exhaustive and may determine other constituents to be hazardous on a case-by-case basis, independent of those specified by the U.S. Environmental Protection Agency in Part 192.

PART 18 - CRITERION 10 HAZARDOUS CONSTITUENTS

- Acetonitrile (Ethanenitrile)

- Acetophenone (Ethanone, 1-phenyl)

- 3-(alpha-Acetonylbenzyl)-4-hydroxycoumarin and salts (Warfarin)
- 2-Acetylaminofluorene (Acetamide, N-(9H- fluoren-2-yl)-)
- Acetyl chloride (Ethanoyl chloride)
- 1-Acetyl-2-thiourea (Acetamide, N- (aminothioxomethyl)-)
- Acrolein (2-Propenal)
- Acrylamide (2-Propenamide)
- Acrylonitrile (2-Propenenitrile)
- Aflatoxins
- Aldrin (1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a,8b-hexahydro-endo,exo-1,4:5,8-Dimethanonaphthalene)
- Allyl alcohol (2-Propen-1-ol)
- Aluminum phosphide
- 4-Aminobiphenyl ([1,1-Biphenyl])-4-amine)
- 6-Amino-1,1a,2,8,8a,8b-hexahydro-8-(hydroxymethyl)-8a-methoxy-5-methyl-carbamate azirino(2,3:3,4)pyrrolo(1,2-a]indole-4,7-dione,(ester) (Mitomycin C) (Azirino[2,3:3,4]pyrrolo(1,2-a)indole-4,7-dione,6-amino-8-[((amino-cabonyl)oxy)methyl)-1,1a,2,8,8a,8b-hexahydro-8a methoxy-5-methyl-)
- 5-(Aminomethyl)-3-isoxazolol (3(2H)-Isoxazolone, 5-(aminomethyl)-)4-Aminopyridine (4-Pyridinamine)
- Amitrole (1H-1,2,4-Triazol-3-amine)
- Aniline (Benzenamine)
- Antimony and compounds, N.O.S. [3]
- Aramite (Sulfurous acid,2-chloroethyl-,2-(4-(1,1-dimethylethyl)phenoxy)-1-methylethyl ester)
- Arsenic and compounds, N.O.S. [3]
- Arsenic acid (Orthoarsenic acid)
- Arsenic pentoxide (Arsenic (V) oxide)
- Arsenic trioxide (Arsenic (III) oxide)
- Auramine (Benzenamine,4,4-carbonimidoylbis (N,N-Dimethyl-,monohydrochloride)
- Azaserine (L-Serine, diazoacetate (ester))
- Barium and compounds, N.O.S. [3]
- Barium cyanide

- Benz(c)acridine (3.4-Benzacridine)
- Benz(a)anthracene (1,2-Benzanthracene)
- Benzene (Cyclohexatriene)
- Benzenearsonic acid (Arsonic acid, phenyl-)
- Benzene, dichloromethyl-(Benzal chloride)
- Benzenethiol (Thiophenol)
- Benzidine ([1,1-Biphenyl]-4,4 diamine)
- Benzo(b)fluoranthene (2,3-Benzofluoranthene)
- Benzo(j)fluoranthene (7,8-Benzofluoranthene)
- Benzo(a)pyrene (3,4-Benzopyrene)
- p-Benzoquinone (1,4-Cyclohexadienedione)
- Benzotrichloride (Benzene, Trichloromethyl)
- Benzyl chloride (Benzene, (chloromethyl)-)
- Beryllium and compounds, N.O.S. [3]
- Bis(2-chloroethoxy)methane (Ethane,1,1-(methylenebis(oxy)]bis[2-chloro-])
- Bis(2-chloroethyl) ether (Ethane, 1,1-oxybis (2-chloro-))
- N,N-Bis(2-chloroethyl)-2-naphthylamine (Chlornaphazine)
- Bis(2-Chloroisopropyl) ether (Propane, 2,2-oxybis[2-chloro-])
- Bis(chloromethyl) ether (methane,oxybis[chloro-])
- Bis(2-ethylhexyl) phthalate (1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester)
- Bromoacetone (2-Propanone, 1-bromo-)
- Bromomethane (Methyl bromide)
- 4-Bromophenyl phenyl ether (Benzene, 1-bromo-4-phenoxy-)
- Brucine (Strychnidin-10-one, 2,3-dimethoxy-)
- 2-Butanone peroxide (Methyl ethyl ketone,peroxide)
- Butyl benzyl phthalate (1,2-Benzenedicarboxylic acid, butylphenylmethyl ester)
- 2-sec-Butyl-4,6-dinitrophenol (DNBP) (Phenol,2,4-dinitro-6-(1-methylpropyl)-)
- Cadmium and compounds, N.O.S. [3]

- Calcium chromate (Chromic acid, calcium salt)
- Calcium cyanide
- Carbon disulfide (Carbon bisulfide)
- Carbon oxyfluoride (Carbonyl fluoride)
- Chloral (Acetaldehyde, trichloro-)
- Chlorambucil (Butanoic acid, 4-(bis(2-chloroethyl)amino)benzene-)
- Chlordane (alpha and gamma isomers)4,7-Methanoindan, 1,2,4,5,6,7,8,8-octachloro-3,4,7,7a-tetrahydro-) (alpha and gammaisomers)
- Chlorinated benzenes, N.O.S. [3]
- Chlorinated ethane, N.O.S. [3]
- Chlorinated fluorocarbons, N.O.S. [3]
- Chlorinated naphthalene, N.O.S. [3]
- Chlorinated phenol, N.O.S. [3]
- Chloroacetaldehyde (Acetaldehyde, chloro-)
- Chloroalkyl ethers N.O.S. [3]
- p-Chloroaniline (Benzenamine, 4-chloro-)
- Chlorobenzene (Benzene, chloro-)
- Chlorobenzilate (Benzeneacetic acid, 4-chloro-alpha-(4-chlorophenyl)-alpha-hydroxy-,ethyl ester)
- p-Chloro-m-cresol (Phenol, 4-chloro-3-methyl)
- 1-Chloro-2,3-epoxypropane (Oxirane, 2-(chloromethyl)-)
- 2-Chloroethyl vinyl ether (Ethene, (2-chloroethoxy)-)
- Chloroform (Methane, trichloro-)
- Chloromethane (Methyl chloride)
- Chloromethyl methyl ether (Methane,chloromethoxy-)
- 2-Chloronaphthalene (Naphthalene,betachloro-)
- 2-Chlorophenol (Phenol, o-chloro-)
- 1-(o-Chlorophenyl) thiourea (Thiourea, (2-chlorophenyl)-)
- 3-Chloropropionitrile (Propanenitrile, 3-chloro-)

- Chromium and compounds, N.O.S. [3]
- Chrysene (1,2-Benzphenanthrene)
- Citrus red No. 2 (2-Naphthol, 1-((2,5-dimethoxyphenyl)azo)-)
- Coal tars
- Copper cyanide
- Creosote (Creosote, wood)
- Cresols (Cresylic acid) (Phenol, methyl-)
- Crotonaldehyde (2-Butenal)
- Cyanides (soluble salts and complexes),N.O.S. [3]
- Cyanogen (Ethanedinitrile)
- Cyanogen bromide (Bromine cyanide)
- Cyanogen chloride (Chlorine cyanide)
- Cycasin (beta-D-Glucopyranoside, (methyl-ONN-azoxy)methyl-)
- 2-Cyclohexyl-4,6-dinitrophenol (phenol, 2-cyclohexyl-4,6-dinitro-)
- Cyclophosphamide (2H-1,3,2-Oxazaphosphorine (bis(2-chloroethyl)amino)-tetrahydro-,2-oxide)
- Daunomycin (5,12-Naphthacenedione, (8S-cis)-8-acetyl-10-((3-amino-2,3,6-trideoxy)-alpha-L-lyxo-hexopyranosyl)oxy)7,8,9,10-tetrahydro-6,8,11-trihydroxy-1-methoxy-)
- DDD (Dichlorodiphenyldichloroethane)(Ethane, 1,1-dichloro-2,2-bis(p-chlorophenyl)-)
- DDE (Ethylene, 1,1-dichloro-2,2-bis(4-chlorophenyl)-)
- DDT (Dichlorodiphenyltrichloroethane) (Ethane, 1,1,1-trichloro-2,2-bis (p-chlorophenyl)-)
- Diallate (S-(2,3-dichloroallyl)diisopropylthiocarbamate)
- Dibenz(a,h)acridine(1,2,5,6-Dibenzacridine)
- Dibenz(a,j)acridine(1,2,7,8-Dibenzacridine)
- Dibenz(a,h)anthracene (1,2,5,6-Dibenzanthracene
- 7H-Dibenzo(c,g)carbazole (3,4,5,6-Dibenzcarbazole)
- Dibenzo(a,e)pyrene(1,2,4,5-Dibenzpyrene)
- Dibenzo(a,h)pyrene(1,2,5,6-Dibenzpyrene)
- Dibenzo(a,i)pyrene(1,2,7,8-Dibenzpyrene)

- 1,2-Dibromo-3-chloropropane (Propane, 1,2-dibromo-3-chloro-)
- 1,2 Dibromoethane (Ethylene dibromide)
- Dibromomethane (Methylene bromide)
- Di-n-butyl phthalate (1,2-Benzenedicarboxylic acid, dibutyl ester)
- o-Dichlorobenzene (Benzene, 1,2-dichloro-)
- m-Dichlorobenzene (Benzene, 1,3-dichloro-)
- p-Dichlorobenzene (Benzene, 1,4-dichlor-)
- Dichlorobenzene, N.O.S. [3] (Benzene, dichloro-N.O.S. [3])
- 3,3-Dichlorobenzidine ([1,1, Biphenyl]-4,4-diamine, 3,3-dichloro-)
- 1,4-Dichloro-2-butene (2-Butene, 1,4-dichloro-)
- Dichlorodifluoromethane (Methane, dichlorodifluoro-)
- 1,1 Dichloroethane (Ethylidene dichloride)
- 1,2 Dichloroethane (Ethylene dichloride)
- trans-1,2-Dichloroethene (1,2-Dichloroethylene)
- Dichloroethylene, N.O.S. [3] (Ethene, dichloro-N.O.S. [3]
- 1,1-Dichloroethylene (Ethene, 1,1-dichloro-)
- Dichloromethane (Methylene chloride)
- 2,4-Dichlorophenol (Phenol, 2,4-dichloro-)
- 2,6-Dichlorophenol (Phenol, 2,6-dichloro-)
- 2,4-Dichlorophenoxyacetic acid (2,4-D), saltsand esters (Acetic acid, 2,4-dichlorophenoxy-, salts and esters)
- Dichlorophenylarsine (Phenyl dichloroarsine)
- Dichloropropane, N.O.S. [3] (Propane, dichloro-N.O.S. [3]
- 1,2-Dichloropropane (Propylene dichloride)
- Dichloropropanol, N.O.S. [3] (Propanol, dichloro-N.O.S. [3])
- Dichloropropene, N.O.S. [3] (Propene, dichloro-N.O.S. [3]
- 1,3-Dichloropropene (1-Propene, 1,3-dichloro-)
- Dieldin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octa-hydro-endo,exo-1,4:5,8-Dimethanonaphthalene)

- 1,2:3,4-Diepoxybutane (2,2,-Bioxirane)
- Diethylarsine (Arsine, diethyl-)
- N,N-Diethylhydrazine (Hydrazine, 1,2-diethyl)
- O,O-Diethyl S-methyl ester of phosphorodithioic acid (Phosphorodithioic acid, O,O-diethyl S-methyl ester)
- O,O-Diethylphosphoric acid, O-p-nitrophenyl ester (Phosphoric acid, diethyl p-nitrophenyl ester)
- Diethyl phthalate (1,2-Benzenedicarboxylic acid, diethyl ester)
- O,O-Diethyl O-2-pyrazinyl phosphorothioate (Phosphorothioic acid, O,0-diethyl O-pyrazinyl ester)
- Diethylstilbesterol (4,4-Stilbenediol,alpha,alpha-diethyl,bis(dihydrogen phosphate, (E)-)
- Dihydrosafrole (Benzene, 1,2-methylenedioxy-4-propyl-)
- 3,4-Dihydroxy-alpha-(methylamino)methylbenzyl alcohol (1,2-Benzenediol, 4-(1-hydroxy-2 (methylamino)ethyl))
- Dilsopropylfluorophosphate (DFP) (Phosphorofluoridic acid, bis(1-methylethyl) ester)
- Dimethoate (Phosphorodithioic acid, O,O-dimethyl S-(2-(methylamino)-2-oxoethyl) ester)
- 3,3,-Dimethoxybenzidine ((1,1,-Biphenyl)-4,4,-diamine, 3-3,-dimethoxy-)
- p-Dimethylaminoazobenzene (Benzenamine, N,N-dimethyl-4-(phenylazo)-)
- 7,12-Dimethylbenz(a)anthracene(1,2-Benzathracene, 7,12-dimethyl-)
- 3,3-Dimethylbenzidine (1,1-Biphenyl)-4,4,diamine, 3,3-dimethyl-)
- Dimethylcarbamoyl chloride (Carbamoyl chloride, dimethyl)
- 1,1 Dimethylhydrazine (Hydrazine, 1,1-dimethyl-)
- 1,2-Dimethylhydrazine (Hydrazine, 1,2-dimethyl-)
- 3,3-Dimethyl-1-(methylthio)-2-butanone, O-[(methylamino) carbonyl] oxime (Thiofanox)
- alpha,alpha-Dimethylphenethylamine (Ethanamine, 1,1-dimethyl-2-phenyl-)
- 2,4-Dimethylphenol (Phenol, 2,4-dimethyl-)
- Dimethyl phthalate (1,2-Benzenedicarboxylic acid, dimethyl ester)
- Dimethyl sulfate (Sulfuric acid, dimethyl ester)
- Dinitrobenzene, N.O.S. [3] (Benzene, dinitro-N.O.S. [3])
- 4,6-Dinitro-o-cresol and salts (Phenol, 2,4-dinitro-6-methyl-, and salts)
- 2,4-Dinitrophenol (Phenol, 2,4-dinitro-)

- 2,4-Dinitrotoluene (Benzene, 1-methyl-2,4-dinitro-)
- 2,6-Dinitrotoluene (Benzene, 1-methyl 2,6-dinitro-)
- Di-n-octyl phthalate (1,2-Benzenedicarboxylic acid, dioctyl ester)
- 1,4-Dioxane (1,4-Diethylene oxide)
- Diphenylamine (Benzenamine, N-phenyl-)
- 1,2-Diphenylhydrazine (Hydrazine, 1,2-diphenyl-)
- Di-n-propylnitrosamine (N-Nitroso-di-n-propylamine)
- Disulfoton (O,O-diethyl S-(2-(ethylthio)ethyl) phosphorodithioate)
- 2,4-Dithiobiuret (Thiomidodicarbonic diamide)
- Endosulfan (5-Norbomene, 2,3-dimethanol,1,4,5,6,7,7-hexachloro-cyclic sulfite)
- Endrin and metabolites (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo, endo-1,4,5,8-dimethanonaphthalene, and metabolites)
- Ethyl carbamate (Urethan) (Carbamic acid, ethyl ester)
- Ethyl cyanide (Propanenitrile)
- Ethylenebisdithiocarbamic acid, salts, and esters (1,2-Ethanediyl-biscarbamodithioic acid, salts and esters)
- Ethyleneimine (Aziridine)
- Ethylene oxide (Oxirane)
- Ethylenethiourea (2-Imidazolidinethione)
- Ethyl methacrylate (2-Propenoic acid, 2-methyl-, ethyl ester)
- Ethyl methanesulfonate (Methanesulfonic acid, ethyl ester)
- Fluoranthene (Benzo[j,k]fluorene)
- Fluorine
- 2-Fluoroacetamide (Acetamide, 2-fluoro-)
- Fluoroacetic acid, sodium salt (Acetic acid, fluoro-sodium salt)
- Formaldehyde (Methylene oxide)
- Formic acid (Methanoic acid)
- Glycidylaldehyde (1-Propanol-2,3 epoxy)
- Halomethane, N.O.S. [3]

- Heptachlor (4,7-Methano-1H-indene.1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-)

- Heptachlor epoxide (alpha, beta, and gamma isomers) (4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-2,3-epoxy-3a,4,7,7-tetrahydro-,alpha, beta, and gamma isomers)

- Hexachlorobenzene (Benzene, hexachloro-)

- Hexachlorobutadiene (1,3-Butadiene, 1,1,2,3,4,4-hexachloro-)

- Hexachlorocyclohexane (all isomers) (Lindane and isomers)

- Hexachlorocyclopentadiene (1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-)

- Hexachloroethane (Ethane, 1,1,1,2,2,2-hexachloro-)

- 1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5,8-endo,endo-dimethanonaphthalene (Hexachlorohexa-hydro-endo,endo-dimethanonaphthalene)

- Hexachlorophene (2,2,-Methylenebis(3,4,6-trichlorophenol)

- Hexachloropropene (1-Propene, 1,1,2,3,3,3-hexachloro-)

- Hexaethyl tetraphosphate (Tetraphosphoric acid, hexaethyl ester)

- Hydrazine (Diamine)

- Hydrocyanic acid (Hydrogen cyanide)

- Hydrofluoric acid (Hydrogen fluoride)

- Hydrogen sulfide (Sulfur hydride)

- Hydroxydimethylarsine oxide (Cacodylic acid)

- Indeno (1,2,3-cd)pyrene(1,10-(1,2-phenylene)pyrene)

- Iodomethane (Methyl iodide)

- Iron dextran (Ferric dextran)

- Isocyanic acid, methyl ester (Methyl isocyanate)

- Isobutyl alcohol (1-Propanol, 2-methyl-)

- Isosafrole (Benzene, 1,2-methylenedioxy-4-allyl-)

- Kepone (decachlorooctahydro-1,3,4-Methano-2H-cyclobuta[cd]pentalen-2-one)

- Lasiocarpine (2-Butenoic acid, 2-methyl-,7-[(2,3-dihydroxy-2-(1-methoxyethyl)-3-methyl-1-oxobutoxy) methyl]2,3,5,7a-tetrahydro-1H-pyrrolizin-1-yl-ester)

- Lead and compounds, N.O.S. [3]

- Lead acetate (Acetic acid, lead salt)

- Lead phosphate (Phosphoric acid, lead salt)
- Lead subacetate (Lead, bis(acetato-O)tetrahydroxytri-)
- Maleic anhydride (2,5-Furandione)
- Maleic hydrazide (1,2-Dihydro-3,6-pyridazinedione)
- Malononitrile (Propanedinitrile)
- Melphalan (Alanine, 3-(p-bis(2-chloroethyl)amino)phenyl-L-)- Mercury fulminate (Fulminic acid, mercury salt)
- Mercury and compounds, N.O.S. [3]
- Methacrylonitrile (2-Propenenitrile,2-methyl-)
- Methanethiol (Thiomethanol)
- Methapyrilene (Pyridine, 2-[(2-dimethylamino)ethyl)]-2-thenylamino-)
- Metholmyl (Acetimidic acid, N-[(methylcarbamoyl)oxy] thio-,methyl ester)
- Methoxychlor (Ethane, 1,1,1-trichloro-2,2,-bis(p-methoxyphenyl)-)
- 2-Methylaziridine (1,2-Propylenimine)
- 3-Methlycholanthrene (Benz[j]aceanthrylene,1,2-dihydro-3-methyl-)
- Methyl chlorcarbonate (Carbonochloridicacid, methyl ester)
- 4,4-Methylenebis (2-chloroaniline) Benzenamine, 4,4-methylenebis-(2-chloro-)
- Methyl ethyl ketone (MEK) (2-Butanone)
- Methyl hydrazine (Hydrazine methyl-)
- 2-Methyllactonitrile (Propanenitrile 2-hydroxy-2-methyl-)
- Methyl methacrylate (2-Propenoic acid, 2-methyl-, methyl ester)
- Methyl methanesulfonate Methanesulfonicacid, methyl ester)
- 2-Methyl-2-(methylthio)propionaldehyde-o-(methylcarbonyl) oxime (Propanal,2-methyl-2(methylthio-0-[(methylamino)carbonyl]oxime)
- N-Methyl-N,-nitro-N-nitrosoguanidine (Guanidine, N-nitroso-N-methyl-N,-nitro-)
- Methyl parathion (0,0-dimethyl 0-(40 nitrophenyl) phosphorothioate)
- Methylthiouracil (4-IH-Pyrimidinone, 2,3-dihydro-6-methyl-2-thioxo-)
- Molybdenum and compounds, N.O.S. [3]
- Mustard gas (Sulfide, bis(2-chloroethyl)-)

- Naphthalene
- 1,4-Naphthoquinone (1,4-Naphthalenedione)
- 1-Naphthylamine (alpha-Naphthylamine)
- 2-Naphthylamine (beta-Naphthylamine)
- 1-Naphthyl-2-thiourea (Thiourea, 1-naphthalenyl-)
- Nickel and compounds, N.O.S. [3]
- Nickel carbonyl (Nickel tetracarbonyl)
- Nickel cyanide (Nickel (II) cyanide)
- Nicotine and salts (Pyridine, (S)-3-(1-methyl-2-pyrrolidinyl)-, and salts)
- Nitric oxide (Nitrogen (II) oxide)
- p-Nitroaniline (Benzenamine, 4-nitro-)
- Nitrobenzine (Benzene, nitro-)
- Nitrogen dioxide (Nitrogen (IV) oxide)
- Nitrogen mustard and hydrochloride salt (Ethanamine, 2-chloro-,N-(2-chloroethyl)-N-methyl-, and hydrochloride salt)
- Nitrogen mustard N-Oxide and hydrochloride salt (Ethanamine, 2-chloro,N-(2-chloroethyl)-N-methyl-and hydrochloride salt)
- Nitroglycerine (1,2,3-Propanetriol, trinitrate)
- 4-Nitrophenol (Phenol, 4-nitro)
- 4-Nitroquinoline-1-oxide (Quinoline,4-nitro-1-oxide-)
- Nitrosamine, N.O.S. [3]
- N-Nitrosodi-n-butylamine (1-Butanamine,N-butyl-N-nitroso-)
- N-Nitrosodiethanolamine (Ethanol, 2,2-(nitrosoimino)bis-)
- N-Nitrosodiethylamine (Ethanamine, N-ethyl-N-nitroso-)
- N-Nitrosodimethylamine (Dimethylnitrosamine)
- N-Nitroso-N-ethylurea (Carbamide, N-ethyl-N-nitroso-)
- N-Nitrosomethylethylamine (Ethanamine, N-methyl-N-nitroso-)
- N-Nitroso-N-methylurea (Carbamide, N-methyl-N-nitroso-)
- N-Nitroso-N-methylurethane (Carbamic acid, methylnitroso-, ethyl ester)

- N-Nitrosomethylvinylamine (Ethenamine,N-methyl-N-nitroso-)
- N-Nitrosomorpholine (Morpholine,-N-nitroso-)
- N-Nitrosonomicotine (Nornicotine,-N-nitroso-)
- N-Nitrosopiperidine (Pyridine, hexahydro-,N-nitroso-)
- Nitrosopyrrolidine (Pyrrole, tetrahydro-N-nitroso-)
- N-Nitrososarcosine (Sarcosine,-N-nitroso-)
- 5-Nitro-o-toluidine (Benzenamine, 2-methyl-5-nitro-)
- Octamethylpyrophosphoramide (Diphosphoramide, octamethyl-)
- Osmium tetroxide (Osmium(VIII)oxide)
- 7-Oxabicyclo(2,2,1)heptane-2,3-dicarboxylic acid (Endothal)
- Paraldehyde (1,3,5-Trioxane, 2,4,6-trimethyl-)
- Parathion (Phosphorothioic acid O,O-diethylO-(p-nitrophenyl) ester)
- Pentachlorobenzene (Benzene, pentachloro-)
- Pentachloroethane (Ethane, pentachloro-)
- Pentachloronitrobenzene (PCNB) (Benzene, Pentachloronitro-)
- Pentachlorophenol (Phenol, pentachloro-)
- Phenacetin (Acetamide, N-(4-ethoxyphenyl)-)
- Phenol (Benzene, hydroxy-)
- Phenylenediamine (Benzenediamine)
- Phenylmercury acetate (Mercury acetatophenyl-)
- N-Phenylthiourea (Thiourea, phenyl-)
- Phosgene (Carbonyl chloride)
- Phosphine (Hydrogen phosphide)
- Phosphorodithioic acid, O,O-diethyl S-[(ethylthio)methyl]ester (Phorate)
- Phosphorothioic acid, O,O-dimethyl O-(p-[(dimethylamino)sulfonyl)phenyl]ester (Famphur)
- Phthalic acid esters, N.O.S. [3] (Benzene, 1,2-dicarboxylic acid, esters, N.O.S. [3])
- Phthalic anhydride (1,2-Benzenedicarboxylic acid anhydride)
- 2-Picoline (Pyridine, 2-methyl-)

- Polychlorinated biphenyl, N.O.S. [3]
- Potassium cynanide
- Potassium silver cyanide (Argentate(1-),dicyano-,potassium)
- Pronamide (3,5-Dichloro-N-(1,1-dimethyl-2-propynyl)benzamide)
- 1,3 Propane sultone (1,2-Oxathiolane, 2,2-dioxide)
- n-Propylamine (1-Propanamine)
- Propylthiouracil (Undecamethylenediamine,N,N-bis(2-chlorobenzyl-),dihydrochloride)
- 2-Propyn-1-ol (Propargyl alcohol)
- Pyridine
- Radium-226 and -228
- Reserpine (Yohimban-16-carboxylic acid,11,17-dimethoxy-18-[3,4,5-trimethoxybenzoyl)oxy]-, methyl ester)
- Resorcinol (1,3-Benzenediol)
- Saccharin and salts (1,2-Benzoisothiazolin-3-one, 1,1-dioxide, and salts)
- Safrele (Benzene, 1,2-methylenedioxy-4-allyl-)
- Selenious acid (Selenium dioxide)
- Selenium and compounds, N.O.S. [3]
- Selenium sulfide (Sulfur selenide)
- Selenourea (Carbamimidoselenoic acid)
- Silver and compounds, N.O.S. [3]
- Silver cyanide
- Sodium cyanide
- Streptozotocin (D-Glucopyranose, 2-deoxy-2-(3-methyl-3-nitrosoureido)-)
- Strontium sulfide
- Strychnine and salts (Strychnidin-10-one, and salts)
- 1,2,4,5-Tetrachlorobenzene (Benzene,1,2,4,5-tetrachloro-)
- 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) (Dibenzo-p-dioxin, 2,3,7,8-tetrachloro-)
- Tetrachloroethane, N.O.S. [3] (Ethane, tetrachloro-N.O.S. [3]

- 1,1,1,2-Tetrachlorethane (Ethane, 1,1,1,2-tetrachloro-)
- 1,1,2,2-Tetrachlorethane (Ethane 1,1,2,2-tetrachloro-)
- Tetrachlorethane (Ethene, 1,1,2,2-tetrachloro-)
- Tetrachloromethane (Carbon tetrachloride)
- 2,3,4,6-Tetrachlorophenol (Phenol 2,3,4,6-tetrachloro-)
- Tetraethyldithiopyrophosphate (Dithiopyrophosphoric acid, tetraethyl-ester)
- Tetraethyl lead (Plumbane, tetraethyl-)
- Tetraethylpyrophosphate (Pyrophosphoricacide, tetraethyl ester)
- Tetranitromethane (Methane, tetranitro-)
- Thallium and compounds, N.O.S. [3]
- Thallic oxide (Thallium (III) oxide)
- Thallium (I) acetate (Acetic acid, thallium (I) salt)
- Thallium (I) carbonate (Carbonic acid dithallium (I) salt)
- Thallium (I) chloride
- Thallium (I) nitrate (Nitric acid, thallium (I) salt)
- Thallium selenite
- Thallium (I) sulfate (Sulfuric acid, thallium (I) salt)
- Thioacetamide (Ethanethioamide)
- Thiosemicarbazide (Hydrazinecarbothioamide)
- Thiourea (Carbamide thio-)
- Thiuram (Bis(dimethylthiocarbamoyl) disulfide)
- Thorium and compounds, N.O.S. [3] when producing thorium byproduct material
- Toluene (Benzene, methyl-)
- Toluenediamine (Diaminotoluene)
- o-Toluidine hydrochloride (Benzenamine, 2-methyl-,hydrochloride)
- Tolylene diisocyanate (Benzene, 1,3-diisocyanatomethyl-)
- Toxaphene (Camphene, octachloro-)
- Tribromomethane (Bromoform)

- 1,2,4-Trichlorobenzene (Benzene, 1,2,4-trichloro-)

- 1,1,1-Trichloroethane (Methyl chloroform)

- 1,1,2-Trichloroethane (Ethane, 1,1,2-trichloro-)

- Trichloroethene (Trichloroethylene)

- Trichloromethanethiol (Methanethiol, trichloro-)

- Trichloromonofluoromethane (Methane, trichlorofluoro-)

- 2,4,5-Trichlorophenol (Phenol, 2,4,5-trichloro-)

- 2,4,6-Trichlorophenol (Phenol, 2,4,6-trichloro-)

- 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T) (Acetic acid, 2,4,5-trichlorophenoxy-)

- 2,4,5-Trichlorophenoxypropionic acid (2,4,5-TP) (Silvex) (Propionoic acid, 2-(2,4,5-trichlorophenoxy)-)

- Trichloropropane, N.O.S. [3] (Propane, trichloro-, N.O.S. [3])

- 1,2,3-Trichloropropane (Propane, 1,2,3-trichloro-)

- O,O,O-Triethyl phosphorothioate (Phosphorothioic acid, O,O,O-triethyl ester)

- sym-Trinitrobenzene (Benzene, 1,3,5-trinitro-)

- Tris(1-azridinyl) phosphine sulfide (Phosphine sulfide, tris(1-aziridinyl-)

- Tris(2,3-dibromopropyl) phosphate (1-Propanol, 2,3-dibromo-, phosphate)

- Trypan blue (2,7-Naphthalenedisulfonic acid, 3,3,-((3,3,-dimethyl (1,1,-biphenyl)-4,4,diyl)bis(azo))bis(5-amino-4-hydroxy-tetrasodium salt)

- Uracil mustard (Uracil-5-[bis(2-chloroethyl]amino)-)

- Uranium and compounds, N.O.S. [3]

- Vanadic acid, ammonium salt (ammonium vanadate)

- Vanadium pentoxide (Vanadium (V) oxide)

- Vinyl chloride (Ethene, chloro-)

- Zinc cyanide

- Zinc phosphide

3 The abbreviation N.O.S. (not otherwise specified) signifies those members of the general class not specifically listed by name in this list.

PART 19: LICENSES AND RADIATION SAFETY REQUIREMENTS FOR IRRADIATORS

LICENSES AND RADIATION SAFETY REQUIREMENTS FOR IRRADIATORS

19.1 Purpose and Scope.

19.1.1 Authority.

Rules and regulations set forth herein are adopted pursuant to the provisions of sections 25-1-108, 25-1.5-101(1)(l), and 25-11-104, CRS.

19.1.2 Basis and Purpose.

A statement of basis and purpose accompanies this part and changes to this part. A copy may be obtained from the Department.

19.1.3 Scope.

Part 19 contains requirements for the issuance of a license authorizing the use of sealed sources containing radioactive materials in irradiators used to irradiate objects or materials using gamma radiation. Part 19 also contains radiation safety requirements for operating irradiators.

19.1.4 Applicability.

19.1.4.1 The regulations in this part apply to panoramic irradiators that have either dry or wet storage of the radioactive sealed sources and to underwater irradiators in which both the source and the product being irradiated are under water. Irradiators whose dose rates exceed 5 gray (500 rad) per hour at 1 meter from the radioactive sealed sources in air or in water, as applicable for the irradiator type, are covered by this part.

19.1.4.2 The regulations in this part do not apply to self-contained dry-source-storage irradiators (those in which both the source and the area subject to irradiation are contained within a device and are not accessible by personnel), medical radiology or teletherapy, radiography (the irradiation of materials for nondestructive testing purposes), gauging, or open-field (agricultural) irradiations.

19.1.4.3 The requirements of this part are in addition to the requirements of Parts 1, 3, 4, 10, 12, 13, and 17.

19.1.4.4 Nothing in this part relieves the licensee from complying with other applicable Federal, State and local regulations governing the siting, zoning, land use, and building code requirements for industrial facilities.

19.1.5 Published Material Incorporated by Reference.

Published material incorporated in Part 19 by reference is available in accord with Part 1, Section 1.4.

19.2 Definitions.

As used in this part, these terms have the definitions set forth as follows.

“Doubly encapsulated sealed source” means a sealed source in which the radioactive material is sealed within a capsule and that capsule is sealed within another capsule.

“Irradiator” means a facility that uses radioactive sealed sources for the irradiation of objects or materials and in which radiation dose rates exceeding 5 gray (500 rad) per hour exist at 1 meter from the sealed radioactive sources in air or water, as applicable for the irradiator type, but does

not include irradiators in which both the sealed source and the area subject to irradiation are contained within a device and are not accessible to personnel.

"Irradiator operator" means an individual who has successfully completed the training and testing described in 19.18 and is authorized by the terms of the license to operate the irradiator without a supervisor present.

"Panoramic dry-source-storage irradiator" means an irradiator in which the irradiations occur in air in areas potentially accessible to personnel and in which the sources are stored in shields made of solid materials. The term includes beam-type dry-source-storage irradiators in which only a narrow beam of radiation is produced for performing irradiations.

"Panoramic irradiator" means an irradiator in which the irradiations are done in air in areas potentially accessible to personnel. The term includes beam-type irradiators.

"Panoramic wet-source-storage irradiator" means an irradiator in which the irradiations occur in air in areas potentially accessible to personnel and in which the sources are stored under water in a storage pool.

"Pool irradiator" means any irradiator at which the sources are stored or used in a pool of water including panoramic wet-source-storage irradiators and underwater irradiators.

"Product conveyor system" means a system for moving the product to be irradiated to, from, and within the area where irradiation takes place.

"Radiation room" means a shielded room in which irradiations take place. Underwater irradiators do not have radiation rooms.

"Seismic area" means any area where the probability of a horizontal acceleration in rock of more than 0.3 times the acceleration of gravity in 250 years is greater than 10 percent, as designated by the U.S. Geological Survey.

"Underwater irradiator" means an irradiator in which the sources always remain shielded under water and humans do not have access to the sealed sources or the space subject to irradiation without entering the pool.

SPECIFIC LICENSING REQUIREMENTS

19.3 Application for a Specific License.

19.3.1 A person shall file an application for a specific license authorizing the use of sealed sources in an irradiator pursuant to 3.8.

19.4 Specific Licenses for Irradiators.

19.4.1 The Department will approve an application for a specific license for the use of licensed material in an irradiator if the applicant meets the requirements contained in this section.

19.4.2 The applicant shall satisfy the general requirements specified in 3.9 of the regulations and the requirements contained in this part.

19.4.3 The applicant must describe the training provided to irradiator operators including:

19.4.3.1 Classroom training;

19.4.3.2 On-the-job or simulator training;

19.4.3.3 Safety reviews;

19.4.3.4 Means employed by the applicant to test each operator's understanding of the Department's regulations and licensing requirements and the irradiator operating and emergency procedures; and

19.4.3.5 Minimum training and experience of personnel who may provide training.

19.4.4 The application must include an outline of the written operating and emergency procedures listed in 19.19 that describes the radiation safety aspects of the procedures.

19.4.5 The application must describe the organizational structure for managing the irradiator, specifically the radiation safety responsibilities and authorities of the radiation safety officer and those management personnel who have important radiation safety responsibilities or authorities.

19.4.5.1 In particular, the application must specify who, within the management structure, has authority to stop unsafe operations.

19.4.5.2 The application must also describe the training and experience required for the position of radiation safety officer.

19.4.6 The application must include:

19.4.6.1 A description of the access control systems required by 19.8;

19.4.6.2 A description of the radiation monitors required by 19.11;

19.4.6.3 A description of the method of detecting leaking sources required by 19.22 including the sensitivity of the method; and

19.4.6.4 A diagram of the facility that shows the locations of all required interlocks and radiation monitors.

19.4.7 If the applicant intends to perform leak testing of dry-source-storage sealed sources, the applicant shall establish procedures for leak testing and submit a description of these procedures to the Department. The description shall include the:

19.4.7.1 Instruments to be used;

19.4.7.2 Methods of performing the analysis; and

19.4.7.3 Pertinent experience of the individual who analyzes the samples.

19.4.8 If licensee personnel are to load or unload sources, the applicant shall describe the qualifications and training of the personnel and the procedures to be used. If the applicant intends to contract for source loading or unloading at its facility, the loading or unloading must be done by an organization specifically authorized by the U.S. Nuclear Regulatory Commission or an Agreement State to load or unload irradiator sources.

19.4.9 The applicant shall describe the inspection and maintenance checks, including the frequency of the checks required by 19.23.

19.5 Start of Construction.

19.5.1 The applicant may not begin construction of a new irradiator prior to the submission to the Department of both the application for a license for the irradiator and the fee required by Part 12 of these regulations.

19.5.1.1 As used in this section, the term “construction” includes the construction of any portion of the permanent irradiator structure on the site but does not include: engineering and design work, purchase of a site, site surveys or soil testing, site preparation, site excavation, construction of warehouse or auxiliary structures, and other similar tasks.

19.5.1.2 Any activities undertaken prior to the issuance of a license are entirely at the risk of the applicant and have no bearing on the issuance of a license with respect to the requirements of the Act, and rules, regulations, and orders issued under the Act.

19.6 Applications for Exemptions.

19.6.1 Any application for a license or for amendment of a license authorizing use of a teletherapy-type unit for irradiation of materials or objects may include proposed alternatives for the requirements of this part. The Department will approve the proposed alternatives if the applicant provides adequate rationale for the proposed alternatives and demonstrates that they are likely to provide an adequate level of safety for workers and the public.

DESIGN AND PERFORMANCE REQUIREMENTS FOR IRRADIATORS

19.7 Requirements and Performance Criteria for Sealed Sources.

Sealed sources shall:

19.7.1 Have a certificate of registration issued by the U.S. Nuclear Regulatory Commission or an Agreement State, or shall have been evaluated in accordance with 10 CFR 32.210 or the equivalent state regulation;

19.7.2 Be doubly encapsulated;

19.7.3 Use radioactive material that is as nondispersible as practical and that is as insoluble as practical if the source is used in a wet-source-storage or wet-source-change irradiator;

19.7.4 Be encapsulated in a material resistant to general corrosion and to localized corrosion, such as 316L stainless steel or other material with equivalent resistance if the sources are used in irradiator pools; and

19.7.5 Have been leak tested in prototype testing and found leak-free after each of the tests described in 19.7.5.1 through 19.7.5.6.

19.7.5.1 Temperature Test.

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

19.7.5.2 Pressure Test.

The test source must be twice subjected for at least 5 minutes to an external pressure (absolute) of 2 megapascal (2 million newton) per square meter.

19.7.5.3 Impact Test.

A 2-kilogram steel weight, 2.5 centimeters in diameter, must be dropped from a height of 1 meter onto the test source.

19.7.5.4 Vibration Test.

The test source must be subjected 3 times for 10 minutes each to vibrations sweeping from 25 hertz to 500 hertz with a peak amplitude of 5 times the acceleration of gravity. In addition, each test source must be vibrated for 30 minutes at each resonant frequency found.

19.7.5.5 Puncture Test.

A 50-gram weight and pin, 0.3-centimeter pin diameter, must be dropped from a height of 1 meter onto the test source.

19.7.5.6 Bend Test.

If the length of the source is more than 15 times larger than the minimum cross-sectional dimension, the test source must be subjected to a force of 2000 newton at its center equidistant from two support cylinders, the distance between which is 10 times the minimum cross-sectional dimension of the source.

19.8 Access Control.

19.8.1 Each entrance to a radiation room at a panoramic irradiator must have a door or other physical barrier to prevent inadvertent entry of personnel if the sources are not in the shielded position.

19.8.1.1 Product conveyor systems may serve as barriers as long as they reliably and consistently function as a barrier.

19.8.1.2 It must not be possible to move the sources out of their shielded position if the door or barrier is open.

19.8.1.3 Opening the door or barrier while the sources are exposed must cause the sources to return promptly to their shielded position.

19.8.1.4 The personnel entrance door or barrier must have a lock that is operated by the same key used to move the sources.

19.8.1.5 The doors and barriers must not prevent any individual in the radiation room from leaving.

19.8.2 In addition, each entrance to a radiation room at a panoramic irradiator must have an independent backup access control to detect personnel entry while the sources are exposed.

19.8.2.1 Detection of entry while the sources are exposed must cause the sources to return to their fully shielded position and must also activate a visible and audible alarm to make the individual entering the room aware of the hazard.

19.8.2.2 The alarm must also alert at least one other individual who is onsite of the entry. That individual shall be trained on how to respond to the alarm and be prepared to promptly render or summon assistance.

19.8.3 A radiation monitor must be provided to detect the presence of high radiation levels in the radiation room of a panoramic irradiator before personnel entry.

19.8.3.1 The monitor must be integrated with personnel access door locks to prevent room access when radiation levels are high.

19.8.3.2 Attempted personnel entry while the monitor measures high radiation levels, must activate the alarm described in 19.8.2.

19.8.3.3 The monitor may be located in the entrance (normally referred to as the maze) but not in the direct radiation beam.

19.8.4 Before the sources move from their shielded position in a panoramic irradiator, the source control must automatically activate conspicuous visible and audible alarms to alert people in the radiation room that the sources will be moved from their shielded position.

19.8.4.1 The alarms must give individuals enough time to leave the room before the sources leave the shielded position.

19.8.5 Each radiation room at a panoramic irradiator must have a clearly visible and readily accessible control that would allow an individual in the room to make the sources return to their fully shielded position.

19.8.6 Each radiation room of a panoramic irradiator must contain a control that prevents the sources from moving from the shielded position unless the control has been activated and the door or barrier to the radiation room has been closed within a preset time after activation of the control.

19.8.7 Each entrance to the radiation room of a panoramic irradiator and each entrance to the area within the personnel access barrier of an underwater irradiator must be posted as required by 4.28.

19.8.7.1 Radiation postings for panoramic irradiators must comply with the posting requirements of 4.28, except that signs may be removed, covered, or otherwise made inoperative when the sources are fully shielded.

19.8.8 If the radiation room of a panoramic irradiator has roof plugs or other movable shielding, it must not be possible to operate the irradiator unless the shielding is in its proper location.

19.8.8.1 This requirement may be met by interlocks that prevent operation if shielding is not placed properly or by an operating procedure requiring inspection of shielding before operating.

19.8.9 Underwater irradiators must have a personnel access barrier around the pool which must be locked to prevent access when the irradiator is not attended.

19.8.9.1 Only operators and facility management may have access to keys to the personnel access barrier.

19.8.9.2 An intrusion alarm shall be installed to detect unauthorized entry when the personnel access barrier is locked.

19.8.9.3 Activation of the intrusion alarm must alert an individual (not necessarily onsite) who is prepared to respond or summon assistance.

19.9 Shielding.

19.9.1 The radiation dose rate in areas that are normally occupied during operation of a panoramic irradiator may not exceed 0.02 millisievert (2 millirem) per hour at any location 30 centimeters or more from the wall of the room when the sources are exposed.

19.9.9.1 The dose rate must be averaged over an area not to exceed 100 square centimeters having no linear dimension greater than 20 centimeters.

19.9.9.2 Areas where the radiation dose rate exceeds 0.02 millisievert (2 millirem) per hour must be locked, roped off, or posted.

19.9.2 The radiation dose at 30 centimeters over the edge of the pool of a pool irradiator may not exceed 0.02 millisievert (2 millirem) per hour when the sources are in the fully shielded position.

19.9.3 The radiation dose rate at 1 meter from the shield of a dry-source-storage panoramic irradiator when the source is shielded may not exceed 0.02 millisievert (2 millirem) per hour and at 5 centimeters from the shield may not exceed 0.2 millisievert (20 millirem) per hour.

19.10 Fire Protection.

19.10.1 The radiation room at a panoramic irradiator must have heat and smoke detectors.

19.10.1.1 The detectors must activate an audible alarm.

19.10.1.2 The alarm must be capable of alerting a person who is prepared to summon assistance promptly.

19.10.1.3 The sources must automatically become fully shielded if a fire is detected.

19.10.2 The radiation room at a panoramic irradiator must be equipped with a fire extinguishing system capable of extinguishing a fire without the entry of personnel into the room.

19.10.2.1 The system for the radiation room must have a shut-off valve to control flooding into unrestricted areas.

19.11 Radiation Monitors.

19.11.1 Irradiators with automatic product conveyor systems must have a radiation monitor with an audible alarm located to detect loose radioactive sources that are carried toward the product exit.

19.11.1.1 If the monitor detects a source, an alarm must sound and product conveyors must stop automatically.

19.11.1.2 The alarm must be capable of alerting an individual in the facility who is prepared to summon assistance.

19.11.1.3 Underwater irradiators in which the product moves within an enclosed stationary tube are exempt from the requirements of this paragraph.

19.11.2 Underwater irradiators that are not in a shielded radiation room must have a radiation monitor over the pool to detect abnormal radiation levels.

19.11.2.1 The monitor must have an audible alarm and a visible indicator at entrances to the personnel access barrier around the pool.

19.11.2.2 The audible alarm may have a manual shut-off. The alarm must be capable of alerting an individual who is prepared to respond promptly.

19.12 Control of Source Movement.

19.12.1 The mechanism that moves the sources of a panoramic irradiator must require a key to actuate.

19.12.1.1 Actuation of the mechanism must cause an audible signal to indicate that the sources are leaving the shielded position.

19.12.1.2 Only one key may be used at any time, and only one operator or facility management may possess it.

19.12.1.3 The key must be attached to a portable radiation survey meter by a chain or cable.

19.12.1.4 The lock for source control must be designed so that the key may not be removed if the sources are in an unshielded position.

19.12.1.5 The door to the radiation room must require the same key.

19.12.2 The console of a panoramic irradiator must have a source position indicator that indicates when the sources are in the fully shielded position, when they are in transit, and when the sources are exposed.

19.12.3 The control console of a panoramic irradiator must have a control that promptly returns the sources to the shielded position.

19.12.4 Each control for a panoramic irradiator must be clearly marked as to its function.

19.13 Irradiator Pools.

19.13.1 Irradiator pools must either:

19.13.1.1 Have a water-tight stainless steel liner or a liner metallurgically compatible with other components in the pool; or

19.13.1.2 Be constructed so that there is a low likelihood of substantial leakage and have a surface designed to facilitate decontamination.

19.13.1.3 In either case, the licensee shall have a method to safely store the sources during repairs of the pool.

19.13.2 Irradiator pools must have no outlets more than 0.5 meter below the normal low water level that could allow water to drain out of the pool.

19.13.2.1 Pipes that have intakes more than 0.5 meter below the normal low water level and that could act as siphons must have siphon breakers to prevent the siphoning of pool water.

19.13.3 A means must be provided to replenish water losses from the pool.

19.13.4 A visible indicator must be provided in a clearly visible location to indicate if the pool water level is below the normal low water level or above the normal high water level.

19.13.5 Irradiator pools must be equipped with a purification system designed to be capable of maintaining the water during normal operation at a conductivity of 20 microsiemens per centimeter or less and with a clarity so that the sources can be seen clearly.

19.13.6 A physical barrier, such as a railing or cover, must be used around or over irradiator pools during normal operation to prevent personnel from accidentally falling into the pool.

19.13.6.1 The barrier may be removed during maintenance, inspection, and service operations.

19.13.7 If long-handled tools or poles are used in irradiator pools, the radiation dose rate on the handling areas of the tools may not exceed 0.02 millisievert (2 millirem) per hour.

19.14 Source Rack Protection.

19.14.1 If the product to be irradiated moves on a product conveyor system, the source rack and the mechanism that moves the rack must be protected by a barrier or guides to prevent products and product carriers from hitting or touching the rack or mechanism.

19.15 Power Failures.

19.15.1 If electrical power at a panoramic irradiator is lost for longer than 10 seconds, the sources must automatically return to the shielded position.

19.15.2 The lock on the door of the radiation room of a panoramic irradiator may not be deactivated by a power failure.

19.15.3 During a power failure, the area of any irradiator where sources are located may be entered only when using an operable and calibrated radiation survey meter.

19.16 Design Requirements.

19.16.1 Irradiators must meet the design requirements of this section.

19.16.1.1 Shielding.

(1) For panoramic irradiators, the licensee shall design shielding walls to meet generally accepted building code requirements for reinforced concrete and design the walls, wall penetrations, and entranceways to meet the radiation shielding requirements of 19.9.

(2) If the irradiator will use more than 2×10^{17} becquerel (5 million curie) of activity, the licensee shall evaluate the effects of heating of the shielding walls by the irradiator sources.

19.16.1.2 Foundations.

(1) For panoramic irradiators, the licensee shall design the foundation, with consideration given to soil characteristics, to ensure it is adequate to support the weight of the facility shield walls.

19.16.1.3 Pool Integrity.

(1) For pool irradiators, the licensee shall design the pool to assure that:

(a) It is leak resistant;

(b) It is strong enough to bear the weight of the pool water and shipping casks;

(c) A dropped cask would not fall on sealed sources;

(d) All outlets or pipes meet the requirements of 19.13.2; and

(e) Metal components are metallurgically compatible with other components in the pool.

19.16.1.4 Water Handling System.

(1) For pool irradiators, the licensee shall verify that the design of the water purification system is adequate to meet the requirements of 19.13.5.

(2) The system must be designed so that water leaking from the system does not drain to unrestricted areas without being monitored.

19.16.1.5 Radiation Monitors.

(1) For all irradiators, the licensee shall evaluate the location and sensitivity of the monitor to detect sources carried by the product conveyor system as required by 19.11.1.

(2) The licensee shall verify that the product conveyor is designed to stop before a source on the product conveyor would cause a radiation overexposure to any person.

(3) For pool irradiators, if the licensee uses radiation monitors to detect contamination under 19.22.2, the licensee shall verify that the design of radiation monitoring systems to detect pool contamination includes sensitive detectors located close to where contamination is likely to concentrate.

19.16.1.6 Source Rack.

(1) For pool irradiators, the licensee shall verify that there are no crevices on the source or between the source and source holder that would promote corrosion on a critical area of the source.

(2) For panoramic irradiators, the licensee shall determine that source rack drops due to loss of power will not damage the source rack and that source rack drops due to failure of cables (or alternate means of support) will not cause loss of integrity of sealed sources.

(3) For panoramic irradiators, the licensee shall review the design of the mechanism that moves the sources to assure that the likelihood of a stuck source is low and that, if the rack sticks, a means exists to free it with minimal risk to personnel.

19.16.1.7 Access Control.

(1) For panoramic irradiators, the licensee shall verify from the design and logic diagram that the access control system will meet the requirements of 19.8.

19.16.1.8 Fire Protection.

(1) For panoramic irradiators, the licensee shall verify that the number, location, and spacing of the smoke and heat detectors are appropriate to detect fires and that the detectors are protected from mechanical and radiation damage.

(2) The licensee shall verify that the design of the fire extinguishing system provides the necessary discharge patterns, densities, and flow characteristics for complete coverage of the radiation room and that the system is protected from mechanical and radiation damage.

19.16.1.9 Source Return.

(1) For panoramic irradiators, the licensee shall verify that the source rack will automatically return to the fully shielded position if facility power is lost for more than 10 seconds.

19.16.1.10 Seismic.

(1) For panoramic irradiators to be built in seismic areas, the licensee shall design the reinforced concrete radiation shields to retain their integrity in the event of an earthquake by designing to the seismic requirements of an appropriate source such as current national standards or local building codes.

19.16.1.11 Wiring.

(1) For panoramic irradiators, the licensee shall verify that electrical wiring and electrical equipment in the radiation room are selected to minimize failures due to prolonged exposure to radiation.

19.17 Construction Monitoring and Acceptance Testing.

19.17.1 The requirements of this section must be met for all irradiators subject to this part prior to loading sources.

19.17.1.1 Shielding.

(1) For panoramic irradiators, the licensee shall monitor the construction of the shielding to verify that its construction meets design specifications and generally accepted building code requirements for reinforced concrete.

19.17.1.2 Foundations.

(1) For panoramic irradiators, the licensee shall monitor the construction of the foundations to verify that their construction meets design specifications.

19.17.1.3 Pool Integrity.

(1) For pool irradiators, the licensee shall verify that the pool meets design specifications and shall test the integrity of the pool. The licensee shall verify that outlets and pipes meet the requirements of 19.13.2.

19.17.1.4 Water Handling System.

(1) For pool irradiators, the licensee shall verify that the water purification system, the conductivity meter, and the water level indicators operate properly.

19.17.1.5 Radiation Monitors.

(1) For all irradiators, the licensee shall verify the proper operation of the monitor to detect sources carried on the product conveyor system and the related alarms and interlocks required by 19.11.1.

(2) For pool irradiators, the licensee shall verify the proper operation of the radiation monitors and the related alarm if used to meet 19.22.2.

(3) For underwater irradiators, the licensee shall verify the proper operation of the over-the-pool monitor, alarms, and interlocks required by 19.11.2.

19.17.1.6 Source Rack.

(1) For panoramic irradiators, the licensee shall test the movement of the source racks for proper operation prior to source loading, and testing must include source rack lowering due to simulated loss of power.

(2) For all irradiators with product conveyor systems, the licensee shall observe and test the operation of the conveyor system to assure that the requirements in 19.14 are met for protection of the source rack and the mechanism that moves the rack.

(3) Testing must include tests of any limit switches and interlocks used to protect the source rack and mechanism that moves the rack from moving product carriers.

19.17.1.7 Access Control.

(1) For panoramic irradiators, the licensee shall test the completed access control system to assure that it functions as designed and that all alarms, controls, and interlocks work properly.

19.17.1.8 Fire Protection.

(1) For panoramic irradiators, the licensee shall test the ability of the heat and smoke detectors to detect a fire, to activate alarms, and to cause the source rack to automatically become fully shielded.

(2) The licensee shall test the operability of the fire extinguishing system.

19.17.1.9 Source Return.

(1) For panoramic irradiators, the licensee shall demonstrate that the source racks can be returned to their fully shielded positions without offsite power.

19.17.1.10 Computer Systems.

(1) For panoramic irradiators that use a computer system to control the access control system, the licensee shall verify that the access control system will operate properly if offsite power is lost and shall verify that the computer has security features that prevent an irradiator operator from commanding the computer to override the access control system when it is required to be operable.

19.17.1.11 Wiring.

(1) For panoramic irradiators, the licensee shall verify that the electrical wiring and electrical equipment that were installed meet the design specifications.

OPERATION OF IRRADIATORS

19.18 Training.

19.18.1 Before an individual is permitted to operate an irradiator without a supervisor present, the individual must be instructed in:

19.18.1.1 The fundamentals of radiation protection applied to irradiators (including the differences between external radiation and radioactive contamination, units of radiation dose, Department dose limits, why large radiation doses must be avoided, how shielding and access controls prevent large doses, how an irradiator is designed to prevent contamination, the proper use of survey meters and personnel dosimeters, other radiation safety features of an irradiator, and the basic function of the irradiator);

19.18.1.2 The requirements of Parts 4, 10 and 19 that are relevant to the irradiator;

19.18.1.3 The operation of the irradiator;

19.18.1.4 Those operating and emergency procedures listed in 19.19 that the individual is responsible for performing; and

19.18.1.5 Case histories of accidents or problems involving irradiators.

19.18.2 Before an individual is permitted to operate an irradiator without a supervisor present, the individual shall pass a written test on the instruction received consisting primarily of questions based on the licensee's operating and emergency procedures that the individual is responsible for performing and other operations necessary to safely operate the irradiator without supervision.

19.18.3 Before an individual is permitted to operate an irradiator without a supervisor present, the individual must have received on-the-job training or simulator training in the use of the irradiator as described in the license application.

19.18.3.1 The individual shall also demonstrate the ability to perform those portions of the operating procedures that he or she is to perform.

19.18.4 The licensee shall conduct safety reviews for irradiator operators at least annually.

19.18.4.1 The licensee shall give each operator a brief written test on the information.

19.18.4.2 Each safety review must include, to the extent appropriate, each of the following:

(1) Changes in operating and emergency procedures since the last review, if any;

(2) Changes in regulations and license conditions since the last review, if any;

(3) Reports on recent accidents, mistakes, or problems that have occurred at irradiators, if any;

(4) Relevant results of inspections of operator safety performance;

(5) Relevant results of the facility's inspection and maintenance checks; and

(6) A drill to practice an emergency or abnormal event procedure.

19.18.5 The licensee shall evaluate the safety performance of each irradiator operator at least annually to ensure that regulations, license conditions, and operating and emergency procedures are followed and shall:

19.18.5.1 Discuss the results of the evaluation with the operator; and

19.18.5.2 Instruct the operator on how to correct any mistakes or deficiencies observed.

19.18.6 Individuals who will be permitted unescorted access to the radiation room of the irradiator or the area around the pool of an underwater irradiator, but who have not received the training required for operators and the radiation safety officer, shall be instructed and tested in any precautions they should take to avoid radiation exposure, any procedures or parts of procedures listed in 19.19 that they are expected to perform or comply with, and their proper response to alarms required in this part. Tests may be oral.

19.18.7 Individuals who must be prepared to respond to alarms required by 19.8.2, 19.8.9, 19.10.1, 19.11.1, 19.11.2, and 19.22.2 shall be trained and tested on how to respond.

19.18.7.1 Each individual shall be retested at least once a year.

19.18.7.2 Tests may be oral.

19.19 Operating and Emergency Procedures.

19.19.1 The licensee shall have and follow written operating procedures for:

19.19.1.1 Operation of the irradiator, including entering and leaving the radiation room;

19.19.1.2 Use of personnel dosimeters;

19.19.1.3 Surveying the shielding of panoramic irradiators;

19.19.1.4 Monitoring pool water for contamination while the water is in the pool and before release of pool water to unrestricted areas;

19.19.1.5 Leak testing of sources;

19.19.1.6 Inspection and maintenance checks required by 19.23;

19.19.1.7 Loading, unloading, and repositioning sources, if the operations will be performed by the licensee; and

19.19.1.8 Inspection of movable shielding required by 19.8.8, if applicable.

19.19.2 The licensee shall have and follow emergency or abnormal event procedures, appropriate for the irradiator type, for:

19.19.2.1 Sources stuck in the unshielded position;

19.19.2.2 Personnel overexposures;

19.19.2.3 A radiation alarm from the product exit portal monitor or pool monitor;

19.19.2.4 Detection of leaking sources, pool contamination, or alarm caused by contamination of pool water;

19.19.2.5 A low or high water level indicator, an abnormal water loss, or leakage from the source storage pool;

19.19.2.6 A prolonged loss of electrical power;

19.19.2.7 A fire alarm or explosion in the radiation room;

19.19.2.8 An alarm indicating unauthorized entry into the radiation room, area around the pool, or another alarmed area;

19.19.2.9 Natural phenomena, including an earthquake, a tornado, flooding, or other phenomena as appropriate for the geographical location of the facility; and

19.19.2.10 The jamming of automatic conveyor systems.

19.19.3 The licensee may revise operating and emergency procedures without Department approval only if all of the following conditions are met:

19.19.3.1 The revisions do not reduce the safety of the facility;

19.19.3.2 The revisions are consistent with the outline or summary of procedures submitted with the license application;

19.19.3.3 The revisions have been reviewed and approved by the radiation safety officer; and

19.19.3.4 The users or operators are instructed and tested on the revised procedures before they are put into use.

19.20 Personnel Monitoring.

19.20.1 Irradiator operators shall wear a personnel dosimeter that is processed and evaluated by an accredited National Voluntary Laboratory Accreditation Program (NVLAP) processor while operating a panoramic irradiator or while in the area around the pool of an underwater irradiator.

19.20.1.1 The personnel dosimeter processor must be accredited for high-energy photons in the normal and accident dose ranges (see 4.17.3).

19.20.1.2 Each personnel dosimeter must be assigned to and worn by only one individual.

19.20.1.3 Film badges must be replaced at least monthly and each other personnel dosimeter must be replaced at least quarterly.

19.20.1.4 After replacement, each personnel dosimeter must be promptly processed.

19.20.2 Other individuals who enter the radiation room of a panoramic irradiator shall wear a dosimeter, which may be a pocket dosimeter.

19.20.2.1 For groups of visitors, only two people who enter the radiation room are required to wear dosimeters.

19.20.2.2 If pocket dosimeters are used to meet the requirements of this paragraph, a check of their response to radiation must be done at least annually.

19.20.2.3 Acceptable dosimeters must read within + or – 20 percent of the true radiation dose.

19.21 Radiation Surveys.

19.21.1 A radiation survey of the area outside the shielding of the radiation room of a panoramic irradiator must be conducted with the sources in the exposed position before the facility starts to operate.

19.21.1.1 A radiation survey of the area above the pool of pool irradiators must be conducted after the sources are loaded but before the facility starts to operate.

19.21.1.2 Additional radiation surveys of the shielding must be performed at intervals not to exceed 3 years and before resuming operation after addition of new sources or any modification to the radiation room shielding or structure that might increase dose rates.

19.21.2 If the radiation levels specified in 19.9 are exceeded, the facility must be modified to comply with the requirements in 19.9.

19.21.3 Portable radiation survey meters must be calibrated at least annually to an accuracy of 20 percent for the gamma energy of the sources in use.

19.21.3.1 The calibration must be done at two points on each scale or, for digital instruments at one point per decade over the range that will be used.

19.21.3.2 Portable radiation survey meters must be of a type that does not saturate and read zero at high radiation dose rates.

19.21.4 Water from the irradiator pool, other potentially contaminated liquids, and sediments from pool vacuuming must be monitored for radioactive contamination before release to unrestricted areas. Radioactive concentrations must not exceed those specified in Part 4, Appendix 4B, Table 4B1, “Annual Limits on Intakes (ALIs) and Derived Air Concentrations (DACs)” , or Table 4B3, “Release to Sewers.”

19.21.5 Before releasing resins for unrestricted use, they must be monitored before release in an area with a background level less than 0.5 microsievert (0.05 millirem) per hour.

19.21.5.1 The resins may be released only if the survey does not detect radiation levels above background levels.

19.21.5.2 The survey meter used must be capable of detecting radiation levels of 0.5 microsievert (0.05 millirem) per hour.

19.22 Detection of Leaking Sources.

19.22.1 Each dry-source-storage sealed source must be tested for leakage at intervals not to exceed 6 months using a leak test kit or method approved by the U.S. Nuclear Regulatory Commission or an Agreement State.

19.22.1.1 In the absence of a certificate from a transferor that a test has been made within the 6 months before the transfer, the sealed source may not be used until tested.

19.22.1.2 The test must be capable of detecting the presence of 200 becquerel (0.005 microcurie) of radioactive material and must be performed by a person approved by the U.S. Nuclear Regulatory Commission or an Agreement State to perform the test.

19.22.2 For pool irradiators, sources may not be put into the pool unless the licensee tests the sources for leaks or has a certificate from a transferor that a leak test has been done within the 6 months before the transfer.

19.22.2.1 Water from the pool must be checked for contamination each day the irradiator operates. This check may be done either by using a radiation monitor on a pool water circulating system or by analysis of a sample of pool water.

19.22.2.2 If a check for contamination is done by analysis of a sample of pool water, the results must be available within 24 hours.

19.22.2.3 If the licensee uses a radiation monitor on a pool water circulating system, the detection of above normal radiation levels must activate an alarm.

(1) The alarm set-point must be set as low as practical, but high enough to avoid false alarms.

(2) The licensee may reset the alarm set point to a higher level if necessary to operate the pool water purification system to clean up contamination in the pool if specifically provided for in written emergency procedures.

19.22.3 If a leaking source is detected, the licensee shall arrange to remove the leaking source from service and have it decontaminated, repaired, or disposed of by a U.S. Nuclear Regulatory Commission or Agreement State licensee that is authorized to perform these functions.

19.22.3.1 The licensee shall promptly check its personnel, equipment, facilities, and irradiated product for radioactive contamination.

19.22.3.2 No product may be shipped until the product has been checked and found free of contamination.

19.22.3.3 If a product has been shipped that may have been inadvertently contaminated, the licensee shall arrange to locate and survey that product for contamination.

19.22.3.4 If any personnel are found to be contaminated, decontamination must be performed promptly.

19.22.3.5 If contaminated equipment, facilities, or products are found, the licensee shall arrange to have them decontaminated or disposed of by a U.S. Nuclear Regulatory Commission or Agreement State licensee that is authorized to perform these functions.

19.22.3.6 If a pool is contaminated, the licensee shall arrange to clean the pool until the water contamination levels do not exceed the appropriate concentration in Part 4, Appendix 4B, Table 4B2, Column 2 (See 4.52 and 4.53 for notification and reporting requirements).

19.23 Inspection and Maintenance.

19.23.1 The licensee shall perform inspection and maintenance checks that include, as a minimum, each of the following at the frequency specified in the license or license application:

19.23.1.1 Operability of each aspect of the access control system required by 19.8;

19.23.1.2 Functioning of the source position indicator required by 19.12.2;

19.23.1.3 Operability of the radiation monitor for radioactive contamination in pool water required by 19.22.2, using a radiation check source, if applicable;

19.23.1.4 Operability of the over-pool radiation monitor at underwater irradiators as required by 19.11.2;

19.23.1.5 Operability of the product exit monitor required by 19.11.1;

19.23.1.6 Operability of the emergency source return control required by 19.12.3;

19.23.1.7 Leak-tightness of systems through which pool water circulates (visual inspection);

19.23.1.8 Operability of the heat and smoke detectors and extinguisher system required by 19.10 (but without turning extinguishers on);

19.23.1.9 Operability of the means of pool water replenishment required by 19.13.3;

19.23.1.10 Operability of the indicators of high and low pool water levels required by 19.13.4;

19.23.1.11 Operability of the intrusion alarm required by 19.8.9, if applicable;

19.23.1.12 Functioning and wear of the system, mechanisms and cables used to raise and lower sources;

19.23.1.13 Condition of the barrier to prevent products from hitting the sources or source mechanism as required by 19.14;

19.23.1.14 Amount of water added to the pool to determine if the pool is leaking;

19.23.1.15 Electrical wiring on required safety systems for radiation damage; and

19.23.1.16 Pool water conductivity measurements and analysis as required by 19.24.2.

19.23.2 Malfunctions and defects found during inspection and maintenance checks must be repaired without undue delay.

19.24 Pool Water Purity.

19.24.1 Pool water purification system must be run sufficiently to maintain the conductivity of the pool water below 20 microsiemens per centimeter under normal circumstances.

19.24.1.1 If pool water conductivity rises above 20 microsiemens per centimeter, the licensee shall take prompt actions to lower the pool water conductivity and shall take corrective actions to prevent future recurrences.

19.24.2 The licensee shall measure the pool water conductivity frequently enough, but no less than weekly, to assure that the conductivity remains below 20 microsiemens per centimeter. Conductivity instruments must be calibrated at least annually.

19.25 Attendance During Operations.

19.25.1 Both an irradiator operator and at least one individual, who is trained on how to respond and prepared to promptly render or summon assistance if the access control alarm sounds, shall be present onsite:

19.25.1.1 Whenever the irradiator is operated using an automatic product conveyor system; and

19.25.1.2 Whenever the product is moved into or out of the radiation room when the irradiator is operated in a batch mode.

19.25.2 At a panoramic irradiator at which static irradiations (no movement of the product) are occurring, an individual who has received the training required in 19.18.7 on how to respond to alarms must be onsite.

19.25.3 At an underwater irradiator, an irradiator operator must be present at the facility whenever the product is moved into or out of the pool.

19.25.3.1 An individual who moves the product into or out of the pool of an underwater irradiator need not be qualified as an irradiator operator; however, each such individual shall have received the training required in 19.18.6 and 19.18.7.

19.26 Entering and Leaving the Irradiation Room.

19.26.1 Upon first entering the radiation room of a panoramic irradiator after an irradiation, the irradiator operator shall use a survey meter to determine that the source has returned to its fully shielded position.

19.26.1.1 The operator shall check the functioning of the survey meter with a radiation check source prior to entry.

19.26.2 Before exiting from and locking the door to the radiation room of a panoramic irradiator prior to a planned irradiation, the irradiator operator shall:

19.26.2.1 Visually inspect the entire radiation room to verify that no one else is in it; and

19.26.2.2 Activate a control in the radiation room that permits the sources to be moved from the shielded position only if the door to the radiation room is locked within a preset time after setting the control.

19.26.3 During a power failure, the area around the pool of an underwater irradiator may not be entered without using an operable and calibrated radiation survey meter unless the over-the-pool monitor required by 19.11.2 is operating with backup power.

19.27 Irradiation of Explosive or Flammable Materials.

19.27.1 Irradiation of explosive material is prohibited unless the licensee has received prior written authorization from the Department.

19.27.1.1 Authorization will not be granted unless the licensee can demonstrate that detonation of the explosive would not rupture the sealed sources, injure personnel, damage safety systems, or cause radiation overexposures of personnel.

19.27.2 Irradiation of more than small quantities of flammable material (flash point below 140°C) is prohibited in panoramic irradiators unless the licensee has received prior written authorization from the Department.

19.27.2.1 Authorization will not be granted unless the licensee can demonstrate that a fire in the radiation room could be controlled without damage to the sealed sources or safety systems and without radiation overexposures of personnel.

RECORDS AND REPORTS

19.28 Records and Retention Periods.

19.28.1 The licensee shall maintain the following records at the irradiator for the periods specified:

19.28.1.1 A copy of the license, license conditions, documents incorporated into a license by reference, and amendments thereto until superseded by new documents or until the Department terminates the license for documents not superseded;

19.28.1.2 Records of each individual's training, tests, and safety reviews provided to meet the requirements of 19.18.1, 19.18.2, 19.18.3, 19.18.4, 19.18.6, and 19.18.7 until 3 years after the individual terminates work;

19.28.1.3 Records of the annual evaluations of the safety performance of irradiator operators required by 19.18.5 for 3 years after the evaluation;

19.28.1.4 A copy of the current operating and emergency procedures required by 19.19 until superseded or the Department terminates the license. Records of the radiation safety officer's review and approval of changes in procedures as required by 19.19.3.3 retained for 3 years from the date of the change;

19.28.1.5 Evaluations of personnel dosimetry (film badge, optically stimulated luminescence and thermoluminescence dosimeter) required by 19.20 in accordance with 4.46;

19.28.1.6 Records of radiation surveys required by 19.21 for 3 years from the date of the survey;

19.28.1.7 Records of radiation survey meter calibrations required by 19.21.3 and pool water conductivity meter calibrations required by 19.24.2 until 3 years from the date of calibration;

19.28.1.8 Records of the results of leak tests required by 19.22.1 and the results of contamination checks required by 19.22.2 for 3 years from the date of each test;

19.28.1.9 Records of inspection and maintenance checks required by 19.23 for 3 years;

19.28.1.10 Records of major malfunctions, significant defects, operating difficulties or irregularities, and major operating problems that involve required radiation safety equipment for 3 years after repairs are completed;

19.28.1.11 Records of the receipt, transfer, and disposal of all licensed sealed sources as required by 3.22 and 4.48;

19.28.1.12 Records on the design checks required by 19.16 and the construction control checks as required by 19.17 until the license is terminated. The records must be signed and dated. The title or qualification of the person signing must be included; and

19.28.1.13 Records related to decommissioning of the irradiator as required by 3.16.6.8.

19.29 Reports.

19.29.1 In addition to the reporting requirements in other parts of the regulations, the licensee shall report the following events:

19.29.1.1 Source stuck in an unshielded position;

19.29.1.2 Any fire or explosion in a radiation room;

19.29.1.3 Damage to the source racks;

19.29.1.4 Failure of the cable or drive mechanism used to move the source racks;

19.29.1.5 Inoperability of the access control system;

19.29.1.6 Detection of radiation source by the product exit monitor;

19.29.1.7 Detection of radioactive contamination attributable to licensed radioactive material;

19.29.1.8 Structural damage to the pool liner or walls;

19.29.1.9 Abnormal water loss or leakage from the source storage pool; or

19.29.1.10 Pool water conductivity exceeding 100 microsiemen per centimeter.

19.29.2 The report must include a telephone report within 24 hours as described in 4.52.2, and a written report within 30 days as described in 4.53.1.2.

PART 20: RESERVED.

EDITOR'S NOTES

6 CCR 1007-1 has been divided into smaller sections for ease of use. Versions prior to 4/1/07 and rule history are located in the first section, 6 CCR 1007-1. Prior versions can be accessed from the History link that appears above the text in 6 CCR 1007-1. To view versions effective on or after 4/1/07, Select the desired part of the rule, for example 6 CCR 1007-1 Part 1 or 6 CCR 1007-1 Parts 8 - 10.

History

[For history of this section, see Editor's Notes in the first section, 6 CCR 1007-1]