(17) RECORDS OF BRACHYTHERAPY SOURCE INVENTORY. (a) A licensee shall maintain a record of brachytherapy source accountability required by s. HFS 157.65 (3) for 3 years.

(b) For temporary implants, the record shall include all of the following:

1. The number and activity of sources removed from storage, the time and date they were removed from storage, the name of the person who removed them from storage and the location of use.

2. The number and activity of sources returned to storage, the time and date they were returned to storage and the name of the person who returned them from storage.

(c) For permanent implants, the record shall include all of the following:

1. The number and activity of sources removed from storage, the date they were removed from storage and the name of the person who removed them from storage.

2. The number and activity of sources returned to storage, the date they were returned to storage and the name of the person who returned them to storage.

3. The number and activity of sources permanently implanted in the patient or human research subject.

(18) RECORDS OF CALIBRATIONS ON BRACHYTHERAPY SOURCES. A licensee shall maintain a record of the calibrations on brachytherapy sources required by s. HFS 157.65 (6) for 3 years after the last use of the source. The record shall include the date of the calibration, the manufacturer's name, model number and serial number for the source and instruments used to calibrate the source, the source output or activity, source positioning accuracy within applicators and the signature of the authorized medical physicist.

(19) RECORDS OF INSTALLATION, MAINTENANCE, ADJUSTMENT AND REPAIR. A licensee shall retain a record of the installation, maintenance, adjustment and repair of remote afterloader units, teletherapy units and gamma stereotactic units as required by s. HFS 157.67 (3) for 3 years. For each installation, maintenance, adjustment and repair, the record shall include the date, description of the service and names of the persons who performed the work.

(20) RECORDS OF DOSIMETRY EQUIPMENT. (a) A licensee shall retain a record of the calibration, intercomparison and comparisons of its dosimetry equipment done under s. HFS 157.67 (6) for the duration of the license.

(b) For each calibration, intercomparison or comparison, the record shall include all of the following:

1. The date.

2. The model numbers and serial numbers of the instruments that were calibrated, intercompared or compared.

3. The correction factor that was determined from the calibration or comparison or the apparent correction factor that was determined from an intercomparison.

4. The names of the persons who performed the calibration, intercomparison or comparison.

(21) RECORDS OF TELETHERAPY, REMOTE AFTERLOADER AND GAMMA STEREOTACTIC RADIOSURGERY FULL CALIBRATIONS. (a) A licensee shall maintain a record of the teletherapy, remote afterloader and gamma stereotactic radiosurgery full calibrations required by s. HFS 157.67 (7) to (9) for 3 years.

(b) The record required under par. (a) shall include all of the following:

1. The date of the calibration.

2. The manufacturer's name, model number and serial number for the teletherapy, remote afterloader and gamma stereotactic radiosurgery unit, source and instruments used to calibrate the unit.

3. The results and an assessment of the full calibrations.

4. The results of the autoradiograph required for low dose-rate remote afterloader units.

5. The signature of the authorized medical physicist who performed the full calibration.

(22) RECORDS OF PERIODIC SPOT-CHECKS FOR TELETHERAPY UNITS. (a) A licensee shall retain a record of each periodic spot-check for teletherapy units required by s. HFS 157.67 (10) for 3 years.

(b) The record required under par. (a) shall include all of the following:

1. The date of the spot-check.

2. The manufacturer's name, model number and serial number for the teletherapy unit, source and instrument used to measure the output of the teletherapy unit.

3. An assessment of timer linearity and constancy.

4. The calculated on-off error.

5. A determination of the coincidence of the radiation field and the field indicated by the light beam localizing device.

6. The determined accuracy of each distance measuring and localization device.

7. The difference between the anticipated output and the measured output.

8. Notations indicating the operability of each entrance door electrical interlock, each electrical or mechanical stop, each source exposure indicator light and the viewing and intercom system and doors.

9. The name of the person who performed the periodic spot-check and the signature of the authorized medical physicist who reviewed the record of the spot-check.

(23) RECORDS OF PERIODIC SPOT-CHECKS FOR REMOTE AFTERLOADER UNITS. (a) A licensee shall retain a record of each spot-check for remote afterloader units required by s. HFS 157.67 (11) for 3 years.

(b) The record required under par. (a) shall include all of the following, as applicable:

1. The date of the spot-check.

2. The manufacturer's name, model number and serial number for the remote afterloader unit and source.

3. An assessment of timer accuracy.

4. Notations indicating the operability of each entrance door electrical interlock, radiation monitors, source exposure indicator lights, viewing and intercom systems and clock and decayed source activity in the unit's computer.

5. The name of the person who performed the periodic spot-check and the signature of the authorized medical physicist who reviewed the record of the spot-check.

(24) RECORDS OF PERIODIC SPOT-CHECKS FOR GAMMA STEREOTACTIC RADIOSURGERY UNITS. (a) A licensee shall retain a record of each spot-check for gamma stereotactic radiosurgery units required by s. HFS 157.67 (12) for 3 years.

(b) The record required under par. (a) shall include all of the following:

1. The date of the spot-check.

2. The manufacturer's name, model number and serial number for the gamma stereotactic radiosurgery unit and the instrument used to measure the output of the unit.

3. An assessment of timer linearity and accuracy.

4. The calculated on-off error.

5. A determination of trunnion centricity.

6. The difference between the anticipated output and the measured output.

7. An assessment of source output against computer calculations.

8. Notations indicating the operability of radiation monitors, helmet microswitches, emergency timing circuits, emergency off buttons, electrical interlocks, source exposure indicator lights, viewing and intercom systems, timer termination, treatment table retraction mechanism and stereotactic frames and localizing devices.

9. The name of the person who performed the periodic spot-check and the signature of the authorized medical physicist who reviewed the record of the spot-check.

(25) RECORDS OF ADDITIONAL TECHNICAL REQUIREMENTS FOR MOBILE REMOTE AFTERLOADER UNITS. (a) A licensee shall retain a record of each check for mobile remote afterloader units required by s. HFS 157.67 (13) for 3 years.

(b) The record required under par. (a) shall include all the following:

1. The date of the check.

2. The manufacturer's name, model number and serial number of the remote afterloader unit.

3. Notations accounting for all sources before the licensee departs from a facility.

4. Notations indicating the operability of each entrance door electrical interlock, radiation monitors, source exposure indicator lights, viewing and intercom system, applicators and source transfer tubes and source positioning accuracy.

5. The signature of the person who performed the check.

(26) RECORDS OF SURVEYS OF THERAPEUTIC TREATMENT UNITS. (a) A licensee shall maintain a record of radiation surveys of treatment units made under s. HFS 157.67 (14) for the duration of use of the unit.

(b) The record required under par. (a) shall include all the following:

1. The date of the measurements.

2. The manufacturer's name, model number and serial number of the treatment unit, source and instrument used to measure radiation levels.

3. Each dose rate measured around the source while the unit is in the off position and the average of all measurements.

4. The signature of the person who performed the test.

(27) RECORDS OF 5-YEAR INSPECTION FOR TELETHERAPY AND GAMMA STEREOTACTIC RADIOSURGERY UNITS. (a) A licensee shall maintain a record of the 5-year inspections for teletherapy and gamma stereotactic radiosurgery units required by s. HFS 157.67 (15) for the duration of use of the unit.

(b) The record required under par. (a) shall contain all the following:

1. The inspector's radioactive materials license number.

2. The date of inspection.

3. The manufacturer's name and model number and serial number of both the treatment unit and source.

4. A list of components inspected and serviced, and the type of service.

5. The signature of the inspector.

(28) RECORDS OF DECAY OF STRONTIUM-90 SOURCES FOR OPHTHALMIC TREATMENTS. (a) A licensee shall maintain a record of the activity of a strontium-90 source required by s. HFS 157.65 (6) for the life of the source.

(b) The record required under par, (a) shall include both of the following:

1. The initial activity of the source and date.

2. For each decay calculation, the date and the source activity as determined under s. HFS 157.65 (6).

HFS 157.72 Reports. (1) REPORTS OF MEDICAL EVENTS. (a) A licensee shall report to the department any event, except for events that result from intervention by a patient or human research subject, in which the administration of radioactive material or resulting radiation results in any of the following:

1. A dose that differs from the prescribed dose by more than 0.05 Sv (5 rem) effective dose equivalent, 0.5 Sv (50 rem) to an organ or tissue or 0.5 Sv (50 rem) shallow dose equivalent to the skin and to which any of the following apply:

a. The total dose delivered differs from the prescribed dose by 20 percent or more.

b. The total dosage delivered differs from the prescribed dosage by 20 percent or more or falls outside the prescribed dosage range.

c. The fractionated dose delivered differs from the prescribed dose, for a single fraction, by 50 percent or more.

2. A dose that exceeds 0.05 Sv (5 rem) effective dose equivalent, 0.5 Sv (50 rem) to an organ or tissue or 0.5 Sv (50 rem) shallow dose equivalent to the skin from any of the following:

a. An administration of a wrong pharmaceutical.

b. An administration of a radioactive drug containing radioactive material by the wrong route of administration.

c. An administration of a dose or dosage to the wrong patient or human research subject.

d. An administration of a dose delivered by the wrong mode of treatment.

e. A leaking sealed source.

3. A dose to an organ outside the intended treatment volume that exceeds the expected dose to that organ by 0.5 Sv (50 rem) where the excess dose is greater than 50 percent of the expected dose to that organ, excluding, for permanent implants, seeds that were implanted in the correct site but migrated outside the treatment site.

(b) A licensee shall report to the department any event resulting from intervention of a patient or human research subject in which the administration of radioactive material or radiation therefrom results or will result in an unintended permanent functional damage to an organ or a physiological system, as determined by a physician.

(c) A licensee shall notify the department by telephone no later than the next calendar day after discovery of the medical event.

(d) 1. A licensee shall submit a written report to the department within 15 working days after discovery of the medical event.

2. The written report required in subd. 1. shall include all the following:

a. The licensee's name.

b. The name of the prescribing physician.

c. A brief description of the event.

d. Why the event occurred.

e. Any effect on the person who received the administration.

f. Any actions that have been taken or are planned to prevent recurrence.

g. Whether the licensee notified the person or the person's responsible relative or guardian and if not, why not.

h. If there was notification, what information was provided.

3. The report required in subd. 1. may not contain the affected individual's name or any other information that could lead to identification of the person.

(e) A licensee shall notify the referring physician of the event and also notify the person who is the subject of the medical event no later than 24 hours after its discovery unless the referring physician personally informs the licensee either that the physician will inform the person or that, based on medical judgement, telling the person would be harmful. A licensee is not required to notify the person without first consulting the referring physician. If the referring physician or the affected person cannot be reached within 24 hours, a licensee shall notify the person as soon as possible thereafter. A licensee may not delay any appropriate medical care for the person, including any necessary remedial care resulting from the medical event, because of any delay in notification. To meet the requirements of this paragraph, the notification of the person who is the subject of the medical event may be made instead to that person's responsible relative or guardian. If a verbal notification is made, a licensee shall inform the person or appropriate responsible relative or guardian that a written description of the event may be obtained from the licensee upon request. A licensee shall provide the written description if requested.

(f) If the person **who is the subject of the medical event** was notified under par. (d), a licensee shall also furnish within 30 days after discovery of the medical event a written report to the person by sending either of the following:

1. A copy of the report that was submitted to the department.

2. A brief description of both the event and the consequences as they may affect the person.

(g) Aside from the notification requirement, nothing in this subsection affects any rights or duties of a licensee or physician in relation to each other, to any person affected by the medical event or to any individual's responsible relatives or guardians.

(h) A licensee shall retain a record of a medical event under s. HFS 157.71 (4). A copy of the record required under s. HFS 157.71 (4) shall be provided to the referring physician if other than the licensee.

(2) REPORT OF A DOSE TO AN EMBRYO OR FETUS OR A NURSING CHILD. (a) A licensee shall report to the department any dose to an embryo or fetus that is greater than 50 mSv (5 rem) dose equivalent that is a result of an administration of radioactive material or radiation from radioactive material to a pregnant individual unless the dose to the embryo or fetus was specifically approved, in advance, by the authorized user.

(b) A licensee shall report to the department any dose to a nursing child that is a result of an administration of radioactive material to a breast-feeding individual that meets either of the following criteria:

1. Greater than 50 mSv (5 rem) total effective dose equivalent.

2. Resulted in unintended permanent functional damage to an organ or a physiological system, as determined by a physician.

(c) A licensee shall notify the department by telephone within 5 days after discovery of a dose to the embryo or fetus or nursing child that requires a report in par. (a) or (b).

(d) 1. A licensee shall submit a written report to the department no later than 30 days after discovery of a dose to the embryo or fetus or nursing child that requires a report in par. (a) or (b). The written report shall include all the following information:

a. The licensee's name.

b. The name of the prescribing physician.

c. A brief description of the event.

d. Why the event occurred.

e. The effect on the embryo or fetus or the nursing child.

f. Any actions that have been taken or are planned to prevent recurrence.

2. The report required under par. (a) may not contain the individual's name or any other information that could lead to identification of the individual.

(e) A licensee shall notify the referring physician and also notify the pregnant person or mother, both hereafter referred to as the mother, within 5 working days of discovery of an event that would require reporting under par. (a) or (b) unless the referring physician personally informs the licensee either that the physician will inform the mother or that, based on medical judgement, telling the mother would be harmful.

(f) To meet the requirements of this subsection, the notification **by the licensee** may be made to the mother's or child's responsible relative or guardian instead of the mother~~, when appropriate~~ **if the mother cannot be located or is unavailable**.

(g) A licensee is not required to notify the mother without first consulting with the referring physician. If the referring physician or mother cannot be reached within 5 days; a licensee shall make the appropriate notifications as soon as possible thereafter. A licensee may not delay any appropriate medical care for the embryo or fetus or for the nursing child, including any necessary remedial care resulting from the event, because of any delay in notification.

(h) If notification was made under pars. (e) or (f), a licensee shall also furnish, within 30 days after discovery of the event, a written report to the mother or responsible relative or guardian by sending either of the following:

1. A copy of the report that was submitted to the department.

2. A brief description of both the event and the consequences as they may affect the embryo or fetus or nursing child.

(i) A licensee shall retain a record of a dose to an embryo or fetus or a nursing child under s. HFS 157.71 (5).

(3) REPORTS OF LEAKING SOURCES. A licensee shall submit a written report to the department within 5 working days if a leakage test required by s. HFS 157.62 (5) reveals the presence of 185 Bq (0.005 μCi) or more of removable contamination. The written report shall include the model number and serial number, if assigned, of the leaking source, the radionuclide and its estimated activity, the results of the test, the date of the test and the action taken.

Subchapter VII – Radiation Safety Requirements for Irradiators

HFS 157.73 Radiation safety requirements. (1) PERFORMANCE CRITERIA FOR SEALED SOURCES. (a) A sealed source installed ~~after the effective date of this subchapter [revisor to insert effective date]~~ **in an irradiator** shall meet all of the following requirements:

1. Be evaluated **and receive a certificate of registration** under 10 CFR 32.210 or the equivalent agreement state regulation.

2. Be doubly encapsulated.

3. Use radioactive material that is as nondispersible and insoluble as practical if the source is used in a wet-source-storage or wet-source-change irradiator.

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 for use in irradiator pools.

5. In prototype testing of the sealed source, be leak tested and found leak-free after each of the tests in par. (b).

(b) A sealed source used in an irradiator shall be subjected to all of the following tests prior to use:

1. 'Temperature.' The test source shall be held at -40°C for 20 minutes, 600°C for one hour, and then be **immediately** subjected to thermal shock test with a temperature drop from 600°C to 20°C within 15 seconds.

2. 'Pressure.' The test source shall be twice subjected for at least 5 minutes to an absolute external pressure of 2 million newtons per square meter.

3. 'Impact.' A 2 kilogram steel weight, 2.5 centimeters in diameter, shall be dropped from a height of one meter on to the test source.

4. 'Vibration.' The test source shall 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 shall be vibrated for 30 minutes at each resonant frequency found.

5. 'Puncture.' A 50 gram weight and pin, 0.3 centimeter pin diameter, shall be dropped from a height of one meter on to the test source.

6. 'Bend.' If the length of the source is more than 15 times larger than the minimum cross-sectional dimension, the test source shall be subjected to a force of 2000 newtons at its center, equidistant from 2 support cylinders, the distance between which is 10 times the minimum cross-sectional dimension of the source.

(2) ACCESS CONTROL. (a) Each entrance to a radiation room at a panoramic irradiator shall have a door or other physical barrier to prevent inadvertent entry of personnel when the sources are not in the shielded position. Product conveyor systems may serve as barriers as long as they reliably and consistently function as a barrier. It ~~must not be possible~~ **shall be impossible** to move the sources out of their shielded position if the door or barrier is open. Opening the door or barrier while the sources are exposed shall cause the sources to return promptly to the shielded position. The personnel entrance door or barrier shall have a lock that is operated by the same key used to move the sources. The control panel lock shall be designed so that the key cannot be removed unless the sources have been returned to the shielded position. The doors and barriers ~~shall~~ **may** not prevent any person in the radiation room from leaving.

(b) Each entrance to a radiation room at a panoramic irradiator shall have an independent backup access control to detect personnel entry while the sources are exposed. Detection of entry while the sources are exposed shall cause the sources to return to their fully shielded position and shall activate a visible and audible alarm to make the person entering the room aware of the hazard. The alarm shall also alert at least one other person who is on-site of the entry. The person alerted shall be trained on how to respond to the alarm and prepared to promptly render or summon assistance.

(c) A radiation monitor shall be provided to detect the presence of high radiation levels in the radiation room of a panoramic irradiator before personnel entry. The monitor shall be integrated with personnel access door locks to prevent room access when radiation levels are high. Attempted personnel entry while the monitor measures high radiation levels shall activate the alarm described in par. (b). The monitor may be located in the entrance, normally referred to as the maze, but not in the direct radiation beam.

(d) Before the sources move from their shielded position in a panoramic irradiator, the source control shall automatically activate conspicuous visible and audible alarms to alert people in the radiation room that the sources will be moved from their shielded position. The alarms shall give persons enough time to leave the room before the sources leave the shielded position.

(e) Each radiation room of a panoramic irradiator shall have a clearly visible and readily accessible control that allows a person in the room to make the sources return to their fully shielded position.

(f) Each radiation room of a panoramic irradiator shall 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.

(g) 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 shall have a sign bearing the radiation symbol and the words, "Caution (or danger), radioactive material." A panoramic irradiator shall have a sign stating "Grave (or Extreme) danger, very high radiation area," but the sign may be removed, covered or otherwise made inoperative when the sources are fully shielded.

(h) If the radiation room of a panoramic irradiator has roof plugs or movable shielding, no person may operate the irradiator unless the shielding is in its proper location. The 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.

(i) An underwater irradiator shall have a personnel access barrier around the pool that shall be locked to prevent access when the irradiator is not attended. Only operators or facility management may have access to keys that operate the personnel access barrier. There shall be an intrusion alarm to detect unauthorized entry when the personnel access barrier is locked. Activation of the intrusion alarm shall alert a person who is not necessarily on-site but who is prepared to respond or summon assistance.

(3) SHIELDING. (a) The radiation dose rate in areas that are normally occupied during operation of a panoramic irradiator may not exceed 0.02 millisievert (2 mrem) per hour at any location 30 centimeters or more from the wall of the room when the sources are exposed. The dose rate shall be averaged over an area not to exceed 100 square centimeters having no linear dimension greater than 20 centimeters. Any area where the radiation dose rate exceeds 0.02 millisievert (2 mrem) per hour shall be locked, roped off or posted.

(b) The radiation dose at 30 centimeters over the edge of the pool of a pool irradiator may not exceed 0.02 millisievert (2 mrem) per hour when the sources are in the fully shielded position.

(c) The radiation dose rate at one meter from the shield of a dry-source-storage panoramic irradiator when the source is shielded may not exceed 0.02 millisievert (2 mrem) per hour and at 5 centimeters from the shield may not exceed 0.2 millisievert (20 mrem) per hour.

(4) FIRE PROTECTION. (a) The radiation room of a panoramic irradiator shall have heat and smoke detectors. The detectors shall activate an audible alarm. The alarm shall be capable of alerting a person who is prepared to summon assistance promptly. The sources shall automatically become fully shielded if a fire is detected.

(b) The radiation room of a panoramic irradiator shall be equipped with a fire extinguishing system capable of extinguishing a fire without the entry of personnel into the room. The system for the radiation room shall have a shut-off valve to control flooding into unrestricted areas.

(5) RADIATION MONITORS. (a) An irradiator with an automatic product conveyor system shall have a radiation monitor with an audible alarm located to detect loose radioactive sources that are carried toward the product exit. If the monitor detects a source, an alarm shall sound and

product conveyors shall stop automatically. The alarm shall be capable of alerting a person in the facility who is prepared to summon assistance. An underwater irradiator in which the product moves within an enclosed stationary tube is exempt from the requirements of this paragraph.

(b) An underwater irradiator that is not in a shielded radiation room shall have a radiation monitor over the pool to detect abnormal radiation levels. The monitor shall have an audible alarm and a visible indicator at entrances to the personnel access barrier around the pool. The audible alarm may have a manual shut-off. The alarm shall be capable of alerting a person who is prepared to respond promptly.

(6) CONTROL OF SOURCE MOVEMENT. (a) The mechanism that moves the sources of a panoramic irradiator shall require a key to actuate. Actuation of the mechanism shall cause an audible signal to indicate that the sources are leaving the shielded position. Only one key may be in use at any time, and only operators or facility management may possess it. The key shall be attached to a portable radiation survey meter by a chain or cable. The lock for source control shall be designed so that the key may not be removed if the sources are in an unshielded position. The door to the radiation room shall require the same key.

(b) The console of a panoramic irradiator shall have a source position indicator that indicates when the sources are in the fully shielded position, in transit and exposed.

(c) The control console of a panoramic irradiator shall have a control that promptly returns the sources to the shielded position.

(d) The function of each control for a panoramic irradiator shall be clearly marked.

(7) IRRADIATOR POOLS. (a) ~~For a license initially issued after the effective date of this subchapter [revisor to insert effective date]~~, An irradiator pool shall be one of the following:

1. Constructed with a water-tight stainless steel liner or a liner metallurgically compatible with other components in the pool.

2. Constructed so that there is a low likelihood of substantial leakage and with a surface designed to facilitate decontamination.

(b) A licensee shall have a method to safely store the sources during repairs of the pool.

(c) ~~For a license initially issued after the effective date of this subchapter [revisor to insert effective date]~~, An irradiator pool shall have no outlets more than 0.5 meter below the normal low water level that may allow water to drain out of the pool. Pipes that have intakes more than 0.5 meter below the normal low water level and that may act as siphons shall have siphon breakers to prevent the siphoning of pool water.

(d) A method shall be available to replenish water losses from the pool.

(e) A visible indicator shall be provided in a clearly observable location to indicate if the pool water level is below the normal low water level or above the normal high water level.

(f) An irradiator pool shall 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~~ **are clearly visible**.

(g) A physical barrier, such as a railing or cover, shall be used around or over irradiator pools during normal operation to prevent personnel from accidentally falling into the pool. The barrier may be removed during maintenance, inspection and service operations.

(h) If long-handled tools or poles are used in an irradiator pool, the radiation dose rate to the operator at the handling areas of the tools may not exceed 0.02 millisievert (2 mrem) per hour.

(8) SOURCE RACK PROTECTION. If the product to be irradiated moves on a product conveyor system, the source rack and the mechanism that moves the rack shall be protected by a carrier or guides to prevent products and product carriers from hitting or touching the rack or mechanism.

(9) POWER FAILURES. (a) If electrical power at a panoramic irradiator is lost for longer than 10 seconds, the sources shall automatically return to the shielded position.

(b) The lock on the door of the radiation room of a panoramic irradiator shall remain locked in the event of a power failure.

(c) 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.

(10) DESIGN REQUIREMENTS. An irradiator ~~whose construction begins after the effective date of this subchapter [revisor to insert effective date]~~ shall meet all of the following design requirements:

(a) *Shielding.* For a panoramic irradiator, a 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 sub. (3). If the irradiator will use more than 2×10^{17} becquerels (5 million Ci) of activity, a licensee shall evaluate the effects of heating of the shielding walls by the irradiator sources.

(b) *Foundations.* For a panoramic irradiator, a licensee shall design the foundation, with consideration given to soil characteristics, to ensure that the foundation is adequate to support the weight of the facility shield walls.

(c) *Pool integrity.* For a pool irradiator, a licensee shall design the pool to ensure all of the following:

1. That the pool is leak resistant.

2. That the pool is strong enough to bear the weight of the pool water and shipping casks.

3. That a dropped shipping cask would not fall on sealed sources.

4. That all outlets or pipes meet the requirements of sub. (7).

5. That metal components are metallurgically compatible with other components in the pool.

(d) *Water handling system.* For a pool irradiator, a licensee shall verify that the design of the water purification system is adequate to meet the requirements of sub. (7) (f). The system shall be designed so that water leaking from the system does not drain to unrestricted areas without being monitored.

(e) *Radiation monitors.* For all irradiators, a licensee shall evaluate the location and sensitivity of the **radiation** monitor to detect sources carried by the product conveyor system as required by sub. (5) (a). A 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. For a pool irradiator, if the licensee uses radiation monitors to detect contamination under sub. (16) (b), 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.

(f) *Source rack.* For a pool irradiator, a 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. For a panoramic irradiator, a 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. For a panoramic irradiator, a licensee shall review the design of the mechanism that moves the sources to ensure that the likelihood of a stuck source is low and that, if the rack sticks, a means exists to free the rack with minimal risk to personnel.

(g) *Access control.* For a panoramic irradiator, a licensee shall verify from the design and logic diagram that the access control system ~~shall~~ meet**s** the requirements of sub. (2).

(h) *Fire protection.* For a panoramic irradiator, a licensee shall verify that the number, locations, and spacing of the smoke and heat detectors are appropriate to detect fires and that the detectors are protected from mechanical and radiation damage. A 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.

(i) *Source return.* For a panoramic irradiator, a licensee shall verify that the source rack will automatically return to the fully shielded position if power is lost for more than 10 seconds.

(j) *Seismic.* For a panoramic irradiator to be built in seismic areas **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**, a licensee shall design the reinforced concrete radiation shields to retain their integrity in the event of an earthquake by designing the irradiator to the seismic requirements of local building codes.

(k) *Wiring.* For a panoramic irradiator, a licensee shall verify that electrical wiring and electrical equipment in the radiation room are selected to minimize failures due to prolonged exposure to radiation.

(11) CONSTRUCTION MONITORING AND ACCEPTANCE TESTING. An irradiator ~~whose construction begins after the effective date of this subchapter [revisor to insert effective date]~~ shall meet all of the following requirements prior to loading sources:

(a) *Shielding.* For a panoramic irradiator, a licensee shall monitor the construction of the shielding to verify that its construction meets design specifications and local building code requirements for reinforced concrete.

(b) *Foundations.* For a panoramic irradiator, a licensee shall monitor the construction of the foundations to verify that their construction meets design specifications.

(c) *Pool integrity.* For a pool irradiator, a licensee shall verify that the pool meets design specifications and shall test the structural integrity of the pool and its ability to hold water. A licensee shall verify that outlets and pipes meet the requirements of sub. (7) ~~(b)~~ **(c)**.

(d) *Water handling system.* For a pool irradiator, a licensee shall verify that the water purification system, the conductivity meter, and the water level indicators operate properly.

(e) *Radiation monitors.* For all irradiators, a licensee shall verify the proper operation of the radiation monitor to detect sources carried on the product conveyor system and the related alarms and interlocks required by sub. (5) (a). For a pool irradiator, a licensee shall verify the proper operation of the radiation monitors and the related alarm, if used, to meet sub. (16) (b). For an underwater irradiator, a licensee shall verify the proper operation of the over-the-pool monitor, alarms, and interlocks required by sub. (5) (b).

(f) *Source rack.* For a panoramic irradiator, a licensee shall test the movement of the source racks for proper operation prior to source loading. The testing shall include source rack lowering due to simulated loss of power. For all irradiators with a product conveyor system, a licensee shall observe and test the operation of the conveyor system to assure that the requirements in sub. (8) are met for protection of the source rack and the mechanism that moves the rack. The testing shall include tests of any limit switches and interlocks used to protect the source rack and mechanism that moves that rack from moving product carriers.

(g) *Access control.* For a panoramic irradiator, a licensee shall test the completed access control system to assure that the control system functions as designed and that all alarms, controls, and interlocks work properly.

(h) *Fire protection.* For a panoramic irradiator, a 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. A licensee shall test the operability of the fire extinguishing system.

(i) *Source return.* For a panoramic irradiator, the licensee shall demonstrate that the source racks may be returned to their fully shielded positions without power.

(j) *Computer systems.* For a panoramic irradiator that uses a computer system to control the access control system, a licensee shall verify that the access control system will operate properly if 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 the system is required to be operable.

(k) *Wiring.* For a panoramic irradiator, a licensee shall verify that the electrical wiring and electrical equipment that were installed meet the design specifications.

(12) TRAINING. (a) Before a person ~~is permitted to~~ **may** act as an irradiator operator without a supervisor present, the person shall be instructed in all the following:

1. The fundamentals of radiation protection applied to irradiators. The fundamentals shall include the differences between external radiation and radioactive contamination, units of radiation dose, 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.

2. The requirements of subch. X and this subchapter.

3. The operation of the irradiator.

4. Operating and emergency procedures listed in sub. (13) **that** the person is responsible for performing.

5. Case histories of accidents or problems involving irradiators.

(b) Before a person ~~is permitted to~~ **may** act as an irradiator operator without a supervisor present, the person shall pass a written test on the instruction received consisting primarily of questions based on the licensee's operating and emergency procedures that the person is responsible for performing and other operations necessary to safely operate the irradiator without supervision.

(c) Before a person ~~is permitted to~~ **may** act as an irradiator operator without a supervisor present, the person shall have received on-the-job training or simulator training in the use of the irradiator as described in the license application. The person shall also demonstrate the ability to perform those portions of the operating and emergency procedures that he or she is to perform.

(d) A licensee shall conduct safety reviews for irradiator operators at least annually. **At the review,** the licensee shall give each operator a written test on the information presented during annual safety training. Each safety review shall include, to the extent appropriate, all of the following:

1. Any changes in operating and emergency procedures since the last review.

2. Any changes in regulations and license conditions since the last review.

3. Any reports on recent accidents, mistakes or problems that have occurred at irradiators.

4. Results of inspections of operator safety performance.

5. Results of the facility's inspection and maintenance checks.

6. A drill to practice an emergency or abnormal event procedure.

(e) A licensee shall evaluate the safety performance of each irradiator operator at least annually to ensure that regulations, license conditions and operating, safety and emergency procedures are followed. The licensee shall discuss the results of the evaluation with the operator and shall instruct the operator on how to correct any mistakes or deficiencies observed.

(f) Persons 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 sub. (13) that they are expected to perform or comply with and their proper response to alarms required in this subchapter. Tests may be oral.

(g) Persons who must be prepared to respond to alarms required by subs. (2) (b) and (i), (4) (a), (5) (a) and (b), and (16) (b) shall be trained and tested on how to respond. Each person shall be retested at least annually. Tests may be oral.

(13) OPERATING AND EMERGENCY PROCEDURES. (a) A licensee shall have and follow written operating procedures for all the following:

1. Operation of the irradiator including entering and leaving the radiation room.

2. Use of personnel dosimeters.

3. Surveying the shielding of panoramic irradiators.

4. Monitoring pool water for contamination while the water is in the pool and before release of pool water to unrestricted areas.

5. Leak testing of sources.

6. Inspection and maintenance checks required by sub. (17).

7. Loading, unloading and repositioning sources if the operations will be performed by the licensee.

8. Inspection of movable shielding required by sub. (2), if applicable.

(b) A licensee shall have and follow emergency or abnormal event procedures, appropriate for the irradiator type, for all of the following situations:

1. Sources stuck in the unshielded position.

2. Personnel overexposures.

3. A radiation alarm from the product exit portal monitor or pool monitor.

4. Detection of leaking sources, pool contamination or alarm caused by contamination of pool water.

5. A low or high water level indicator, an abnormal water loss or leakage from the source storage pool.

6. A prolonged loss of electrical power.

7. A fire alarm or explosion in the radiation room.

8. An alarm indicating unauthorized entry into the radiation room, area around pool or another alarmed area.

9. Natural phenomena, including an earthquake, a tornado, flooding or other phenomena as appropriate for the geographical location of the facility.

10. The jamming of automatic conveyor systems.

(c) A licensee may revise operating and emergency procedures without department approval only if all of the following conditions are met:

1. The revisions do not reduce the safety of the facility.

2. The revisions are consistent with the outline or summary of procedures submitted with the license application.

3. The revisions have been reviewed and approved by the radiation safety officer.

4. The users or operators are instructed and tested on the revised procedures before the procedures are implemented.

(14) PERSONNEL MONITORING. (a) Any irradiator operator shall wear either a film badge, a thermoluminescent dosimeter ~~(TLD)~~ or similar approved device while operating a panoramic irradiator or while in the area around the pool of an underwater irradiator. The film badge or TLD processor shall be accredited by the national voluntary laboratory accreditation program for high energy photons in the normal and accident dose ranges. Each film badge or TLD shall be assigned to and worn by only one person. Film badges shall be processed at least monthly and TLDs shall be processed at least quarterly.

Note: See s. HFS 157.25 (1) (c) for instructions concerning dosimetry processing.

(b) ~~Other persons~~ **A person other than an irradiator operator** who enters the radiation room of a panoramic irradiator shall wear a dosimeter, which may be a pocket dosimeter. For groups of visitors, only 2 people who enter the radiation room are required to wear dosimeters.

(c) If pocket dosimeters are used to meet the requirements of par. (b), a check of their response to radiation shall be performed at least annually. Acceptable dosimeters shall read within plus or minus 20 percent of the true radiation dose.

(15) RADIATION SURVEYS. (a) A radiation survey of the area outside the shielding of the radiation room of a panoramic irradiator shall be conducted with the sources in the exposed position before the facility starts to operate. A radiation survey of the area above the pool of pool irradiators shall be conducted after the sources are loaded but before the facility starts to operate. Additional radiation surveys of the shielding shall 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.

(b) If the radiation levels specified in sub. (3) are exceeded, the facility shall be modified to comply with the requirements in sub. (3).

(c) Portable radiation survey meters shall be calibrated at least annually to an accuracy of plus or minus 20 percent for the gamma energy of the sources in use. The calibration shall be performed at 2 points on each scale or, for digital instruments, at one point per decade over the range that will be used. Portable radiation survey meters shall be of a type that does not fail and read zero at high radiation dose rates.

(d) Water from the irradiator pool, other potentially contaminated liquids and sediments from pool vacuuming shall be monitored for radioactive contamination before release to unrestricted areas. Radioactive concentrations may not exceed those specified in Table II, Column 2 or Table III of Appendix E.

(e) Before releasing resins for unrestricted use, the resins shall be monitored before release in an area with a background level less than 0.5 microsievert (0.05 mrem) per hour. The resins may be released only if the survey does not detect radiation levels above background radiation levels. The survey meter used shall be capable of detecting radiation levels of 0.5 microsievert (0.05 mrem) per hour.

(16) DETECTION OF LEAKING SOURCES. (a) Each dry-source-storage sealed source shall be tested for leakage at intervals not to exceed 6 months using a leak test kit or a method approved by the department, the ~~U.S. nuclear regulatory commission~~ **NRC**, another agreement state or a licensing state. 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. The test shall be capable of detecting the presence of 200 becquerels (0.005 µCi) of radioactive material and shall be performed by a person approved by the department, the ~~U.S. nuclear regulatory commission~~ **NRC**, another agreement state or a licensing state to perform the test.

(b) For a pool irradiator, sources may not be put into the pool unless a licensee tests the sources for leaks or has a certificate from a transferor that a leak test has been performed within the 6 months before the transfer. Water from the pool shall be checked for contamination each day the irradiator operates. The 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. If a check for contamination is performed by analysis of a sample of pool water, the results of the analysis shall be available within 24 hours. If the licensee uses a radiation monitor on a pool water circulating system, the detection of above normal radiation levels shall activate an alarm. The alarm set-point shall be set as low as practical, but high enough to avoid false alarms. A licensee may reset the alarm set-point to a higher level if necessary to operate the pool water purification system to clear up contamination in the pool if specifically provided for in written emergency procedures.

(c) If a leaking source is detected, a licensee shall arrange to remove the leaking source from service and have it decontaminated, repaired or disposed of by a department~~, U.S. nuclear regulatory commission~~ **NRC**, another agreement state or a licensing state licensee authorized to perform decontamination, repair or disposal. A licensee shall promptly check its personnel, equipment, facilities and irradiated product for radioactive contamination. No product may be shipped until the product has been checked and found free of contamination. If a product has been shipped that may have been inadvertently contaminated, the licensee shall arrange to locate and survey that product for contamination. If any personnel are found to be contaminated, decontamination shall be performed immediately. If contaminated equipment, facilities or products are found, a licensee shall arrange to have the equipment, facilities or products decontaminated or disposed of by a **the** department, **the** U.S. nuclear regulatory commission, another agreement state or a licensing state licensee authorized to perform decontamination or disposal. If a pool is contaminated, a licensee shall arrange to clean the pool until the contamination levels do not exceed the appropriate concentration in Table II, Column 2 of Appendix E.

(17) INSPECTION AND MAINTENANCE. (a) A licensee shall perform inspection and maintenance checks that include each of the following at the frequency specified in the license or license application:

1. Operability of each aspect of the access control system required by sub. (2).

2. Functioning of the source position indicator required by sub. (6) (b).

3. Operability of the radiation monitor for radioactive contamination in pool water required by sub. (16) (b) using a radiation check source, if applicable.

4. Operability of the over-pool radiation monitor at underwater irradiators as required by sub. (5) (b).

5. Operability of the product exit monitor required by sub. (5) (a).

6. Operability of the emergency source return control required by sub. (6) (c).

7. Visual inspection of leak-tightness of systems through which pool water circulates.

8. Operability of the heat and smoke detectors and extinguisher system required by sub. (4), without turning extinguishers on.

9. Operability of the means of pool water replenishment required by sub. (7) ~~(c)~~ **(d)**.

10. Operability of the indicators of high and low pool water levels required by sub. (7) ~~(d)~~**(e)**.

11. Operability of the intrusion alarm required by sub. (2) (i), if applicable.

12. Functioning and wear of the system, mechanisms and cables used to raise and lower sources.

13. Condition of the barrier to prevent products from hitting the sources or source mechanism as required by sub. (8).

14. Amount of water added to the pool to determine if the pool is leaking.

15. Electrical wiring on required safety systems for radiation damage.

16. Pool water conductivity measurements and analysis as required by sub. (18) (b).

(b) Malfunctions and defects found during inspection and maintenance checks shall be repaired within time frames specified in the license or license application.

(18) POOL WATER PURITY. (a) A pool water purification system shall ~~be run sufficiently to~~ maintain the conductivity of the pool water below 20 microsiemens per centimeter under normal circumstances. If pool water conductivity rises above 20 microsiemens per centimeter, a licensee shall take prompt actions to lower the pool water conductivity and shall take corrective actions to prevent future recurrences.

(b) A 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 meters must be calibrated at least annually.

(19) ATTENDANCE DURING OPERATION. (a) Both an irradiator operator and at least one other person who is trained on how to respond and prepared to promptly render or summon assistance if the access control alarm sounds shall be present on site during any of the following times:

1. Whenever the irradiator is operated using an automatic product conveyor system.

2. Whenever the product is moved into or out of the radiation room when the irradiator is operated in a batch mode.

(b) A person who has received the training on how to respond to alarms described in sub. (12) (g) shall be on site at a panoramic irradiator at which product is exposed to radiation with no movement of the product.

(c) At an underwater irradiator, an irradiator operator shall be present at the facility whenever the product is moved into or out of the pool. Persons who move the product into or out of the pool of an underwater irradiator need not be qualified as irradiator operators, but shall have received the training described in sub. (12) (f) and (g). Static irradiations may be performed without a person present at the facility.

(20) ENTERING AND LEAVING THE RADIATION ROOM. (a) 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. The operator shall check the functioning of the survey meter with a radiation check source prior to entry.

(b) Before exiting from and locking the door to the radiation room of a panoramic irradiator prior to a planned irradiation, the irradiator operator shall do all the following:

1. Visually inspect the entire radiation room to verify that no one else is in it.

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.

(c) 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 sub. (5) (b) is operating with backup power.

(21) IRRADIATION OF EXPLOSIVE OR FLAMMABLE MATERIALS. (a) Irradiation of explosive material is prohibited unless a licensee has received prior written authorization from the department. Authorization may not be granted unless a licensee demonstrates that detonation of the explosive would not rupture the sealed sources, injure personnel, damage safety systems or cause radiation overexposures of personnel.

(b) Irradiation of more than small quantities of flammable material with a flash point below 140°F is prohibited in panoramic irradiators unless a licensee has received prior written authorization from the department. Authorization ~~shall~~ **may** not be granted unless a licensee demonstrates that a fire in the radiation room could be controlled without damage to sealed sources or safety systems and without radiation overexposures of personnel.

(22) RECORDS AND RETENTION PERIODS. A licensee shall maintain all the following records at the irradiator for the periods specified:

(a) A copy of the license, the license conditions, documents incorporated into the license by reference and amendments thereto until superseded by new documents or until the department terminates the license for documents not superseded.

(b) Records of each individual's training, tests and safety reviews provided to meet the requirements of sub. 12 (a) to (d), (f) and (g) until 3 years after the person terminates work.

(c) Records of the annual evaluations of the safety performance of irradiator operators required by sub. (12) (e) for 3 years after the evaluation.

(d) A copy of the current operating and emergency procedures required by sub. (13) until superseded or until the department terminates the license. Records of the radiation safety officer's review and approval of changes in procedures as required by sub. (13) (c) 3. shall be retained for 3 years from the date of the change.

(e) Dosimetery results required by sub. (14) (a) and (b) until the department terminates the license.

(f) Records of radiation surveys required by sub. (15) for 3 years from the survey date.

(g) Records of radiation survey meter calibrations required by sub. (15) and pool water conductivity meter calibrations required by sub. (18) (b) until 3 years from the calibration date.

(h) Records of the results of leak tests required by sub. (16) (a) and the results of contamination checks required by sub. (16) (b) for 3 years from the date of each test.

(i) Records of inspection and maintenance checks required by sub. (17) for 3 years.

(j) 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.

(k) Records of the receipt, transfer and disposal of all licensed sealed sources as required by s. HFS 157.13 (12), 10 CFR 30.51 or the equivalent agreement state or licensing state regulations.

(L) Records on the design checks required by sub. (10) and the construction control checks as required by sub. (11) until the license is terminated. The records shall be signed and dated. The title or qualification of the person signing shall be included.

(m) Records related to decommissioning of the irradiator as required by this chapter, 10 CFR 30.35(g) or the equivalent state regulation.

(23) REPORTS. (a) In addition to the reporting requirements in other parts of this chapter, a licensee shall report to the department all of the following events:

1. Source stuck in an unshielded position.

2. Any fire or explosion in a radiation room.

3. Damage to the source racks.

4. Failure of the cable or drive mechanism used to move the source racks.

5. Inoperability of the access control system.

6. Detection of radiation source by the product exit monitor.

7. Detection of radioactive contamination attributable to licensed radioactive material.

8. Structural damage to the pool liner or walls.

9. Water loss or leakage from the source storage pool, greater than the irradiator pool design parameters submitted by the licensee or applicant.

10. Pool water conductivity exceeding 100 microsiemens per centimeter.

(b) For any event in par. (a), a licensee shall provide a telephone report within 24 hours that meets the requirements of s. HFS 157.32 (2) and a written report within 30 days that meets the requirements of s. HFS 157.32 (3).

Subchapter VIII - X-ray Device Requirements

HFS 157.74 Administrative requirements. (1) GENERAL. The registrant shall be responsible for directing the operation of the x-ray systems under their administrative control. The registrant or the registrant's agent shall ensure the requirements of this section are met. An x-ray system shall meet the provisions of this subchapter to be operated for diagnostic or screening purposes. All images, hard copy or electronic, shall be interpreted by a licensed practitioner for the patient record.

(2) RADIATION SAFETY REQUIREMENTS. ~~(a) Any person operating a radiation machine for medical diagnosis or screening, except bone density devices, shall have or be one of the following:~~

~~1. Certified or be eligible for certification in radiography by the American registry of radiologic technologists.~~

~~2. A licensed practitioner.~~

~~3. Completed training that meets the requirements of Appendix L if the person is performing radiography limited to the chest or extremities, except bone density devices.~~

~~4. Licensed or certified by another state with requirements comparable to those of the American registry of radiologic technologists.~~

~~Note: The ARRT may be contacted at: The American Registry of Radiologic Technologists, 1255 Northland Drive, St. Paul, MN 55120-1155 or http://www.arrt.org.~~

~~5. Operators of bone density devices shall be specifically trained in the use of the device, including safe operation and emergency procedures.~~

~~(b) The names and training of all personnel currently operating a radiation machine shall be kept on file at the facility. Training information on former operators shall be retained for a period of at least 3 years beyond the last date they were authorized to operate a radiation machine at that facility.~~

(a) Each individual who operates x-ray equipment shall be instructed in the safe operating procedures for each specific device and be competent in the safe use of the equipment as determined by the registrant.

~~(c)~~ (b) A chart shall be provided next to the control panel of a diagnostic x-ray system that specifies, for all examinations performed with that system, all of the following information:

1. Patient's body part to be examined and anatomical size, body part thickness or, for pediatrics, age versus technique factors to be utilized.

2. Type and size of the film or film-screen combination to be used.

3. Type and focal distance of the grid to be used, if any.

4. Except for dental intra-oral radiography, source to image receptor distance to be used.

5. Type and location of placement of patient shielding to be used.

Note: This chart may be electronic in the form of pre-programmed controls.

~~(d)~~ (c) The registrant of a facility shall create and make available to x-ray operators written safety procedures, including patient holding procedures and any restrictions of the operating technique required for the safe operation of the particular x-ray system. The operator shall be able to demonstrate familiarity with these procedures.

~~(e)~~ (d) Only the staff, ancillary personnel or other persons required for the medical procedure or training may be in the room during the radiographic exposure. Other than the patient, the following applies to all persons in the room:

1. All persons shall be positioned such that no part of the body will be struck by the useful beam unless protected by not less than 0.5 millimeter lead equivalent material. If the hands must be in the beam and unprotected, a ring badge on the hand in the beam shall be worn unless contraindicated by the clinical procedure.

2. All persons, including any patients who cannot be removed from the room, shall be protected from the direct scatter radiation by whole body protective barriers of not less than 0.25 millimeter lead equivalent material or shall be so positioned that all parts of the person's body are at least 2 meters from all of the following:

a. The tube head.

b. The direct beam.

c. The nearest part of the examined patient's body being struck by the useful beam.

~~(f)~~ (e) Gonad shielding of not less than 0.5 millimeter lead equivalent material shall be used for human patients who have not passed the reproductive age during radiographic procedures in which the gonads are in the useful beam, except for cases in which the shielding would interfere with the diagnostic procedure or for computed radiographic examinations.

~~(g)~~ (f) Persons ~~shall~~ may not be exposed to the useful beam except for healing arts purposes and unless such exposure has been authorized by a licensed practitioner of the healing arts. Deliberate exposure for any of the following purposes is prohibited:

1. Exposure of a person for training, demonstration or other non-healing arts purpose.

2. Exposure of a person for healing arts screening, except as authorized by the department.

Note: The procedure for requesting permission to conduct screening x-ray examination is in Appendix M.

~~(h)~~(g) When a patient or film must be provided with additional support during a radiation exposure, all of the following applies:

1. The human holder shall be instructed in personal radiation safety and protected as required by subd. 2. Written safety procedures are required.

2. In those cases where the patient must hold the film, any portion of the body other than the area of clinical interest struck by the useful beam shall be protected by not less than 0.5 millimeter lead equivalent material.

3. Each facility shall have leaded aprons and gloves available in sufficient numbers to provide protection to all personnel who are involved with x-ray operations and who are otherwise not shielded.

4. Leaded aprons and gloves shall be inspected at least every 3 years for defects and replaced if defective. If visual inspection reveals possible defects, radiographic inspections shall be performed.

~~(i)~~(h) Procedures and auxiliary equipment designed to minimize patient and personnel exposure commensurate with the needed diagnostic information shall be utilized, as follows:

1. The speed of the screen and film combinations used shall be of a speed consistent with the diagnostic objective of the examinations. Film cassettes without intensifying screens may not be used for any routine diagnostic radiological imaging, with the exception of veterinary radiography and standard film packets for intra-oral use in dental radiography.

2. The radiation exposure to the patient shall be the minimum exposure required to produce images of good diagnostic quality.

~~3. Portable or mobile x-ray equipment shall be used only for examinations where it is impractical to transfer the patient to a stationary x-ray installation.~~

43. An x-ray system may not be utilized in a procedure where the source to patient distance is less than 30 centimeters, except for a veterinary system, bone density unit or a unit granted an exemption by the US food and drug administration.

~~5~~4. If grids are used between the patient and the image receptor to decrease scatter to the film and improve contrast, the grid shall meet all of the following requirements:

a. Be positioned with tube side facing the in right direction, and grid centered to the central ray.

b. Be of the proper focal distance for the SIDs being used. Grids shall be of the proper ratio to adequately reduce scatter for the procedure being performed.

c. Antiscatter grids or an appropriate air gap technique to reduce scatter to the image receptor shall be used for all x-ray examinations of the human torso utilizing stationary x-ray equipment for patients 12 years of age or older.

~~(j)~~ **(i)** All persons associated with the operation of an x-ray system are subject to the requirements of s. HFS 157.22 (1), (5), (7) and (8).

~~(k)~~ **(j)** A person proposing to conduct a healing arts screening program may not initiate a program without the department's prior approval. When requesting approval, the person shall submit the information outlined in Appendix M. If any information submitted to the department becomes invalid or outdated, the department shall be immediately notified.

~~(L)~~ **(k)** All facilities performing mammography shall meet the requirements of 21 CFR 900, US food and drug administration, Mammography Quality Standards Act.

(3) X-RAY FILM PROCESSING EQUIPMENT AND PROCESSING PROCEDURES. (a) Each installation using a radiographic x-ray system for human diagnosis or screening and using analog image receptors shall have available suitable equipment for handling and processing radiographic film according to the film and chemistry manufacturer's instructions.

(b) Quality control and maintenance procedures shall be performed on a regular schedule according to the device manufacturer's recommendations.

(c) X-ray film processing control tests shall be performed on days when human patient films are being processed and prior to the processing of the first films of the day, except dental ~~facilities~~ and podiatry **facilities**.

(d) X-ray film processors in ~~chiropractic,~~ dental and podiatry facilities shall be tested at least once a week.

(4) OTHER REQUIREMENTS. (a) Pass boxes, if provided, shall be constructed to exclude light from the darkroom when cassettes are placed in or removed from the boxes and shall incorporate adequate shielding from stray radiation to prevent exposure of undeveloped film.

(b) The darkroom shall be light tight with proper safelights so that any film type in use exposed in a cassette to x-radiation sufficient to produce an optical density from one to 2 when processed may not suffer an increase in density greater than 0.1, or 0.05 for mammography, when exposed in the darkroom for 2 minutes with all safelights on. If used, daylight film handling boxes shall preclude fogging of the film. Darkrooms typically used by more than one person shall be provided a method to prevent accidental entry while undeveloped films are being handled or processed.

(c) Film shall be stored according to the manufacturer's requirements and shall be protected from exposure to stray radiation. Film in open packages shall be stored in a light tight container.

(d) Film cassettes and intensifying screens shall be inspected periodically and shall be cleaned and replaced as necessary and consistent with the manufacturer's instructions to best assure radiographs of good diagnostic quality.

(e) Outdated x-ray film may not be used for diagnostic radiographs.

(f) Film developing solutions shall be prepared using instructions given by the manufacturer and maintained in strength by replenishment or renewal so that full development is accomplished within the time specified by the manufacturer.

HFS 157.75 General requirements for all diagnostic x-ray systems. Diagnostic x-ray systems shall meet all the following requirements:

(1) WARNING LABEL. The control panel containing the main power switch shall bear the following warning statement, legible and accessible to view: "WARNING: This x-ray unit may be dangerous to patient and operator unless safe exposure factors and operating instructions are observed."

(2) BATTERY CHARGE INDICATOR. On battery-powered x-ray generators, visual means shall be provided on the control panel to indicate whether the battery is in a state of charge adequate for proper operation.

(3) LEAKAGE RADIATION FROM THE DIAGNOSTIC SOURCE ASSEMBLY. The leakage radiation from the diagnostic source assembly measured at a distance of one meter in any direction from the source may not exceed one mGy (115 milliroentgens) in one hour when an x-ray tube is operated at its leakage technique factors. Compliance shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than 20 centimeters. **Leakage technique factors may be any of the following:**

(a) For diagnostic source assemblies intended for capacitor energy storage equipment, the maximum-rated peak tube potential and the maximum-rated number of exposures in an hour for operation at the maximum-rated peak tube potential with the quantity of charge per exposure being 10 millicoulombs, which is 10 mAs, or the minimum obtainable from the unit, whichever is larger.

(b) For diagnostic source assemblies intended for field emission equipment rated for pulsed operation, the maximum-rated peak tube potential and the maximum-rated number of x-ray pulses in an hour for operation at the maximum-rated peak tube potential.

(c) For all other diagnostic source assemblies, the maximum-rated peak tube potential and the maximum-rated continuous tube current for the maximum-rated peak tube potential.

(4) RADIATION FROM COMPONENTS OTHER THAN THE DIAGNOSTIC SOURCE ASSEMBLY. The radiation emitted by a component other than the diagnostic source assembly may not exceed 20μGy (2.15 milliroentgens) in one hour at 5 centimeters from any accessible surface of the component when it is operated in an assembled x-ray system under any conditions for which it was designed. Compliance shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than 20 centimeters.

(5) BEAM QUALITY. (a) The half-value layer of the useful beam for a given x-ray tube potential may not be less than the values shown in Table HFS 157.75. If it is necessary to

determine the half-value layer at an x-ray tube potential that is not listed in Table HFS 157.75, linear interpolation or extrapolation may be made.

TABLE HFS 157.75

HALF-VALUE LAYER REQUIREMENTS

Design Operating Range	Measured Potential (kVp)	Half-Value Layer In mm Aluminum	
		Dental Intra-Oral	All Other Diagnostic X-Ray Systems
Below 51	30	N/A	0.3
	40	N/A	0.4
	50	1.5	0.5
51 to 70	51	1.5	1.2
	60	1.5	1.3
	70	1.5	1.5
Above 70	71	2.1	2.1
	80	2.3	2.3
	90	2.5	2.5
	100	2.7	2.7
	110	3.0	3.0
	120	3.2	3.2
	130	3.5	3.5
	140	3.8	3.8
	150	4.1	4.1

(b) For x-ray systems using capacitor discharge to provide power to an x-ray tube, half-value layer shall be determined with the system fully charged and a setting of 10 mAs for each exposure.

(c) The required minimal half-value layer of the useful beam shall include the filtration contributed by all materials that are permanently between the source and the patient.

(d) For x-ray systems with variable filtration controls, the system shall prevent an exposure unless the appropriate filtration is in place for the kilovolts peak selected.

(6) MULTIPLE TUBES. When 2 or more radiographic tubes are controlled by one exposure switch, the tube that has been selected shall be clearly indicated prior to initiation of the exposure. The indication shall be both on an x-ray control panel and at or near the selected tube housing assembly.

(7) MECHANICAL SUPPORT OF TUBE HEAD. The tube housing assembly supports shall be adjusted such that the tube housing assembly will remain stable during an exposure unless tube-housing movement is a designed function of an x-ray system.

(8) TECHNIQUE INDICATORS. (a) The technique factors to be used during an exposure shall be indicated before the exposure begins. If automatic exposure controls are used, the technique factors, which are set prior to the exposure, shall be indicated.

(b) The requirement in par. (a) may be met by permanent markings on equipment having fixed technique factors. Indication of technique factors shall be visible from the operator's position except in the case of spot films made by the fluoroscopist.

(9) MAINTAINING COMPLIANCE. Diagnostic x-ray systems and their associated components used on humans and certified under the federal x-ray equipment performance standard, 21 CFR 1020, shall be maintained in compliance with applicable requirements of that standard.

(10) LOCKS. All position locking, holding and centering devices on x-ray system components and systems shall function as intended.

HFS 157.76 Fluoroscopic x-ray systems. All fluoroscopic x-ray systems shall be image intensified and, with the exception of therapy simulators, meet all the following requirements:

(1) LIMITATION OF USEFUL BEAM. (a) The fluoroscopic imaging assembly shall be provided with a primary protective barrier that intercepts the entire cross section of the useful beam at any SID.

(b) An x-ray tube used for fluoroscopy ~~shall~~ **may** not produce x-rays unless the barrier is in position to intercept the entire useful beam.

(c) For fluoroscopic systems with or without a spot film device, neither the length nor the width of the x-ray field in the plane of the image receptor shall exceed that of the visible area of the image receptor by more than 3 percent of the SID. The sum of the excess length and the excess width shall be no greater than 4 percent of the SID.

(d) For uncertified fluoroscopic systems with a spot film device, the x-ray beam with the shutters fully opened during fluoroscopy or spot filming shall be no larger than the largest spot film size for which the device is designed. Measurements shall be made at the minimum SID available but at no less than 20 centimeters table top to the film plane distance.

(e) Means shall be provided to permit further limitation of the field. Beam-limiting devices manufactured after May 22, 1979, and incorporated in equipment with a variable SID or a visible area of greater than 300 square centimeters shall be provided with means for stepless adjustment of the x-ray field.

(f) All equipment with a fixed SID and a visible area of 300 square centimeters or less shall be provided with either stepless adjustment of the x-ray field or with means to further limit the x-ray field size at the plane of the image receptor to 125 square centimeters or less.

(g) If provided, stepless adjustment shall, at the greatest SID, provide continuous field sizes from the maximum attainable to a field size of 5 centimeters by 5 centimeters or less.

(h) For equipment manufactured after February 25, 1978, when the angle between the image receptor and beam axis is variable, means shall be provided to indicate when the axis of the x-ray beam is perpendicular to the plane of the image receptor.

(i) For non-circular x-ray fields used with circular image receptors, the error in alignment shall be determined along the length and width dimensions of the x-ray field which pass through the center of the visible area of the image receptor.

(j) Means shall be provided between the source and the patient for adjustment of the x-ray field size in the plane of the film to the size of that portion of the film that has been selected on the spot film selector. The adjustment shall be automatically accomplished except when the x-ray field size in the plane of the film is smaller than that of the selected portion of the film. For spot film devices manufactured after June 21, 1979, if the x-ray field size is less than the size of the selected portion of the film, the means for adjustment of the field size shall be only at the operator's option.

(k) Neither the length nor the width of the x-ray field in the plane of the image receptor shall differ from the corresponding dimensions of the selected portion of the image receptor by more than 3 percent of the SID when adjusted for full coverage of the selected portion of the image receptor. The sum, without regard to sign, of the length and width differences may not exceed 4 percent of the SID.

(L) It shall be possible to adjust the x-ray field size in the plane of the film to a size smaller than the selected portion of the film. The minimum field size at the greatest SID shall be equal to or less than 5 centimeters by 5 centimeters.

(m) The center of the x-ray field in the plane of the film shall be aligned with the center of the selected portion of the film to within 2 percent of the SID.

(n) On spot-film devices manufactured after February 25, 1978, if the angle between the plane of the image receptor and beam axis is variable, means shall be provided to indicate when the axis of the x-ray beam is perpendicular to the plane of the image receptor, and compliance shall be determined with the beam axis indicated to be perpendicular to the plane of the image receptor.

(o) If a method exists to override any of the automatic x-ray field size adjustments, that method shall meet all of the following requirements:

1. Designed for use only in the event of system failure.

2. Incorporates a signal visible at the fluoroscopist's position, which will indicate whenever the automatic field size adjustment is overridden.

3. Clearly and durably labeled as follows:

FOR X-RAY FIELD
LIMITATION SYSTEM FAILURE

(2) ACTIVATION OF THE FLUOROSCOPIC TUBE. A device that requires continuous pressure by the fluoroscopist for the entire time of any exposure shall control x-ray production in the fluoroscopic mode. When recording serial fluoroscopic images, the fluoroscopist shall be able

to terminate the x-ray exposure at any time. A method of permitting completion of any single exposure of the series in process may be utilized.

(3) AIR KERMA RATE LIMITS AND ENTRANCE AIR KERMA ALLOWABLE LIMITS. Fluoroscopic equipment may not be operable at any tube potential and current that will result in an air kerma rate in excess of 10 cGy/minute (11.5 R/min) at the point where the center of the useful beam enters the patient except under either of the following conditions:

(a) During the recording of images from an x-ray image intensifier tube using photographic film or a video camera when an x-ray source is operated in pulse mode.

(b) When an optional high-level control is activated, the equipment may not be operable at any combination of tube potential and current that will result in an air kerma rate in excess of 20 cGy/minute (23 R/min) at the point where the center of the useful beam enters the patient. Special means of activation of the high-level controls shall be required. The high-level control shall only be operable when the operator provides continuous manual activation. A continuous signal audible to the fluoroscopist shall indicate that the high-level control is being employed.

(4) AIR KERMA MEASUREMENTS. (a) Annual measurements of both typical and maximum air kerma shall be made by a medical physicist or a person approved by a medical physicist.

Note: Materials should be placed in the useful beam to protect the imaging system when conducting these periodic measurements. Air kerma measurements do not include backscatter radiation.

~~(a)~~ (b) Measurements shall be made annually or after any maintenance of the system that may affect the air kerma.

~~(b)~~ (c) Conditions of periodic measurement of typical entrance air kerma rate are as follows:

1. The kVp, mA or other selectable parameters shall be adjusted to those settings typical of clinical use on a patient with a 23-centimeter thick abdominal measurement.

2. An x-ray system that incorporates automatic exposure rate control shall have sufficient attenuating material placed in the useful beam to produce a milliamperage or kilovoltage to simulate a patient with a 23 centimeter abdominal measurement.

~~3.~~ (d) Conditions of periodic measurement of maximum entrance air kerma rate are as follows:

~~a~~ 1. The kVp, mA or other selectable parameters shall be adjusted to those settings that give the maximum entrance air kerma rate.

~~b~~ 2. An x-ray system or systems that incorporate automatic exposure rate control shall have sufficient attenuating material placed in the useful beam to produce the maximum entrance air kerma rate of the system.

~~4.~~ (e) Compliance shall be determined as follows:

~~a~~ 1. If the source is below the x-ray table, the exposure rate shall be measured one centimeter above the tabletop or cradle attachment that allows the proper positioning of the patient in relation to an x-ray tube.

~~b~~ 2. If the source is above an x-ray table, the exposure rate shall be measured at 30 centimeters above the tabletop with the end of the beam-limiting device or spacer positioned as closely as possible to the point of measurement.

~~c~~ 3. For a C-arm type of fluoroscope, the exposure rate shall be measured 30 centimeters from the input surface of the fluoroscopic imaging assembly with the source positioned at any available SID, provided that the end of the beam-limiting device or spacer is no closer than 30 centimeters from the input surface of the fluoroscopic imaging assembly.

~~d~~ 4. For a lateral type fluoroscope, the exposure rate shall be measured at a point 15 centimeters from the centerline of the x-ray table and in the direction of the x-ray source with the end of the beam-limiting device or spacer positioned as closely as possible to the point of measurement. If the tabletop is movable, it shall be positioned as closely as possible to the lateral x-ray source with the end of the beam-limiting device or spacer no closer than 15 centimeters to the centerline of the x-ray table.

~~e~~ 5. The entrance air kerma rate shall be measured in a manner that excludes scatter contributions from any attenuating material placed into the useful beam or from the image receptor.

~~f~~ 6. Fluoroscopic units used for therapy simulation are exempt from subd. pars. d. and e.

(5) BARRIER TRANSMITTED RADIATION RATE LIMITS. (a) The exposure rate due to transmission through the primary protective barrier with the attenuation block in the useful beam, combined with radiation from the image intensifier, if provided, may not exceed 20 uGy (2.15 milliroentgens) per hour at 10 centimeters from any accessible surface of the fluoroscopic imaging assembly beyond the plane of the image receptor for each 1.0 cGy (one roentgen) per minute of entrance air kerma rate.

(b) Measurement of barrier transmission rates shall meet all the following criteria:

1. The exposure rate due to transmission through the primary protective barrier combined with radiation from the image intensifier shall be determined by measurements averaged over an area of 100 square centimeters with no linear dimension greater than 20 centimeters.

2. If the source is below the tabletop, the measurement shall be made with the input surface of the fluoroscopic imaging assembly positioned 30 centimeters above the tabletop.

3. If the source is above the tabletop and the SID is variable, the measurement shall be made with the end of the beam-limiting device or spacer as close to the tabletop as it may be placed, provided that it may not be closer than 30 centimeters.

4. Movable grids and compression devices shall be removed from the useful beam during the measurement.

(6) INDICATION OF POTENTIAL AND CURRENT. During fluoroscopy and cinefluorography, the kV and the mA shall be continuously indicated.

(7) SOURCE-TO-SKIN DISTANCE. The ~~SSD~~ **source-to-skin distance** may not be less than one of the following:

(a) Thirty-eight centimeters on stationary fluoroscopic systems manufactured on or after August 1, 1974.

(b) Thirty-five and one-half centimeters on stationary fluoroscopic systems manufactured prior to August 1, 1974.

(c) Thirty centimeters on all mobile fluoroscopes, **except as provided in par. (d)**.

(d) Twenty centimeters for all mobile fluoroscopes when used for specific surgical applications.

(8) FLUOROSCOPIC TIMER. (a) A method shall be available to preset the cumulative on-time of the fluoroscopic x-ray tube. The maximum cumulative time of the timing device may not exceed 5 minutes without resetting.

(b) A signal audible to the fluoroscopist shall indicate the completion of any preset cumulative on-time. The signal shall continue to sound while x-rays are produced until the timing device is reset. As an alternative to the requirements of this subsection, radiation therapy simulators may be provided with a means to indicate the total cumulative exposure time during which x-rays were produced, and which is capable of being reset between x-ray examinations.

(9) CONTROL OF SCATTERED RADIATION. (a) Fluoroscopic table designs when combined with procedures utilized may not expose any unprotected part of any staff or ancillary individual's body to unattenuated scattered radiation originating from under the table. The attenuation required shall be not less than 0.25-millimeter lead equivalent.

(b) No portion of any staff or ancillary person's body, except the extremities, may be exposed to the unattenuated scattered radiation emanating from above the tabletop unless either of the following conditions are met:

1. The person is at least 2 meters from the nearest part to the patient's body being struck by the useful beam or from the image receptor.

2. The radiation has passed through not less than 0.25 millimeter lead equivalent material including drapes, panels or self-supporting curtains, in addition to any lead equivalency provided by the protective apron.

(c) The department may grant exemptions to lead drapes where a sterile field will not permit the use of the normal protective barriers only if the use of pre-fitted sterilized covers for the barriers is impractical.

Note: See Appendix N for a list of fluoroscopic procedures where an exemption ~~will be~~ **is** automatically granted.

(10) SPOT FILM EXPOSURE REPRODUCIBILITY. Fluoroscopic systems equipped with analog spot film mode shall meet the exposure reproducibility requirements when operating in the spot film mode.

(11) RADIATION THERAPY SIMULATION SYSTEMS. Radiation therapy simulation systems are exempt from all the following:

(a) Subsection (3).

(b) Subsections (1) and (5) provided that no individual other than the patient is in an x-ray room during periods of time when the system is producing x-rays.

(c) Subsection (8) if the systems are provided with a means of indicating the cumulative time that an individual patient has been exposed to x-rays. Procedures shall require that the timer be reset between examinations.

(12) EQUIPMENT OPERATIONS. (a) The registrant shall allow the operation of x-ray fluoroscopy systems only under the direct supervision of a medical licensed practitioner.

(b) All imaging formed by the fluoroscopic x-ray systems shall be viewed, directly or indirectly, and interpreted by a licensed medical practitioner.

(c) Fluoroscopy systems shall not be used as a positioning tool for general purpose radiographic examinations which would not normally involve fluoroscopy.

HFS 157.77 ~~Radiographic systems other than fluoroscopic, dental intraoral or computed tomography x-ray systems~~ General purpose radiographic systems. (1) BEAM LIMITATION~~, EXCEPT MAMMOGRAPHIC SYSTEMS~~. (a) *Collimation.* The useful beam shall be limited to the area of clinical interest. This requirement is met if a positive beam-limiting device meeting manufacturer's specifications has been properly used or if evidence of collimation is shown on at least 3 sides or 3 corners of the film. Mammography systems are exempt from the collimation requirement.

(b) *General purpose stationary and mobile x-ray systems.* General purpose stationary and mobile x-ray systems, including veterinary systems other than portable, shall meet both of the following requirements:

1. Only x-ray systems provided with means for independent stepless adjustment of at least 2 dimensions of the x-ray field may be used.

2. A method shall be provided for visually defining the perimeter of the x-ray field. The total misalignment of the edges of the visually defined field with the respective edges of the x-ray field along either the length or width of the visually defined field may not exceed 2 percent of the distance from the source to the center of the visually defined field when the surface upon which it appears is perpendicular to the axis of the x-ray beam.

(c) *Stationary general purpose x-ray systems.* Stationary general purpose x-ray systems, both certified and non-certified, shall meet all the following requirements:

1. A method shall be provided to indicate when the axis of the x-ray beam is perpendicular to the plane of the image receptor, to align the center of the x-ray field with respect to the center of the image receptor to within 2 percent of the SID and to indicate the SID to within 2 percent.

2. The beam-limiting device shall indicate numerically the field size in the plane of the image receptor to which it is adjusted.

3. Field size dimensions and SIDs shall be specified in inches or centimeters and shall ensure that aperture adjustments result in x-ray field dimensions in the plane of the image receptor that correspond to those indicated by the beam-limiting device to within 2 percent of the SID when the beam axis is indicated to be perpendicular to the plane of the image receptor.

(d) *X-ray systems designed for one image receptor size.* Radiographic equipment designed for only one image receptor size at a fixed SID shall be provided with means to limit the field at the plane of the image receptor to dimensions no greater than those of the image receptor, and to align the center of the x-ray field with the center of the image receptor to within 2 percent of the SID, or shall be provided with means to both size and align the x-ray field such that the x-ray field at the plane of the image receptor does not extend beyond any edge of the image receptor.

(e) *Miscellaneous and veterinary x-ray systems.* X-ray systems other than those described in pars. (a) to (c), veterinary systems installed prior to the effective date of this subchapter [revisor to insert effective date] and all portable veterinary x-ray systems shall meet all of the following requirements:

1. Means shall be provided to limit the x-ray field in the plane of the image receptor so that such field does not exceed each dimension of the image receptor by more than 2 percent of the SID when the axis of the x-ray beam is perpendicular to the plane of the image receptor.

2. Means shall be provided to align the center of the x-ray field with the center of the image receptor to within 2 percent of the SID, or means shall be provided to both size and align the x-ray field such that the x-ray field at the plane of the image receptor does not extend beyond any edge of the image receptor. Compliance shall be determined with the axis of the x-ray beam perpendicular to the plane of the image receptor.

3. The requirements in subds. 1. and 2. may be met with a collimator system that meets the requirements for a general purpose x-ray system or, when alignment means are also provided, may be met with either of the following:

a. An assortment of removable, fixed-aperture, beam-limiting devices sufficient to meet the requirement for each combination of image receptor size and SID for which the unit is designed with each such device having clear and permanent markings to indicate the image receptor size and SID for which it is designed.

b. A beam-limiting device with multiple fixed apertures sufficient to meet the requirement for each combination of image receptor size and SID for which the unit is designed. Permanent, clearly legible markings shall indicate the image receptor size and SID that each aperture is designed for and shall indicate which aperture is in position for use.

(2) RADIATION EXPOSURE CONTROL. (a) *Exposure initiation.* Means shall be provided to initiate the radiation exposure by a deliberate action on the part of the operator, such as the depression of a switch. Radiation exposure ~~shall~~ **may** not be initiated without such an action. In addition, ~~it shall not be possible to initiate an exposure~~ **exposure may not be initiated** when the timer is set to a "zero" or "off" position if either position is provided.

(b) *Exposure indication.* Means shall be provided for visual indication observable at or from the operator's protected position whenever x-rays are produced. In addition, a signal audible to the operator shall indicate that the exposure has terminated.

(c) *Exposure termination.* Means shall be provided to terminate the exposure at a preset time interval, preset product of current and time, a preset number of pulses or a preset radiation exposure to the image receptor. Except for dental panoramic systems, termination of an exposure shall cause automatic resetting of the timer to its initial setting or to "zero."

(d) *Manual exposure control.* An x-ray control shall be incorporated into each x-ray system so that the operator may terminate an exposure at any time except for any one of the following:

1. Exposure of 0.5 second or less.

2. During serial radiography when means shall be provided to permit completion of any single exposure of the series in process.

(e) *Automatic exposure controls.* When an automatic exposure control is provided, it shall meet all the following requirements:

1. Indication shall be made on the control panel when this mode of operation is selected.

2. If the x-ray tube potential is equal to or greater than 50 kVp, the minimum exposure time for field emission equipment rated for pulsed operation shall be equal to or less than a time interval equivalent to 2 pulses.

3. The minimum exposure time for all equipment other than field emission equipment shall be equal to or less than one-sixtieth ~~(1/60)~~ second or a time interval required to deliver 5 mAs, whichever is greater.

4. Either the product of peak x-ray tube potential, current, and exposure time shall be limited to not more than 60 kWs per exposure, or the product of x-ray tube current and exposure time shall be limited to not more than 600 mAs per exposure except that, when the x-ray tube potential is less than 50 kVp, the product of x-ray tube current and exposure time shall be limited to not more than 2000 mAs per exposure.

5. A visible signal shall indicate when an exposure has been terminated and manual resetting shall be required before further automatically timed exposures ~~can~~ **may** be made.

(f) *Exposure duration linearity.* For systems having independent selection of exposure time settings, the average ratios of exposure to the indicated timer setting, in units of .001mGy/s (mR/s), obtained at any 2 clinically used timer settings may not differ by more than 0.10 times their sum as expressed as:

$$(X_1 - X_2) \leq 0.1\ (X_1 + X_2)$$

where X_1 and X_2 are the average .001 mGy/s (mR/s).

(g) *Exposure control location.* The x-ray exposure control shall be placed so that the operator may view the patient while making any exposure and at least 3 feet from the end of the protective barrier.

(h) *Operator protection, except veterinary systems.* X-ray systems, excluding veterinary systems, shall meet all the following requirements to protect the operator during system use, as applicable:

1. Stationary x-ray systems shall be required to have the x-ray control permanently mounted in a protected area so that the operator is required to remain in that protected area during the entire exposure.

2. Mobile and portable x-ray systems used continuously for greater than one week in the same location shall meet the requirements of stationary systems.

3. Mobile and portable x-ray systems used for less than one week at the same location shall be provided with either a protective barrier at least 2 meters (6.5 feet) high for operator protection during exposures or a means to allow the operator to be at least 2 meters (6.5 feet) from the tube housing assembly during the exposure.

(i) *Operator protection for veterinary systems.* All stationary, mobile or portable x-ray systems used for veterinary work shall be provided with either a 2 meter (6.5 feet) high protective barrier for operator protection during exposures or a means to allow the operator to be at least 2 meters (6.5 feet) from the tube housing assembly during exposures. Persons restraining the animal during radiography shall be protected with at least 0.5mm lead aprons and full coverage gloves or full coverage mittens containing not less than 0.5mm lead equivalent material. The exposure control may be foot operated.

(3) SOURCE-TO-SKIN DISTANCE. All mobile or portable radiographic systems shall be provided with means to limit the source-to-skin distance to equal to or greater than 30 centimeters, except for veterinary systems.

(4) AIR KERMA REPRODUCIBILITY. When all technique factors are held constant, including control panel selections associated with automatic exposure control systems, the coefficient of variation of air kerma for both manual and automatic exposure control systems may not exceed 0.05. This requirement applies to clinically used techniques.

(5) RADIATION FROM CAPACITOR ENERGY STORAGE EQUIPMENT IN STANDBY STATUS. Radiation emitted from the x-ray tube when the system is fully charged and the exposure switch or timer is not activated may not exceed a rate of 0.2 cGy (2 milliroentgens) per hour at 5 centimeters from any accessible surface of the diagnostic source assembly with the beam-limiting device fully open.

(6) ACCURACY. Deviation of measured technique factors from indicated values of kVp and exposure time may not exceed the limits specified for that system by its manufacturer. In the absence of manufacturer's specifications, the deviation may not exceed 10 percent of the indicated value for kVp and 10 percent ~~for time~~ **of the time limit**.

(7) mA/mAs LINEARITY. X-ray equipment that is operated on a power supply as specified by the manufacturer for any fixed x-ray tube potential within the range of 40 percent to 100 percent of the maximum rated shall meet all the following requirements:

(a) *Equipment having independent selection of x-ray tube current (mA).* The average ratios ~~(X_i)~~ of exposure to the indicated milliampere-seconds product ~~(.001 mGy/mAs (or mR/mAs))~~ obtained at any 2 consecutive tube current settings may not differ by more than 0.10 times their sum:

$$X_1 - X_2 \leq 0.10\,(X_1 + X_2)$$

where X_1 and X_2 are the average values obtained at any of 2 consecutive tube current settings or at 2 settings differing by no more than a factor of 2 where the tube current selection is continuous.

(b) *Equipment having a combined x-ray tube current-exposure time product selector, but not a separate tube current selector.* The average ratios ~~(X_i)~~ of exposure to the indicated

milliampere-seconds product, in units of .001 mGy/mAs (~~or~~ mR/mAs), obtained at any 2 consecutive mAs selector settings may not differ by more than 0.10 times their sum:

$$X_1 - X_2 \leq 0.10 (X_1 + X_2)$$

where X_1 and X_2 are the average values obtained at any 2 consecutive mAs selector settings, or at 2 settings differing by no more than a factor of 2 where the mAs selector provides continuous selection.

(c) *Measuring compliance.* Determination of compliance shall be based on 10 exposures taken within a time period of one hour at each of the 2 settings. These 2 settings may include any 2 focal spot sizes except where one is equal to or less than 0.45 millimeters and the other is greater than 0.45 millimeters. For purposes of this requirement, focal spot size is the nominal focal spot size specified by an x-ray tube manufacturer.

(8) ADDITIONAL REQUIREMENTS APPLICABLE TO CERTIFIED SYSTEMS ONLY. A diagnostic x-ray system incorporating one or more certified components shall meet all of the following additional requirements that relate to that certified component or components:

(a) *Beam limitation for stationary and mobile general purpose x-ray systems.* Stationary and mobile general purpose x-ray systems shall meet all the following beam limitation requirements:

1. There shall be provided a means of stepless adjustment of the size of the x-ray field. The minimum field size at a SID of 100 centimeters shall be equal to or less than 5 centimeters by 5 centimeters.

2. When a light localizer type of collimator is used to define the x-ray field, it shall provide an average illumination of not less than 160 lux or 15 footcandles at 100 centimeters or at the maximum SID, whichever is less. The average illumination shall be based upon measurements made in the approximate center of each quadrant of the light field. Radiation therapy simulation systems manufactured on and after May 27, 1980, are exempt from this requirement.

3. The edge of the light field at 100 centimeters or at the maximum SID, whichever is less, shall have a contrast ratio, corrected for ambient lighting, of not less than 4 in the case of beam-limiting devices designed for use on stationary equipment, and a contrast ratio of not less than 3 in the case of beam-limiting devices designed for use on mobile equipment. The contrast ratio is defined as I_1/I_2 where I_1 is the illumination 3 millimeters from the edge of the light field toward the center of the field; and I_2 is the illumination 3 millimeters from the edge of the light field away from the center of the field. Compliance shall be determined with a measuring instrument aperture of one millimeter in diameter.

(b) *Beam limitation and alignment on stationary general purpose x-ray systems equipped with PBL.* If PBL is being used, the x-ray system shall meet all of the following requirements:

1. PBL shall prevent the production of x-rays when either one of the following occurs:

a. The length or width of the x-ray field in the plane of the image receptor differs, except as permitted by manual override, from the corresponding image receptor dimensions by more than 3 percent of the SID.

b. The sum of the length and width differences, without regard to positive or negative mathematical sign, exceeds 4 percent of the SID.

2. Compliance for exposure lock-out shall be determined when the equipment indicates that the beam axis is perpendicular to the plane of the image receptor. Compliance shall be determined no more than 5 seconds after insertion of the image receptor.

3. The PBL system shall be capable of operation, at the discretion of the operator, such that the size of the field may be made smaller than the size of the image receptor through adjustment of the field size. The minimum field size at a SID of 100 centimeters shall be equal to or less than 5 centimeters by 5 centimeters.

4. The PBL system shall be designed such that a change in image receptor ~~must~~ causes the automatic return to PBL.

(c) *Beam limitation for portable x-ray systems.* Beam limitation for portable x-ray systems shall meet the beam limitation requirements for manual collimators.

(9) TUBE STANDS FOR PORTABLE X-RAY SYSTEMS. A tube stand or other mechanical support shall be used for portable x-ray systems so that the x-ray tube housing assembly need not be hand-held during exposures.

HFS 157.78 Intraoral dental radiographic systems. (1) GENERAL. In addition to the provisions of ss. HFS 157.74 and 157.75, the requirements in this section apply to x-ray equipment and associated facilities used for dental radiography. Requirements for extraoral dental radiographic systems are contained in s. HFS 157.77.

~~(1)~~(2) SOURCE-TO-SKIN DISTANCE ~~(SSD)~~. X-ray systems designed for use with an intraoral image receptor shall be provided with means to limit ~~SSD~~ **source-to-skin distance** to not less than either one of the following:

(a) 20 centimeters (8 inches) if operable above 50 kVp. Beam-limiting devices shall be lead lined.

(b) 10 centimeters (4 inches) if operable at 50 kVp only. Beam-limiting devices shall be lead lined.

~~(2)~~(3) BEAM LIMITATION. Radiographic systems designed for use with an intraoral image receptor shall be provided with means to limit the x-ray beam such that the beam at the minimum SSD shall be contained in a circle having a diameter of no more than 7 centimeters.

~~(3)~~(4) RADIATION EXPOSURE CONTROL. Intraoral radiographic systems shall meet all of the following exposure control requirements:

(a) *Exposure initiation.* Means shall be provided to initiate the radiation exposure by a deliberate action on the part of the operator, such as the depression of a switch. Radiation exposure may not be initiated without such an action. An exposure may not be made when the timer is set to a "zero" or "off" position if either position is provided.

(b) *Exposure indication.* Means shall be provided for visual **exposure** indication observable at or from the operator's protected position whenever x-rays are produced. In addition, a signal audible to the operator shall indicate that the exposure has terminated.

(c) *Exposure termination.* Means shall be provided to terminate the exposure at a preset time interval, preset product of current and time, a preset number of pulses or a preset radiation exposure to the image receptor. Termination of an exposure shall cause automatic resetting of the timer to its initial setting or to "zero" except for panoramic systems that may pause during the exposure cycle.

(d) *Exposure control location and operator protection.* An x-ray system shall meet all the following requirements, as applicable, to ensure operator protection during use of the system:

1. A stationary x-ray system shall have an x-ray exposure control that may be moved to a protected area so that the operator is required to remain in that protected area during the entire exposure. The exposure cord shall be of sufficient length to allow the operator to be at least 2 meters (6.5 feet) from the x-ray tube head and not in the direction the tube is pointed. The operator shall be able to determine when the exposure has completed either by audible tone or by visible signal.

2. A mobile or portable x-ray system that is used for greater than one week in the same location, ~~i.e.,~~ **which is** a room or suite, shall meet the requirements of stationary dental equipment.

3. A mobile or portable x-ray system that is used for less than one week in the same location shall be provided with either a protective barrier at least 2 meters (6.5 feet) high for operator protection or means to allow the operator to be at least 2 meters (6.5 feet) from the tube housing assembly while making exposures.

~~(4)~~**(5)** REPRODUCIBILITY. When the equipment is operated on an adequate power supply as specified by the manufacturer, the estimated coefficient of variation of air kerma may be no greater than 0.05 for any specific combination of selected technique factors.

~~(5)~~**(6)** mA/mAs LINEARITY. X-ray equipment that is operated on a power supply as specified by the manufacturer for any fixed x-ray tube potential within the range of 40 percent to 100 percent of the maximum rated shall meet all of the following requirements:

(a) *Equipment having independent selection of x-ray tube current ~~(mA)~~.* The average ratios ~~(X_i)~~ of air kerma to the indicated milliampere-seconds product, in units of .001 mGy/mAs (mR/mAs), obtained at any 2 consecutive tube current settings may not differ by more than 0.10 times their sum:

$$X_1 - X_2 \leq 0.10\,(X_1 + X_2)$$

where X_1 and X_2 are the average values obtained at each of 2 consecutive tube current settings, or at 2 settings differing by no more than a factor of 2 where the tube current selection is continuous.

(b) *Equipment having a combined x-ray tube current-exposure time product selector but not a separate tube current ~~(mA)~~ selector.* The average ratios ~~(X_i)~~ of air kerma to the indicated milliampere-seconds product, in units of .001 mGy/mAs (mR/mAs), obtained at any 2 consecutive mAs selector settings may not differ by more than 0.10 times their sum:

$$X_1 - X_2' \leq 0.10\,(X_1 + X_2)$$

where X_1 and X_2 are the average values obtained at any 2 consecutive mAs selector settings, or at 2 settings differing by no more than a factor of 2 where the mAs selector provides continuous selection.

(c) *Measuring compliance.* Determination of compliance shall be based on 10 exposures taken within a time period of one hour at each of the 2 settings. The 2 settings may include any 2 focal spot sizes except where one is equal to or less than 0.45 millimeters and the other is greater than 0.45 millimeters. For purposes of this requirement, focal spot size is the nominal focal spot size specified by an x-ray tube manufacturer.

~~(6)~~(7) ACCURACY. Deviation of technique factors from indicated values for kVp and exposure time, if time is independently selectable, may not exceed the limits specified for that system by its manufacturer. In the absence of manufacturer's specifications the deviation may not exceed 10 percent of the indicated value for kVp and 10 percent for time.

~~(7)~~(8) KVP LIMITATIONS. Dental x-ray machines with a nominal fixed kVp of less than 50 kVp may not be used to make diagnostic dental radiographs of humans.

~~(8)~~(9) ADMINISTRATIVE CONTROLS. (a) Intraoral film holding devices shall be used.

(b) The tube housing and the cone may not be hand-held during an exposure.

(c) The tube shall be stationary during exposure, except for panoramic systems. Any oscillation of the tube head shall cease before exposure is made.

HFS 157.79 Veterinary medicine x-ray systems. (1) GENERAL. The requirements of this section apply to all animal use x-ray systems used in veterinary practice and are in addition to other provisions in subchs. I and III.

(2) EQUIPMENT. (a) The tube housing shall be electrically shock proof and of a diagnostic type. The x-ray tube may not be hand-held during exposures.

(b) A device shall be provided to terminate the exposure after a preset time or exposure.

(c) A deadman type of exposure switch shall be provided with an electrical cord of sufficient length so that the operator may stand out of the useful beam and at least 2 meters (6.5 feet) from the animal during all x-ray exposures. A foot operated exposure switch may be used.

(3) OPERATING PROCEDURES. (a) The operator shall stand at least 2 meters (6.5 feet) from the tube housing and the animal during radiographic exposures. The operator may not stand in the useful beam. Hand-held fluoroscopic screens may not be used. The tube housing may not be held by the operator. No person other than the operator may be in an x-ray room while exposures are being made unless another person's assistance is required.

(b) During any application in which the operator is not located behind a protective barrier, the operator and any other persons in the room during exposures shall wear protective clothing consisting of a protective apron having a lead equivalent of not less than 0.5 millimeter unless measurements indicate otherwise.

(c) Any person holding or supporting an animal or the film during radiation exposure shall wear protective gloves that surround the hand and a protective apron having a lead equivalent of not less than 0.5 millimeter. Devices that only partially shield the hands are prohibited.

(d) Veterinary fluoroscopy systems shall be operated only under the direct supervision of the licensed veterinarian.

(4) ANIMAL SUPPORT. Mechanical restraints shall be used to restrict movement of the animal unless the restraints interfere with the examination of the animal. No persons may be regularly utilized to hold or support animals during radiation exposures. Operating personnel may not perform this service except in cases where no other person is available.

HFS 157.80 Computed tomography x-ray systems. (1) EQUIPMENT REQUIREMENTS. A computed tomography (CT) x-ray system shall meet all of the following requirements, as applicable:

(a) *Termination of exposure.* Means shall be provided to terminate the x-ray exposure automatically by either de-energizing the x-ray source or shuttering the x-ray beam in the event of equipment failure affecting data collection. The termination shall occur within an interval that limits the total scan time to no more than 110 percent of its preset value through the use of either a back-up timer or devices which monitor equipment function. A visible signal shall indicate when the x-ray exposure has been terminated. The operator shall be able to terminate the x-ray exposure at any time during a scan, or series of scans under CT x-ray system control, of greater than one-half second duration.

(b) *Tomographic plane indication and alignment.* A computed tomography x-ray system shall meet all of the following plane indication and alignment requirements, as applicable:

1. A single tomogram system shall allow for visual determination of the tomographic plane or a reference plane offset from the tomographic plane.

2. A multiple tomogram system shall allow for visual determination of the location of a reference plane. ~~The reference plane can be offset from the location of the tomographic planes.~~

Note: The reference plane may be offset from the location of the tomographic planes.

3. If a device using a light source is used to satisfy the requirements in subd. 2., the light source shall provide illumination levels sufficient to permit visual determination of the location of the tomographic plane or reference plane under ambient light conditions of up to 500 lux.

(c) *Beam-on and shutter status indicators and control switches.* The CT x-ray control and gantry shall provide visual indication whenever x-rays are produced and, if applicable, whether the shutter is open or closed. Each emergency button or switch shall be clearly labeled as to its function.

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

(e) *Maximum surface CTDI100 identification.* The angular position where the maximum surface CTDI100 occurs shall be identified to allow for reproducible positioning of a CT dosimetry phantom.

(f) *CT x-ray systems containing a gantry manufactured after September 3, 1985.* A computed tomography x-ray system containing a gantry that was manufactured after September 3, 1985, shall meet all the following requirements:

1. The total error in the indicated location of the tomographic plane or reference plane may not exceed 5 millimeters.

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

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

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

(2) OPERATING PROCEDURES. (a) A CT x-ray system may only be operated **for diagnostic procedures by an American registry of radiologic technologists** ~~by a~~ certified person who has been specifically trained in its operation.

(b) Information shall be available at the control panel regarding the operation and calibration of the system. The information shall include all of the following components:

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

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

3. The distance in millimeters between the tomographic plane and the reference plane if a reference plane is utilized.

4. A current technique chart available at the control panel, which specifies for each routine examination the CT conditions of operation and the number of scans per examination including body part size and correct kV/mA for that body part. **The technique chart shall be used to adjust techniques based on the body part being examined.**

(c) **Calibration and spot check measurements shall be made at a frequency recommended by the manufacturer.** If the calibration or spot check of the CT x-ray system identifies that a system operating parameter has exceeded a tolerance established by the medical physicist, use of the CT x-ray system on patients shall be limited to those uses permitted by established written instructions of the medical physicist.

(d) A facility shall follow the manufacturer's daily start up routines and preventative maintenance schedules for a specific computed tomography x-ray system.

HFS 157.81 Shielding plan review. (1) PLAN REVIEW AND APPROVAL. Prior to construction, the floor plans, shielding specifications and equipment arrangement of all new installations, or modifications of existing installations, utilizing ionizing radiation machines shall be submitted to the department for review and approval.

Note: Plans may be mailed to the department at: Department of Health and Family Services, Radiation Protection Section, P.O. Box 2659, Madison WI 53701-2659 or package delivery to: Department of Health and Family Services, Radiation Protection Section, Room 150, 1 West Wilson St, Madison WI 53702-0007.

(2) EXEMPTIONS. Dental, mammography, and bone density devices are exempt from this section.

(3) PLAN SUBMITTAL REQUIREMENTS. (a) A shielding plan for a facility with two or more x-ray rooms shall include a medical physicist recommendation for shielding.

(b) A shielding plan submitted for department review shall include all of the following:

1. The maximum rated technique factors of each machine.

2. A scale drawing of the room in which a stationary radiation machine system is located with such drawing indicating the use of areas adjacent to the room and an estimation of the extent of occupancy by a person in such areas. In addition, the drawing shall include all of the following:

a. The type and thickness of materials, or lead equivalency, of each protective barrier.

b. The use and occupancy of the areas surrounding an x-ray room, including occupied areas above or below ~~the~~ **an** x-ray room.

c. The construction materials used for the floor and ceiling, if appropriate.

(c). The operator booth described in the shielding plan shall be designed to meet all the following requirements:

1. The view area of the window shall be at least 0.09 m^2 (144 sqaure inches).

2. The window shall be placed so that the edge of the view window is at least 0.45 meters (18 inches) from the end of the barrier. The window shall be placed so that the patient may be observed at all times and each entrance to the room is observed from the operator position. Patient and entrance observation may be accomplished by the use of electronic devices or mirrors.

3. The shielding value of the window shall be equal to the wall in which it is mounted.

4. Booth walls shall be 2.1 meters (7 feet) in height and permanently attached to the floor or walls. The booth shall be at least 1.3 meters (4 feet) from the nearest vertical cassette holder or 0.3 meters (one foot) from the nearest corner of the examining table.

5. When a door or moveable panel is used as an integral part of the booth structure, it shall have a permissive device that prevents an exposure when the door or panel is not closed.

6. Verbal communication with the patient shall be possible at all times during the x-ray procedure.

(4) OPERATIONAL ANALYSIS. The department may require additional modifications to a shielding plan after initial approval of the plan if a subsequent analysis of operating conditions indicates the possibility of a person receiving a dose in excess of the limits prescribed in ss. HFS 157.22 (1) and (5) to (8) and 157. 23 (1) and (2). **An existing x-ray room constructed using 5 mSv (500 mR) as the public exposure limit may continue to operate without modification until the x-ray equipment is replaced or the room is modified.**

HFS 157.82 General administrative requirements for facilities using therapeutic radiation machines for human use. (1) ADMINISTRATIVE CONTROLS. A registrant shall be responsible for directing the operation of the therapeutic radiation machines that have been registered with the department. All persons ~~associated with the operation of~~ **operating** a therapeutic radiation machine shall be instructed in and shall comply with the provisions of the radiation safety requirements of ss. HFS 157.22 (1) and (5) **to (8)** and 157.25 (2). A therapeutic radiation machine that does not meet the provisions of this subchapter but is of a type accepted by the US food and drug administration ~~shall~~ **may** not be used for irradiation of human patients.

(2) TRAINING FOR EXTERNAL BEAM RADIATION THERAPY ~~AUTHORIZED~~ USERS. (a) A registrant for any therapeutic radiation machine, except dermatology units under 150 kV, shall require the authorized user to be a physician who meets any of the following requirements:

1. Certified or board eligible in one or more of the following:

a. Radiology or therapeutic radiology by the American board of radiology.

b. Radiation oncology by the American osteopathic board of radiology.

c. Radiology, with specialization in radiotherapy, as a British "Fellow of the Faculty of Radiology" or "Fellow of the Royal College of Radiology".

d. Therapeutic radiology by the Canadian royal college of physicians and surgeons.

2. Actively practices therapeutic radiology and has completed all of the following:

a. The radiation therapy residency.

b. Two hundred hours of instruction in basic radiation techniques applicable to the use of an external beam radiation therapy unit.

c. Five hundred hours of supervised work experience in therapeutic radiology.

d. A minimum of 3 years of supervised clinical experience or 5 years of post graduate clinical experience in therapeutic radiology.

3. Has equivalent training and submits the training of the prospective ~~authorized~~ user physician for department review on a case-by-case basis.

(b) A dermatologist using x-ray units under 150 kV shall be board certified in dermatology or have 40 hours of instruction and 100 hours of supervised therapeutic work using x-ray units for the treatment of skin diseases.

(3) VISITING ~~AUTHORIZED~~ USERS. A registrant may permit any physician qualified under sub. (2) to act as a visiting ~~authorized~~ user under the term of the registrant's registration for up to 60 days per ~~calendar~~ year under all the following conditions:

(a) The visiting ~~authorized~~ user has the prior written permission of the registrant's management and if the use occurs on behalf of an institution, the institution's radiation safety committee.

(b) The registrant maintains copies of all records documenting the qualifications of the visiting ~~authorized~~ user for 3 years from the date of the last visit.

(4) MEDICAL PHYSICIST SUPPORT. **(a) The services of a medical physicist is required in facilities having one or more therapeutic radiation machines.**

~~(a)~~**(b)** The registrant for any therapeutic radiation machine shall require the medical physicist to have any of the following:

1. Certification by the American board of radiology in one or more of the following:

a. Therapeutic radiological physics.

b. Roentgen-ray and gamma-ray physics.

c. X-ray and radium physics.

d. Radiological physics.

2. Certification by the American board of medical physics in radiation oncology physics.

3. Certification by the Canadian college of medical physics.

4. A master's or doctor's degree in physics, biophysics, radiological physics or health physics and have completed one year of full-time training in therapeutic radiological physics and one year of full-time work experience under the supervision of a medical physicist at a medical institution. **A person qualifying under this subdivision shall work under the supervision of a medical physicist qualified under subd. 1., 2. or 3. A registrant employing a physicist who qualifies under this subdivision shall provide the department with a statement of training and experience, signed by the preceptor medical physicist or provide a letter from another state accepting the person as a therapeutic medical physicist.**

~~(b)~~**(c)** ~~The services of a medical physicist shall be required in facilities having therapeutic radiation machines.~~ The medical physicist shall be responsible for all of the following:

1. Full calibrations and protection surveys.

2. Supervision and review of dosimetry.

3. Beam data acquisition and transfer for computerized dosimetry and supervision of its use.

4. Quality control, including quality control check review.

5. Consultation with the physician user in treatment planning, as needed.

6. Performance of calculations and assessments regarding medical events.

7. Acceptance testing of the machine after any repair or service that may have altered the machine's performance characteristics.

~~(c)~~**(d)** If the medical physicist is not a full-time employee of the registrant, the operating procedures shall also specifically address how the medical physicist is to be contacted for problems or emergencies, as well as the specific actions to be taken until the medical physicist ~~can~~ **may** be contacted.

(5) QUALIFICATION OF OPERATORS. (a) A person who will be operating a therapeutic radiation machine for medical use shall be an American registry of radiologic technologists ~~(ARRT)~~ registered radiation therapy technologist~~, an authorized user or a medical physicist~~ **or a user authorized under sub. (2) or (3)**. A person who is not an ARRT registered radiation therapy technologist shall submit evidence that he or she has satisfactorily completed a radiation therapy technologist training program that complies with the requirements of the joint review committee on education in radiologic technology.

Note: "Essentials and Guidelines of an Accredited Educational Program for the Radiation Therapy Technologist", Joint Review Committee on Education in Radiologic Technology, 1988, establishes the requirements for a therapy technologist training program. The document is available at: http://www.jrcert.org/.

(b) The names and training of all personnel currently ~~operating~~ **authorized to operate** a therapeutic radiation machine shall be kept on file at the facility. Information on former operators shall be retained for a period of at least 3 years beyond the last date they were authorized to operate a therapeutic radiation machine at that facility.

(6) SAFETY PROCEDURES. Written safety procedures and rules shall be developed by a medical physicist and shall be available in the control area of a therapeutic radiation machine, including any restrictions required for the safe operation of the particular therapeutic radiation machine. The operator shall be able to demonstrate familiarity with these rules.

(7) ~~PRESCRIPTION~~ **WRITTEN DIRECTIVE** REQUIRED. Persons ~~shall~~ **may** not be exposed to the useful beam except for medical therapy purposes and unless exposure has been ordered in writing by a ~~licensed practitioner of the healing arts who is specifically identified on the registration~~ **physician user qualified under sub. (2) or (3).** This provision specifically prohibits deliberate exposure of an person for training, demonstration or other non-healing arts purposes.

(8) INFORMATION AND RECORDS. The registrant shall maintain all of the following information in a separate file or package for each therapeutic radiation machine for inspection by the department:

(a) Report of acceptance testing.

(b) Records of all surveys, calibrations and periodic quality control checks of the therapeutic radiation machine, as well as the names of persons who performed those activities.

(c) Records of maintenance or modifications performed on the therapeutic radiation machines, as well as the names of persons who performed these services.

(d) Signature of each person authorizing the return of a therapeutic radiation machine to clinical use after service, repair or upgrade.

(9) RECORD RETENTION. All records required by sub. (8) shall be retained for 3 years or until disposal is authorized by the department. Any required record generated prior to the last department inspection may be microfilmed or otherwise archived as long as a complete legible copy of the record may be retrieved.

HFS 157.83 Administrative policies and procedures for radiation therapy machines. (1) WRITTEN POLICIES. A registrant shall have written policies and procedures to ensure that radiation will be administered as directed by an authorized user. The policies shall meet all of the following specific objectives:

(a) Prior to administration, a written ~~prescription~~ **directive** is prepared for any external beam radiation therapy dose. A written revision to an existing written ~~prescription~~ **directive** may be made provided that the revision is dated and signed by an authorized user prior to administration of the external beam radiation therapy dose or the next external beam radiation therapy fractional dose. If, because of the patient's condition, a delay to provide a written revision to an existing written ~~prescription~~ **directive** would jeopardize the patient's health, an oral revision to an existing written ~~prescription~~ **directive** shall be acceptable provided that the oral revision is documented immediately in the patient's record and a revised written ~~prescription~~ **directive** is signed by an authorized user within 24 hours of the oral revision.

(b) Prior to the administration of each course of radiation treatments, the patient's identity is verified, by more than one method, as the person named in the written ~~prescription~~ **directive**.

(c) External beam radiation therapy final plans of treatment and related calculations are according to the respective written directives.

(d) Each administration is according to the written ~~prescription~~ **directive**.

(e) Any unintended deviation from the written ~~prescription~~ **directive** is identified, documented, evaluated and appropriate action is taken.

(2) DEVELOPMENT OF THE OPERATIONAL PROCEDURES PROGRAM. A therapy device registrant shall do all the following:

(a) Develop an operational procedures program that specifies staff duties and responsibilities, and equipment and procedures. The registrant shall implement the program upon issuance of a certificate of registration by the department.

(b) Develop procedures for and conduct a review of the program including, since the last review, an evaluation of a representative sample of patient administrations and all recordable events to verify compliance with all aspects of the operational procedures program.

(c) Conduct program reviews at intervals not to exceed 12 months.

(d) Evaluate each of the reviews specified in par. (b) to determine the effectiveness of the program and, if required, make modifications to meet the requirements of par. (b).

(e) Maintain records of each review specified in par. (b), including the evaluations and findings of the review, in an auditable form for 3 years.

(3) MEDICAL EVENTS. (a) A registrant shall report any of the following medical events:

1. A dose that differs from the prescribed dose by more than 0.05 Sv (5 rem) effective dose equivalent, 0.5 Sv (50 rem) to an organ or tissue or 0.5 Sv (50 rem) shallow dose equivalent to the skin and any of the following exist:

a. The total dose delivered differs from the prescribed dose by 20 percent or more.

b. The fractionated dose delivered exceeds the prescribed dose, for a single fraction, by 50 percent or more.

2. A dose that exceeds 0.05 Sv (5 rem) effective dose equivalent, 0.5 Sv (50 rem) to an organ or tissue or 0.5 Sv (50 rem) shallow dose equivalent to the skin under any of the following **conditions**:

a. An administration of a dose to the wrong patient or human research subject.

b. An administration of a dose delivered by the wrong mode of treatment.

3. A dose to an organ outside the intended treatment volume that exceeds the expected dose to that organ by 0.5 Sv (50 rem) where the excess dose is greater than 50 percent of the expected dose to that organ.

(b) In response to a medical event, a registrant shall do all of the following:

1. Notify their department head no later than the next calendar day after discovery of the medical event.

2. a. Submit a written report to the department within 15 working days after discovery of the medical event. The written report shall include: the registrant's name; the prescribing physician's name; a brief description of the event; the effect on the patient; what improvements are needed to prevent recurrence; actions taken to prevent recurrence; whether the registrant notified the patient or the patient's responsible relative or guardian and if not, why not; and if the patient was notified, what information was provided to the patient.

Note: Mail the report to the Department at: Department of Health and Family Services, Radiation Protection Section, PO Box 2659, Madison WI 53701-2659.

b. The report in subd. par. a. may not include the patient's name or other information that could lead to identification of the patient.

3. Notify the referring physician and the patient of the medical event no later than 24 hours after the medical event's discovery, unless the referring physician personally informs the registrant either that he or she will inform the patient or that, based on medical judgment, telling the patient would be harmful. The registrant is not required to notify the patient without first consulting the

referring physician. If the referring physician or patient cannot be reached within 24 hours, the registrant shall notify the patient of the medical event as soon as possible. The registrant may not delay any appropriate medical care for the patient, including any necessary remedial care as a result of the medical event, because of any delay in notification.

4. Retain a record of each medical event for 3 years. The record shall contain all of the following:

a. The names of all persons involved.

b. The patient's ~~social security number or identification number if one has been assigned~~ **unique identification number**.

c. A brief description of the event, why it occurred and the effect on the patient.

d. What improvements are needed to prevent recurrence and the actions taken to prevent recurrence.

e. Whether the registrant notified the patient or patient's guardian and if not, why not, and if the patient was notified, what information was provided to the patient.

f. If information was not given to the patient at the direction of the referring physician, the reason why the information was not given to the patient.

5. If the patient was notified, furnish, within 15 working days after discovery of the medical ~~misadministration~~ **event**, a written report to the patient by sending either a copy of the report that was submitted to the department, or a brief description of both the event and the consequences as they may affect the patient, if a statement is included that the report submitted to the department may be obtained from the registrant.

(4) RIGHTS. Aside from the notification requirement, nothing in this section affects any rights or duties of registrants and physicians in relation to each other, patients or the patient's responsible relatives or guardians.

HFS 157.84 Technical requirements for facilities using therapeutic radiation machines. (1) RADIATION PROTECTION SURVEYS. (a) A registrant shall ensure that radiation protection surveys of all new facilities and existing facilities not previously surveyed are performed with an operable, calibrated survey instrument. The radiation protection survey shall be performed by or under the direction of a medical physicist and shall verify that, with the therapeutic radiation machine in a "BEAM-ON" condition, with the largest clinically available treatment field and with a scattering phantom in the useful beam of radiation, all of the following requirements are met:

1. Radiation levels in restricted areas are not likely to cause personnel exposures in excess of the limits specified in s. HFS 157.22 (1) (a).

2. Radiation levels in unrestricted areas do not exceed the limits specified in s. HFS 157.23 (1) (a) and (b).

(b) A radiation protection survey shall be performed prior to any subsequent medical use after making any of the following changes:

1. Any change in the treatment room shielding.

2. Any change in the location of the therapeutic radiation machine within the treatment room.

3. Relocating the therapeutic radiation machine.

4. Using the therapeutic radiation machine in a manner that could result in increased radiation levels in areas outside the external beam radiation therapy treatment room.

(c) The survey record shall indicate all of the following:

1. Instances where the facility, in the opinion of the medical physicist, is in violation of applicable regulations.

2. The date of the measurements.

3. The reason the survey is required.

4. The radiation therapy machine manufacturer's name.

5. The model and serial number of the therapeutic radiation machine.

6. The instruments used to measure radiation levels and their last date of calibration.

7. A floor plan of the areas surrounding the treatment room that were surveyed.

8. The radiation level at several points in each area expressed in microsieverts or millirems per hour.

9. The calculated maximum level of radiation over a period of one week for each restricted and unrestricted area.

10. The signature of the person responsible for conducting the survey.

(d) If the results of radiation protection surveys indicate any radiation levels in excess of the respective limit, the registrant shall lock the control in the "OFF" position and may not use the unit except under one or more of the following conditions:

1. As may be necessary to repair, replace or test the therapeutic radiation machine, the therapeutic radiation machine shielding or the treatment room shielding.

2. Until the registrant has received a specific exemption from the department.

(2) MODIFICATION OF RADIATION THERAPY UNIT OR ROOM BEFORE BEGINNING A TREATMENT PROGRAM. If the survey indicates that a person in an unrestricted area may be exposed to levels of radiation greater than those permitted by s. HFS 157.23 (1) (a) and (b), before beginning the treatment program, the registrant shall do all of the following:

(a) Equip the unit with beam direction interlocks or add additional radiation shielding to ensure compliance with s. HFS 157.23 (1) (a) and (b).

(b) Perform the survey again.

(c) Include in the report the results of the initial survey, a description of the modification made and the results of the second survey.

(d) Submit facility design information to the department prior to installation of a therapeutic radiation machine of higher energy into a room not previously approved for that energy and receive approval from the department prior to actual installation of the therapeutic radiation machine.

(3) DOSIMETRY EQUIPMENT. (a) 1. A registrant shall have a calibrated dosimetry system available for use. The dosimetry system shall be calibrated by a certified calibration facility at least every 24 months and after any servicing that may affect system calibration.

~~1~~2. For beams with energies greater than one MeV, the dosimetry system shall be calibrated for Cobalt-60.

~~2~~3. For beams with energies equal to or less than one ~~MV~~ MeV, the dosimetry system shall be calibrated at an energy or energy range appropriate for the radiation being measured.

(b) A registrant shall have a dosimetry system for quality control check measurements. The system may be compared with another system whose calibration is traceable to the national institute of standards and technology. The comparison shall be performed at least every 24 months and after each servicing that may affect system calibration.

(c) A registrant shall maintain a record of each dosimetry system calibration, intercomparison and comparison for the duration of the registration. For each calibration, intercomparison or comparison, the record shall include all of the following:

1. The date.

2. The model and serial numbers of the instruments that were calibrated, inter-compared or compared.

3. The correction factors that were determined.

4. The names of the persons who performed the calibration, intercomparison or comparison.

5. Evidence that the intercomparison was performed by or under the direct supervision and in the physical presence of a medical physicist.

(4) SURVEY INSTRUMENTS. Except for dermatology offices with systems operating at less than 150 kV, each facility location authorized to use a therapeutic radiation machine shall possess appropriately calibrated portable monitoring equipment. Equipment shall include a portable radiation measurement survey instrument capable of measuring dose rates over the range 10 µSv (one mrem) per hour to 10 mSv (1000 mrem) per hour. The survey instruments shall be operable and calibrated.

(5) SHIELDING AND SAFETY DESIGN REQUIREMENTS. (a) ~~Each therapeutic radiation machine shall be provided with primary or secondary barriers as are necessary to ensure compliance with ss. HFS 157.22 (1) and 157.23 (1)~~ Facility design information for all new installations of a therapeutic radiation machine or installations of a therapeutic radiation machine of

higher energy into a room not previously approved for that energy shall be submitted to the department and approved by the department prior to actual installation of the therapeutic radiation machine.

(b) Observation and communication with the patient shall be possible at all times.

HFS 157.85 Therapeutic radiation machines. (1) LEAKAGE RADIATION. (a) When a therapeutic radiation machine is operated at its maximum dose rate, the leakage air kerma rate may not exceed the value specified at the distance specified for that classification of therapeutic radiation machine.

(b) Leakage radiation from contact therapy systems may not exceed one mGy (103 mR) per hour at 5 centimeters from the surface of the tube housing assembly. Contact therapy tube housing assemblies shall have a removable shield of material, equivalent in attenuation to 0.5 millimeters of lead at 100 kV, which may be positioned over the entire useful beam exit port during periods when the beam is not in use.

(c) Leakage radiation from systems operating at 150 kV or less may not exceed one mGy (103 mR) per hour at one meter from the tube housing.

(d) Leakage radiation from systems operating above 150 kV may not exceed 0.1 percent of the useful beam one meter from the source housing for any of its operating conditions.

(2) PERMANENT BEAM-LIMITING DEVICES. Permanent, non-adjustable collimators used for limiting the useful beam shall provide at least the same degree of attenuation as required for the tube housing assembly.

(3) ADJUSTABLE OR REMOVEABLE BEAM-LIMITING DEVICES. (a) All removable beam-limiting devices or diaphragms may not transmit more than one percent of the useful beam for the most penetrating beam used. This paragraph does not apply to beam shaping blocks or shaping materials.

(b) When adjustable beam-limiting devices are used, the position and shape of the useful beam shall be indicated by a light beam. These devices may transmit not more than 5 percent of the useful beam.

(4) FILTER SYSTEMS. The filter system shall be designed to meet all of the following requirements:

(a) Accidental displacement of filters is not possible at any tube orientation.

(b) If the proper filter is not in place, an interlock system shall prevent irradiation.

(c) The air kerma rate escaping from the filter placement opening slot in the tube head may not exceed 100 mGy (one rad) per hour at one meter under any operating conditions.

(d) Each filter shall be marked as to its material of construction and its thickness.

(e) Each wedge filter that is removable from the system shall be clearly marked with an identification number. For removable wedge filters, the nominal wedge angle shall appear on the wedge or wedge tray. If the wedge or wedge tray is significantly damaged, the wedge transmission factor shall be reestablished.

(f) If the absorbed dose rate information relates exclusively to operation with a field flattening filter or beam scattering foil in place, that foil or filter shall be removable only by the use of tools.

(5) TUBE IMMOBILIZATION. (a) An x-ray tube shall be mounted so that it cannot accidentally turn or slide with respect to the opening in the tube housing through which radiation is emitted.

(b) The tube housing assembly shall be capable of being immobilized.

(6) EMERGENCY SWITCHES. At least one emergency power cutoff switch shall be present. If more than one emergency power cutoff switch is installed and not all switches are tested at once, each switch shall be tested on a rotating basis. Safety quality control checks of the emergency power cutoff switches may be conducted at the end of the treatment day to minimize possible stability problems with the therapeutic radiation machine.

(7) SOURCE MARKING. An x-ray tube housing assembly shall be marked so that it is possible to determine the location of the focal spot to within 5 millimeters and the marking shall be readily accessible for use during calibration procedures.

(8) TIMER. (a) A suitable irradiation control device shall be provided to terminate the irradiation after a preset time interval **or after a preset radiation dose has been delivered**.

~~(a)~~(b) A timer with a display shall be provided at the treatment control panel. The timer shall have a pre-set time selector and an elapsed time or time remaining indicator.

~~(b)~~(c) ~~The~~ A timer shall be a cumulative timer that activates with an indication of "BEAM-ON" and retains its reading after irradiation is interrupted or terminated. After irradiation is terminated and before irradiation may be reinitiated, it shall be necessary to reset the elapsed time indicator.

~~(c)~~(d) ~~The~~ A timer shall terminate irradiation when a pre-selected time has elapsed, if any dose monitoring system present has not previously terminated irradiation.

~~(d)~~(e) ~~The~~ A timer may not permit an exposure if set at zero.

~~(e)~~(f) ~~The~~ A timer ~~shall~~ may not activate until the shutter is opened when irradiation is controlled by a shutter mechanism unless calibration includes a timer end effect correction to compensate for mechanical lag.

~~(f)~~(g) ~~The~~ A timer shall be accurate to within one percent of the selected value or one second, whichever is greater.

(9) CONTROL PANEL INDICATORS. ~~The~~ An x-ray unit shall have all of the following:

(a) An indication at the control panel of whether electrical power is on and if activation of the x-ray tube is possible.

(b) An indication of whether x-rays are being produced.

(c) A means for indicating x-ray tube potential and current.

(d) A means for terminating an exposure at any time.

(e) A locking device that will prevent unauthorized use of the therapeutic radiation machine.

(10) TARGET TO SKIN DISTANCE. There shall be a means of determining the central axis target to skin distance to within 2 millimeters and of reproducing this measurement to within 2 millimeters thereafter.

(11) SHUTTERS. Unless it is possible to bring the x-ray tube output to the prescribed exposure parameters within 5 seconds after the x-ray "ON" switch is energized, the beam shall be attenuated by a shutter having a shielding equivalency not less than that of the tube housing assembly. In addition, after the unit is at operating parameters, the shutter shall be controlled by the operator from the control panel. An indication of shutter position shall appear at the control panel.

(12) LOW FILTRATION MACHINES. Each therapeutic radiation machine equipped with a beryllium or other low filtration window shall be clearly labeled on the tube housing assembly and shall be provided with a permanent warning device on the control panel that is activated when no additional filtration is present, to indicate that the dose rate is very high.

(13) FULL CALIBRATION MEASUREMENTS. (a) Full calibration of a therapeutic radiation machine shall be performed by or under the direct supervision of a medical physicist under all of the following conditions:

1. Before the first medical use following installation or reinstallation of the therapeutic radiation machine.

2. At intervals not exceeding 12 months.

3. Before medical use under all of the following conditions:

a. Whenever quality control check measurements indicate that the radiation output differs by more than 5 percent from the value obtained at the last full calibration and the difference cannot be reconciled.

b. Following any component replacement, major repair or modification of components that could significantly affect the characteristics of the radiation beam.

~~4.~~**(b)** Full calibration of therapeutic radiation machines with multi-energy capabilities is required only for those operational modes or radiation energies that are not within their acceptable range.

~~5.~~**(c)** If the repair, replacement or modification does not affect all energies, full calibration shall be performed on the affected energy that is in most frequent clinical use at the facility. The remaining energies may be validated with quality control check procedures.

~~(b)~~**(d)** Full calibration shall include all measurements recommended for annual calibration by protocols approved by recognized national or international organizations. An acceptable protocol is the "Protocol for clinical reference dosimetry of high-energy photon and electron beams" as stated in AAPM Report No. 67, American Association of Physicists in Medicine, 1999.

Note: Report No. 67 "Protocol for Clinical Reference Dosimetry of High-Energy Photon and Electron Beams," was published in *Medical Physics*, 26 (9), September 1999, pp. 1847-70. The report may also be obtained from: Medical Physics Publishing, 4531 Vernon Blvd., Madison WI 53705-4964 or ordered from their website: www.medicalphysics.org.

~~(c)~~(e) A registrant shall maintain a record of each calibration for the duration of the registration. The record shall include all of the following:

1. The date of the calibration.

2. The manufacturer's name, model and serial number for both the therapeutic radiation machine and the x-ray tube.

3. The model and serial numbers of the instruments used to calibrate the therapeutic radiation machine.

4. The signature of the medical physicist responsible for performing the calibration.

(14) QUALITY CONTROL CHECKS. (a) Quality control checks shall be performed on therapeutic radiation machines.

(b) Quality control checks shall meet all of the following requirements:

1. A registrant shall perform quality control checks using written procedures established by a medical physicist.

2. The quality control check procedures shall specify ~~the frequency at which tests or measurements are to be performed. The quality control check procedures shall specify that the quality control check be performed during calibration. The acceptable tolerance for each parameter measured in the quality control check when compared to the value for that parameter shall be stated.~~**all of the following:**

a. The frequency at which tests or measurements are to be performed.

b. Which quality control checks are to be performed during calibration.

c. The acceptable tolerance for each parameter measured in the quality control check when compared to the value for that parameter.

(c) The cause for a parameter exceeding a tolerance set by the medical physicist shall be investigated and corrected before the system is used for patient irradiation.

(d) Whenever a quality control check indicates a significant change in the operating characteristics of a system, as specified in the medical physicist's quality control check procedures, the system shall be recalibrated.

(e) A registrant shall have the medical physicist review and sign the results of each radiation output quality control check within 10 working days of the date that the check was performed.

(f) A registrant shall ensure that daily safety quality control checks of therapeutic radiation machines are performed.

(g) Safety quality control checks shall **be performed prior to the first treatment of the day to** ensure proper operation of all of the following:

1. Electrical interlocks at each external beam radiation therapy room entrance.

2. The "BEAM-ON" and termination switches.

3. Beam status indicator lights on the access doors, control console and in the radiation therapy room.

4. Viewing systems.

5. If applicable, electrically operated treatment room doors from inside and outside the treatment room.

(h) A registrant shall maintain a record of each quality control check for 3 years. The record shall include all of the following:

1. The date of the quality control check.

2. The manufacturer's name, model and serial number of the therapeutic radiation machine.

3. The manufacturer's name, model number and serial number for the instruments used to measure the radiation output of the therapeutic radiation machine.

4. The signature of the person who performed the periodic quality control check.

(15) QUALITY CONTROL CHECKS FOR ACCELERATORS. (a) Periodic quality control checks shall be performed on all therapeutic radiation machines at intervals ~~not to exceed those specified in "*Comprehensive QA for Radiation Oncology: Report of AAPM Radiation Therapy Committee Task Group 40*," AAPM Report No. 46, American Association of Physicists in Medicine, April, 1994~~ **recommended by the manufacturer or by recognized national or international organizations**.

Note: An acceptable reference is "*Comprehensive QA for Radiation Oncology: Report of AAPM Radiation Therapy Committee Task Group 40*," AAPM Report No. 46, American Association of Physicists in Medicine, April, 1994.

(b) Quality control checks shall include determination of central axis radiation output and a representative sampling of periodic quality control checks ~~contained in "*Comprehensive QA for Radiation Oncology: Report of AAPM Radiation Therapy Committee Task Group 40*," AAPM Report No. 46, American Association of Physicists in Medicine, April, 1994~~ **according to recommendations of national or international organizations**. Representative sampling shall include all referenced periodic quality control checks in an interval not to exceed 14 consecutive calendar months.

Note: An acceptable reference is "*Comprehensive QA for Radiation Oncology: Report of AAPM Radiation Therapy Committee Task Group 40,*" AAPM Report No. 46, American Association of Physicists in Medicine, April, 1994. The publication may be consulted at the Department of Health and Family Services, Radiation Protection Section, 1 West Wilson St, Room 150, Madison

WI 53701. AAPM reports may be obtained from Medical Physics Publishing, 4531 Vernon Blvd., Madison WI 53705-4964 or ordered from their website: www.medicalphysics.org.

~~(c) A registrant shall use a dosimetry system specified in s. HFS 157.84 (3) that has been inter-compared with a calibrated dosimetry system within the previous 12 months.~~

(16) OPERATING PROCEDURES. (a) A therapeutic radiation machine ~~shall~~ **may** not be left unattended unless secured.

(b) When a patient must be held in position for radiation therapy, mechanical supporting or restraining devices **or other means recommended by a physician** shall be used.

(c) ~~The~~ **An** x-ray tube housing assembly ~~shall~~ **may** not be held by a person during operation unless the assembly is designed to require holding and the peak tube potential of the system does not exceed 50 kV. In these cases, the holder shall wear protective gloves and apron of not less than 0.5 millimeters lead equivalency at 100 kV.

(d) A copy of the current operating and emergency procedures shall be maintained at the therapeutic radiation machine control console.

(e) No person other than the patient may be in the treatment room during exposures from therapeutic radiation machines operating above 150 kV. At energies less than or equal to 150 kV, any person, other than the patient, in the treatment room shall be protected by a barrier sufficient to meet the requirements of s. HFS 157.22 (1).

(f) A registrant shall promptly repair any system that is not operating properly.

~~(g) A registrant shall maintain a record of each quality control check for 3 years. The record shall include all of the following:~~

~~1. The date of the quality control check.~~

~~2. The manufacturer's name, model and serial number of the therapeutic radiation machine.~~

~~3. The manufacturer's name, model number and serial number for the instruments used to measure the radiation output of the therapeutic radiation machine.~~

~~4. The signature of the person who performed the periodic quality control check.~~

HFS 157.86 Registration of radiation machine facilities. (1) REGISTRATION FEES. (a) An annual registration fee shall be levied for each site registration under this section, according to the following schedule:

1. For a site having an ionizing radiation installation serving physicians and clinics, osteopaths and clinics, chiropractors or hospitals, the fee shall be $36 for each site and $44 for each x-ray tube.

2. For a podiatric or veterinary site having an ionizing radiation installation, the fee shall be $36 for each site and $44 for each x-ray tube.

3. For a dental site having an ionizing radiation installation, the fee shall be $36 for each site and $30 for each x-ray tube.

4. For an industrial, school, research project or other site having an ionizing radiation installation, the fee shall be $36 for each site and $44 for each x-ray tube.

5. An additional fee of $25, regardless of the number of devices, shall be required for each registration whenever the annual fee for renewal is not paid prior to the expiration of the registration.

6. A change of ownership requires re-registration and fees paid by the new registrant.

7. Any change in registration information shall be submitted to the department within 30 days after the change takes place. No fee is required for recording changes in registration information.

8. Manufacturing, testing or servicing facilities shall be considered as one x-ray tube for registration purposes.

9. Electron microscopes and extremity bone densitometers are exempt from registration fees after the initial registration.

(2) EXEMPTIONS. The following items are exempted from the requirements of this section:

(a) Electronic equipment that produces radiation incidental to its operation for other purposes**, such as x-rays from radio or television transmitter high voltage tubes**. ~~The production, testing or factory servicing of the equipment shall not be exempt. Manufacturing, testing or servicing facilities shall be considered as one x-ray tube for registration purposes. Electron microscopes and extremity bone densitometers are exempt from registration fees after the initial registration.~~

(b) Radiation machines in transit or storage.

(c) Domestic television receivers and computer monitors.

(3) RECIPROCAL RECOGNITION OF OUT-OF-STATE RADIATION MACHINES. (a) Whenever any radiation machine is to be brought into the state, for any temporary use, the person proposing to bring the machine into the state shall give written notice to the department by mail or facsimile at least 48 hours before the machine is to be used in the state. The notice shall include all the following information:

1. The type of radiation machine.

2. The nature, duration and scope of intended use.

3. The exact location or locations where the radiation machine is intended to be used.

4. States in which the machine is registered.

(b) If, for a specific case, the 48-hour notice period would impose an undue hardship on the person, that person may apply to the department for verbal permission to proceed sooner.

Note: The department may be contacted by phone at 608-267-4784 or facsimile at 608- 267-4799.

(c) The person in control shall do all the following:

1. Comply with all applicable rules of the department.

2. Supply the department with other information as the department requests.

3. Not operate within the state on a temporary basis in excess of 30 calendar days per year without obtaining a Wisconsin registration.

Subchapter IX – Cabinet and Analytical X-ray Systems

HFS 157.87 Radiation safety requirements. (1) GENERAL REQUIREMENTS. For certified cabinet x-ray systems including those designed to allow admittance of individuals, all of the following requirements apply:

(a) No registrant may permit any individual to operate a cabinet x-ray system until the individual has received a copy of and instruction in the operating procedures for the system. Records that demonstrate training compliance with this paragraph shall be maintained for department inspection until disposal is authorized by the department.

(b) Tests for proper operation of all interlocks shall be conducted and recorded at intervals not to exceed 12 months. Records of these tests shall be maintained for department inspection until disposal is authorized by the department.

(c) Compliance with dose limit requirements and radiation monitoring requirements of s. HFS 157.23 (1) (a) to (c) and 21 CFR 1020.40 shall be evaluated at intervals not to exceed one year. Records of these evaluations shall be maintained for department inspection for 3 years after the evaluation.

(d) A certified cabinet x-ray system shall be maintained in compliance with 21 CFR 1020.40. No modification may be made to the system without prior department approval.

Note: The title of 21 CFR 1020.40 is Cabinet X-ray Systems (39 Federal Register 12986, April 10, 1974).

(2) RADIATION SAFETY REQUIREMENTS FOR ANALYTICAL X-RAY SYSTEMS. The following safety equipment shall be used with all analytical x-ray systems except as otherwise noted:

(a) *Safety device.* An analytical x-ray system utilizing an open beam configuration shall incorporate a safety device that prevents any portion of an individual's body from entering the primary x-ray beam path or **that** causes the beam to be shut off upon entry into its path. The person in control at the facility may apply to the department for an exemption from the requirement for a safety device. The application shall include all the following information:

1. A description of the various safety devices that have been evaluated by the person in control.

2. The reason each device evaluated in subd. 1. cannot be used.

3. A description of the alternative safety methods available to minimize the possibility of an accidental exposure, including procedures to assure that operators and others in the area will be informed of the absence of safety devices. The department shall approve the alternate safety devices prior to their installation on the system.

(b) *Warning devices.* Open-beam configurations shall be provided with a readily discernible indication of either of the following:

1. ~~X-ray tube status (ON-OFF) located near the radiation source housing~~ **An indication of whether the x-ray tube is on or off**, if the primary beam is controlled in this manner.

Note: The x-ray tube status is located near the radiation source housing.

2. ~~Shutter status (OPEN-CLOSED) located near each port on the radiation source housing~~ **An indication of whether the shutter is open or closed**, if the primary beam is controlled in this manner. Warning devices shall be labeled so that their purpose is easily identified.

Note: The shutter status is located near each port on the radiation source housing.

(c) *Ports.* Unused ports on radiation source housings shall be secured in the closed position in a manner that will prevent casual opening.

(d) *Labeling.* All analytical x-ray equipment shall be labeled with a readily discernible sign or signs bearing the radiation symbol and the words:

1. "CAUTION - HIGH INTENSITY X-RAY BEAM," or words having a similar intent, on an x-ray source housing.

2. "CAUTION RADIATION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED," or words having a similar intent, near any switch that energizes an x-ray tube if the radiation source is an x-ray tube.

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

(f) *Warning lights.* An easily visible warning light labeled with the words "X-RAY ON," or words having a similar intent, shall be located as follows:

1. Near any switch that energizes an x-ray tube and illuminates only when the tube is energized.

2. In the case of a radioactive source, near any switch that opens a housing shutter and illuminates only when the shutter is open.

(g) *Radiation source housing.* An x-ray tube housing shall be so constructed that with all shutters closed the leakage radiation measured at a distance of 5 centimeters from its surface is not be capable of producing an air kerma in excess of 25 uSv (2.5 mrem) in one hour at any specified tube rating.

(h) *Generator cabinet.* An x-ray generator shall be contained within a protective cabinet which limits leakage radiation measured at a distance of 5 centimeters from its surface to no more than 2.5 uSv (2.5 mrem) in one hour.

(3) AREA REQUIREMENTS. (a) *Radiation levels.* The local components of an analytical x-ray system shall be located and arranged and shall include sufficient shielding or access control so no radiation levels exist in any area surrounding the local component group that could result in a dose to any individual in excess of the dose limits in s. HFS 157.23 (1). For systems utilizing x-ray tubes, the permissible radiation levels shall be met at any specified tube rating.

(b) *Surveys.* To demonstrate compliance with par. (a), radiation surveys of an analytical x-ray system shall be performed according to all the following criteria:

1. Upon installation of the equipment.

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

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

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

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

6. Whenever personnel monitoring devices show an increase of 50 percent over the previous monitoring period or the readings are approaching the limits of sub. (2) (g) or (h). Radiation survey measurements are not be required if a person in control demonstrates compliance with par. (a) in some other manner.

(c) *Posting.* Each area or room containing analytical x-ray equipment shall have at least one sign conspicuously posted bearing the radiation symbol and the words "CAUTION – X-RAY EQUIPMENT" or words having a similar intent.

(4) OPERATING REQUIREMENTS. (a) *Procedures.* Operating procedures shall be written and available to all analytical x-ray equipment workers. No individual may operate analytical x-ray equipment in any manner other than that specified in the procedures unless the individual has obtained written approval of the person in control.

(b) *Bypassing.* No individual may intentionally bypass a safety device unless the individual has obtained the approval of the person in control. When a safety device has been bypassed, a readily discernible sign bearing the words "SAFETY DEVICE NOT WORKING" or words having a similar intent shall be placed on the radiation source housing.

(5) PERSONNEL REQUIREMENTS. (a) *Instruction.* No individual may operate or maintain analytical x-ray equipment unless the individual has received instruction in and demonstrated competence in all the following:

1. Identification of radiation hazards associated with use of the equipment.

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

3. Proper operating procedures for the equipment.

4. Symptoms of an acute localized exposure that may cause a radiation burn.

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

(b) *Personnel monitoring.* Finger or wrist dosimetry devices shall be provided to and used by any of the following individuals:

1. An analytical x-ray equipment worker using a system having an open-beam configuration and not equipped with a safety device.

2. Personnel maintaining analytical x-ray equipment if the maintenance procedures require the presence of a primary x-ray beam when any local component in the analytical x-ray system is disassembled or removed. Reported dose values may not be used for the purpose of determining compliance with s. HFS 157.22 unless the dose values are evaluated by a medical physicist.

(6) IMAGING DEVICES. Industrial uses of hand-held imaging intensification devices are exempt from the requirements of this subchapter if the air kerma 18 inches from the source of radiation to any individual does not exceed 25 uSv (2.5 mrem) per hour. A device that exceeds this limit shall meet the requirements of this subchapter and the licensing or registration requirements of subchs. II or VIII.

Subchapter-X-Notices, Instructions and Reports to Workers

HFS 157.88 Posting, notification and reporting requirements. (1) POSTING OF NOTICES TO WORKERS. (a) Except as provided in par. (b), a licensee or registrant shall post current copies of all the following documents in a conspicuous location that is accessible to workers on the way to or from the worker's work station or job location:

1. This subchapter and subch. III.

2. The license, conditions or documents incorporated into the license by reference and license amendments.

3. The operating procedures applicable to activities under the license or registration.

4. Any notice of violation, forfeiture assessment or order issued under s. 254.37 or 254.45, Stats., or this chapter and any response from the licensee or registrant until removal is authorized by the department.

5. The certificate of registration.

6. Emergency procedures that apply to activities conducted under the license or registration.

7. A "Notice to Employees" form that details the types of information that employers must give to their employees and department contact information.

Note: The "Notice to Employees" form may be obtained from the Department by writing: Department of Health and Family Services, Radiation Protection Section, P.O. Box 2659, Madison WI 53701-2659 or from the Department's website www.dhfs.state.wi us/licensing.

(b) If posting of the documents specified in par. (a) 1. to 3. is not physically practical, a licensee or registrant may post a summary of the documents that states where the full documents may be examined. The documents specified in par. (a) 4. to 7. shall be posted in their entirety.

(c) A document posted under par. (a) 4. shall be posted within 2 working days after receipt of the document from the department. A licensee's or registrant's response, if any, shall be posted within 2 working days after submitting the document to the department. The documents shall remain posted for a minimum of 5 working days or until the violation has been corrected, whichever is later.

(d) Documents, notices and forms posted under par. (a) shall be replaced within 10 days if defaced or altered.

(2) INSTRUCTIONS TO WORKERS. (a) All individuals who in the course of employment are likely to receive an occupational dose in excess of one mSv (100 millirem) in a year shall be given all of the following information annually:

1. The proper storage, transfer and use of sources of radiation in the licensee's or registrant's workplace.

2. Health risks to the individual and potential offspring associated with exposure to radiation and radioactive material, precautions and procedures the individual should use in the workplace to protect themselves and minimize exposure to radiation and radioactive material, and the purposes and functions of protective devices.

3. A worker's responsibility to report promptly to the licensee or registrant any condition which may constitute, lead to or cause a violation of ss. 254.31 to 254.45, Stats., this chapter or a condition of the license.

4. How to respond in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material.

5. Radiation exposure reports provided to workers under sub. (3).

(b) The extent of the instructions provided under par. (a) shall be commensurate with potential radiological health protection problems present in the workplace and shall take into consideration assigned activities during normal and abnormal situations involving exposure to radiation or radioactive material that can be reasonably be expected to occur during the life of the licensee's or registrant's activities.

(c) Records of instructions to workers required by this subsection shall be maintained by the licensee or registrant until reviewed by the department or for 5 years.

(3) NOTIFICATIONS AND REPORTS TO INDIVIDUALS. (a) *Radiation exposure reports.* Every 12 months, a licensee or registrant shall provide a written report of radiation exposure to

each employee who is required to be monitored for radiation exposure under s. HFS 157.25 (2). The report shall include all of the following:

1. Name of the licensee or registrant, the name of the individual and the individual's identification number.

2. Results of any measurements, analyses and calculations of radioactive material deposited or retained in the body of the individual being monitored.

3. Any order issued under this chapter.

4. Any condition of the license or registration as shown in records maintained by the licensee or registrant under s. HFS 157.31 (7) **that relates to radiation exposure of employees**.

5. Each calendar quarter in which the worker's activities involved exposure to sources of radiation and the dates and locations of work. If a report under this paragraph is being provided to employees under par. (b) or (c), the report shall include the calendar quarter within which the employee terminates employment or requests a report under this subsection.

6. The radiation exposure report for each year the worker was required to be monitored under s. HFS 157.25 (2).

7. The statement: "This report is furnished to you under the provisions of Wisconsin Administrative Code, Chapter HFS 157, Radiation Protection. You should retain this report for future reference."

(b) *Reports to employees upon termination.* A licensee or registrant shall provide the report required under par. (a) to each employee within 30 days of the employee's termination.

(c) *Reports to employees upon request.* A licensee or registrant shall provide an employee with the report required under par. (a) within 30 days of receiving a written request from the employee, or within 30 days after the dose of the individual has been determined by the licensee or registrant, whichever is later.

(d) *Reports to the department.* A licensee or registrant required to provide a report under s. HFS 157.32 (2) to (4) shall, on the same day, provide a copy of the report to the subject of the report.

(e) *Exposure request at time of termination.* At the request of a licensee's or registrant's employee or of a worker employed by another person but working in a licensee's or registrant's facility, a licensee or registrant shall, upon a worker's termination, provide to the worker, or to the worker's designee, a written report of the radiation dose received by that worker from operations of the licensee or registrant during the current calendar quarter or fraction thereof. If the most recent individual monitoring results are not available at that time, a licensee or registrant shall provide a written estimate of the dose, clearly indicating that it is an estimate.

(f) *Documentation required to be maintained.* Documentation that a report was provided as required under this subsection shall be maintained by the licensee or registrant for 3 years after generation of the documentation.

Subchapter XI - Inspection by the Department

HFS 157.89 Inspection requirements. (1) ACCESS BY DEPARTMENT INSPECTORS. The department may inspect a licensee's or registrant materials, machines, devices, activities, facilities, premises and records under this chapter at any reasonable time.

(2) PRESENCE OF REPRESENTATIVES OF LICENSEE OR REGISTRANT DURING INSPECTION. (a) A licensee, registrant or designee may accompany department inspectors during an inspection.

(b) If, at the time of inspection, an individual has been authorized by the workers to represent them during department inspections, a licensee or registrant shall notify the inspectors of that authorization and shall permit the workers' representative to accompany the inspectors during the inspection of physical working conditions.

(c) Each workers' representative shall be routinely engaged in work under control of the licensee or registrant and shall have received instructions as specified in s. HFS 157.88 (2).

(d) Different representatives of a licensee or registrant or workers may accompany the department's inspectors during different phases of an inspection if there is no interference with the conduct of the inspection, but only one workers' representative at a time may accompany the inspectors.

(e) With the approval of a licensee or registrant and the workers' representative, an individual who is not routinely engaged in work under control of the licensee or registrant, such as a consultant to the licensee or registrant or to the workers' representative, may accompany department inspectors during the inspection of physical working conditions.

(f) ~~Notwithstanding the other provisions of this subsection,~~ Department inspectors may refuse to permit any individual who deliberately interferes with a fair and orderly inspection to accompany them on the inspection. An individual may accompany an inspector in areas containing information classified by an agency of the U.S. government in the interest of national security only if the individual is authorized to do so by the licensee or registrant. The workers' representative may enter an area containing proprietary information only if the representative has been previously authorized by the licensee or registrant to enter that area.

(3) CONSULTATION WITH WORKERS DURING INSPECTIONS. (a) Department inspectors may consult privately with workers to the extent the inspectors deem necessary for the conduct of an effective and thorough inspection.

(b) Consultation with a worker under par. (a) may be written or oral and concern any past or present condition that the worker believes contributed to, caused or may cause a violation of ~~the Act~~ **ss. 254.31 to 254.45, Stats.**, this chapter or a condition of the license, or any unnecessary exposure of an individual to sources of radiation under the licensee's or registrant's control. Written information received by inspectors under this paragraph shall comply with the requirements of sub. (4).

(4) REQUEST BY WORKERS FOR AN INSPECTION. (a) A worker or workers' representative who believes that a violation of ~~the Act~~ **ss. 254.31 to 254.45, Stats.**, this chapter or a condition of a license exists or has occurred may request an inspection by the department. The request shall be in writing, set forth the reasons for the request and be signed by the worker or workers' representative. The department shall provide a copy of the request to the licensee or registrant at the time of inspection granted under sub. (5). Upon request of the worker giving

notice, the department shall remove from the licensee's or registrant's copy of the request the worker or workers' representative's name and the names of other individuals.

(b) No licensee, registrant, contractor or subcontractor of a licensee or registrant may discharge or in any manner discriminate against any worker or workers' representative because the worker or workers' representative has filed a complaint under this subsection or instituted or caused to be instituted a proceeding under this chapter or has testified or is about to testify in any proceeding under this chapter, or because of the exercise by the worker on behalf of himself or herself or others of any right established under this subchapter.

Note: Requests may be made in writing to: Department of Health and Family Services, Radiation Protection Section, PO Box 2659, Madison WI 53701-2659.

(5) INSPECTION WARRANTED. If after reviewing a request submitted under sub. (4), the department determines it is probable an alleged violation has occurred, the department shall conduct an inspection as soon as is practicable. An inspection under this subsection need not be limited to an allegation set forth in a request under sub. (4).

(6) INSPECTION NOT WARRANTED. (a) If after reviewing a request submitted under sub. (4), the department decides not to conduct an inspection, the department shall notify the worker or workers' representative in writing of that determination.

(b) A worker or workers' representative may request a review of a decision under par. (a) by submitting a written request for review and statement of position to the department. The department shall send by certified mail to the licensee or registrant a copy of the statement of position received by the department under this paragraph.

(c) The licensee or registrant may submit to the department a written response to a statement of position submitted under par. (b). The department shall send by certified mail to the worker or workers' representative a copy of the response received by the department under this paragraph.

(d) Upon the request of the worker or workers' representative or the licensee or registrant, the department may ~~next~~ hold an informal conference in which the worker or the workers' representative and the licensee or registrant may orally present their views on the reason for the initial request for inspection. Disclosure of the identity of the worker or the workers' representative may be made only following receipt of written authorization from the worker or the workers' representative. After considering all written and oral views presented, the department shall affirm, modify or reverse the original determination and furnish the worker or the workers' representative and the licensee or registrant a written notice of the decision and the reason for the decision.

Note: Requests may be made in writing to: Department of Health and Family Services, Radiation Protection Section, PO Box 2659, Madison WI 53701-2659.

Subchapter XII – Enforcement

HFS 157.90 Violation and penalty criteria. (1) SEVERITY LEVELS. (a) Each violation of a condition of a license or registration or a requirement of ss. 254.31 to 254.45, Stats., or this chapter shall be classified as specified in pars. (b) to (f) after considering all of the following:

1. The actual or potential injury to the environment or to occupational or public health.

2. The actual or potential costs of the damage or injury to the environment or to occupational or public health caused by the violation.

3. The potential danger to the environment or to occupational or public health.

4. The willfulness of the violation.

5. The compliance history of the licensee or registrant.

(b) A violation may be classified at severity level one if any of the following exist:

1. Actual damage or injury to occupational or public health or to the environment are caused by the violation.

2. The violation is characterized by any of the following:

a. Willful action.

b. Multiple occurrence between inspections.

c. Contribution to one or more additional violations.

(c) A violation may be classified at severity level 2 if both of the following exist:

1. The violation results in a circumstance that creates a significant potential for injury or costs to occupational or public health or to the environment.

2. Any of the factors listed in par. (b) 2. are present.

(d) A violation may be classified at severity level 3 if any of the following exist:

1. The potential for danger to the environment or occupational or public health is significant.

2. Any of the factors listed in par. (b) 2. b. and c. are present.

(e) A violation may be classified at severity level 4 if both of the following exist:

1. The violation threatens the environment or occupational or public health.

2. The potential for danger to the environment or occupational or public health is probable.

(f) A violation may be classified at severity level 5 if it is unlikely to cause actual costs or injury to the environment or to occupational or public health.

Note: See Appendix R for examples of severity levels one through 5 violations.

(2) ASSESSMENT OF FORFEITURES. (a) The department may assess a direct forfeiture for each violation. If the department assesses a forfeiture, the amount of the forfeiture shall be derived from Tables HFS 157.90A and 157.90B.

(b) A forfeiture assessment ~~shall~~ may not be less than $100 nor more than $100,000 for each violation.

Table HFS 157.90A

BASE FORFEITURES

Type of User	Amount
All licensees or registrants	$5,000
Persons not licensed or registered	$10,000

Table HFS 157.90B

PERCENTAGE OF BASE AMOUNTS BASED ON SEVERITY LEVEL OF VIOLATION

Severity Level	Percent of Amount Listed in Table 157.90A
1	100
2	75
3	50
4	15
5	5

(c) Each day of continued violation constitutes a separate offense.

(d) The department shall send written notice of a forfeiture assessment to the person against whom the forfeiture is assessed. The notice shall specify all of the following:

1. The forfeiture amount.

2. The violation and severity level of the violation on which the forfeiture is based.

3. The statute or rule alleged to have been violated.

4. Notice that the person may contest the department's assessment of a forfeiture by requesting a hearing before the division of hearings and appeals. The notice shall describe the appeal process under s. HFS 157.91 (4).

(e) The department may, at any time, negotiate a settlement related to a violation.

(3) FORFEITURE PAYMENT. (a) A person against whom the department has assessed a forfeiture shall pay the forfeiture to the department within 10 days of the receipt of the notice under sub. (2) (d).

(b) **Except as provided in par. (c),** if a person contests a forfeiture under s. HFS 157.91 (4), and the division of hearings and appeals upholds the forfeiture assessment, the person shall pay the forfeiture within 10 days after receipt of the final decision after exhaustion of administrative review.

(c) If a person petitions for judicial review under ch. 227, Stats., and the court upholds the forfeiture assessment, the person shall pay the forfeiture within 10 days after receipt of the final judicial decision.

Note: Send forfeiture payments to: Department of Health and Family Services, Radiation Protection Section, P.O. Box 2659, Madison, WI 53701-2659. Certified mail may be sent to: Department of Health and Family Services, Radiation Protection Section, 1 West Wilson St., Room 150, Madison, WI 53702-0007.

(d) The department shall remit all forfeitures paid to the state treasurer for deposit in the school fund.

HFS 157.91 Notices, orders, reviews and appeals. (1) NOTICE OF VIOLATION AND ORDER OF ABATEMENT. (a) If the department finds that a source of radiation as constructed, operated or maintained results in a violation of ss. 254.31 to 254.45, Stats., or of this chapter, the department shall notify in writing, the person in control that is causing, allowing or permitting the violation as to the nature of the violation. The notification shall do all of the following:

1. Specify each statute, rule or condition of a license or registration alleged to have been violated and the severity level of each violation.

2. Order, that prior to a specified time, the person in control shall cease and abate causing, allowing or permitting the violation and take such action as may be necessary to have the source of radiation constructed, operated, or maintained in compliance with ch. 254, Stats., or this chapter.

3. Give notice of any forfeiture assessment.

4. Give notice that an order issued under this paragraph is subject to review by the department.

(b) If the department finds that a condition exists that constitutes an immediate threat, the department shall include in a notice of violation and order issued under par. (a), the recitation of the existence of the threat and the findings pertaining to the threat. The department may summarily cause the abatement of the violation.

(c) Upon receipt of a notice of violation and order under this subsection the person in control shall do all of the following:

1. Cease and abate the violation and take action as necessary to comply with ss. 254.31 to 254.45, Stats., or this chapter, before the time specified in the order.

2. Send to the department a written plan of correction for each violation, within 10 days after receipt of the notice of violation and order, that describes the action taken to comply with the order and the date within which the violation was corrected.

(d) The department shall, within a reasonable period after receipt of the plan of correction, inspect the source of radiation to ensure that the violation that is the subject of an order under this subsection is in compliance with ss. 254.31 to 254.45, Stats., and this chapter.

(e) The department may extend the period specified in par. (c) 2., for submission by the person in control of a plan of correction.

Note: A plan of correction should be sent to: Department of Health and Family Services, Radiation Protection Section, P.O. Box 2659, Madison, WI 53701-2659. Certified mail may be sent to: Department of Health and Family Services, Radiation Protection Section, 1 West Wilson St., Room 150, Madison, WI 53702-0007.

(2) PETITION FOR REVIEW. (a) A person to whom an order is issued under sub. (1) may petition the department for review of the order by submitting within 10 days after receipt of the department's order, to the administrator of the division of public health, a written petition for review. A petition for review shall include all of the following:

1. Name and address of the person filing the petition.

2. License number.

3. Reason for requesting the review.

4. Alternative solution.

5. Relief sought.

6. A copy of the notice of violation and order subject to review.
7. Written documentation in support of the petition for review.

Note: A petition for review should be sent to: Department of Health and Family Services, Radiation Protection Section, P.O. Box 2659, Madison, WI 53701-2659. Certified mail may be sent to: Department of Health and Family Services, Radiation Protection Section, 1 West Wilson St, Room 150, Madison, WI 53702-0007.

(b) Failure to petition the department for review as required under par. (a) may result in a denial of the review.

(3) EMERGENCY ORDERS. (a) If the department finds that an emergency exists concerning a matter subject to regulation under ss. 254.31 to 254.45, Stats., or this chapter, that requires immediate action to protect the public health or safety, the department may issue an emergency order without hearing or notice. The order shall recite the existence of the emergency and state such action the department deems necessary to mitigate the emergency.

(b) An emergency order shall be issued within 24 hours of finding the emergency and shall be effective upon issuance. An emergency order shall remain in effect for up to 90 days after issuance, unless revoked or modified by the results of a hearing held under sub. (4). Any person to whom an emergency order is issued shall immediately comply with the order.

(c) A person to whom an emergency order is issued may contest the action by filing with the division of hearings and appeals, within 10 days after receipt of the emergency order, a written request for hearing under sub. (4).

(4) HEARING. (a) Any person against whom the department takes an action under sub. (3) or s. HFS 157.90 (2), may contest the action by sending to the division of hearings and appeals, within 10 days after receipt of the action, a written request for hearing under s. 227.44, Stats. The hearing request shall contain all of the following:

1. Name and address of the person filing the request.

2. The license number.

3. Reason for the hearing request.

4. Relief sought.

5. A copy of any notice issued by the department that is the subject of the action.

(b) Materials mailed to the division of hearings and appeals shall be considered filed with the division on the date of the postmark. Materials submitted by personal service or by inter-departmental mail shall be considered filed on the date the materials are received by the division. Materials transmitted by facsimile shall be considered filed on the date the materials are received by the division as recorded on the division facsimile machine.

Note: The mailing address of the Division of Hearings and Appeals is: 5005 University Avenue, Suite 201, Madison, WI 53705-5400. The facsimile transmission number is 608-267-2744.

(c) On the date a hearing request is sent to the division of hearings and appeals under par. (a), the petitioner shall send a copy of the hearing request to the department.

Note: A copy of the hearing request should be sent to: Department of Health and Family Services, Radiation Protection Section, P.O. Box 2659, Madison, WI 53701-2659. Certified mail may be sent to: Department of Health and Family Services, Radiation Protection Section, 1 West Wilson St, Room 150, Madison, WI 53702-0007.

(d) The division of hearings and appeals shall commence a hearing within 30 days of receipt of a request for hearing and issue a final decision within 15 days after the close of the hearing. Proceedings before the division shall be governed by ch. 227, Stats.

Subchapter XIII – Transportation

HFS 157.92 General regulatory provisions. (1) REQUIREMENT FOR LICENSE. No person may 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 under s. 254.365, Stats., or unless exempt under sub. (2).

(2) EXEMPTIONS. (a) Common and contract carriers, freight forwarders and warehouse workers who are subject to the requirements of 49 CFR 170 to 189 or the U.S. postal service

regulations in the U.S. postal service domestic mail manual (DMM), Section C-023.9.0, and the U.S. postal service are exempt from the requirements of this section 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 U.S. department of transportation or U.S. postal service are subject to sub. (1).

(b) A licensee who delivers to a carrier for transport a package containing radioactive material having a specific activity not greater than 70 becquerel per gram ~~(0.002 μCi/g) shall be~~ **is** exempt from the requirements of this subchapter.

Note: The U.S. postal service domestic mail manual (DMM), Section C-023.9.0, is available at http://pe.usps.gov/.

(c) Any physician licensed by the state of Wisconsin to dispense drugs in the practice of medicine is exempt from sub. (1) with respect to transport by the physician of radioactive material for use in the practice of medicine provided the physician is an authorized user under subch. II of this chapter.

(d) A licensee is exempt from all requirements of this subchapter except sub. (3) (a) and s. HFS 157.94 (2), with respect to shipment or transport any of the following:

1. Packages containing no more than Type A quantities of radioactive material if the package contains no fissile material.

2. A package containing low specific activity ~~(LSA)~~ material in group LSA-1 or surface contaminated objects ~~(SCO)~~ in group SCO-1.

(3) TRANSPORT OF LICENSED MATERIAL. (a) A licensee who transports licensed material outside the site of usage, as specified in the department license, or on public highways, or to a carrier for transport, shall do all the following:

1. Comply with the requirements, appropriate to the mode of transport, of the regulations of the U.S. department of transportation in all the following areas:

a. Packaging – 49 CFR 173: Subparts A and B and I.

b. Marking and labeling - 49 CFR 172: Subpart D, 172.400 to 172.407, 172.436 to 172.440 and Subpart E.

c. Placarding – 49 CFR 172: Subpart F, especially 172.500 to 172.519, 172.556 and Appendices B and C.

d. Accident reporting - 49 CFR 171: 171.15 and 171.16.

e. Shipping papers and emergency information - 49 CFR 172: Subpart C and Subpart G.

f. Hazardous material employee training - 49 CFR 172: Subpart H.

g. Hazardous material shipper/carrier registration - 49 CFR 107: Subpart G.

2. Comply with U.S. department of transportation regulations pertaining to all the following modes of transportation:

a. Rail – 49 CFR 174: Subparts A to D and K.

b. Air - 49 CFR 175.

c. Vessel - 49 CFR 176: Subparts A to F and M.

d. Public Highway - 49 CFR 177 and 49 CFR 390 to 397.

3. Send or otherwise make available any special instructions needed to safely open the package to the consignee under s. HFS 157.29 (6) (e).

(b) If the regulations of the U.S. department of transportation are not applicable to a shipment of licensed material, a licensee shall comply with the requirements of 49 CFR 170 to 189, appropriate to the mode of transport as if the shipment was subject to the regulations. **A request for modification, waiver or exemption from these requirements and any notification referred to in these requirements shall be submitted in writing to the department.**

Note: A request for modification, waiver or exemption shall be submitted to the department at the following address: Department of Health and Family Services, Radiation Protection Section, P.O. Box 2659, Madison, WI 53701-2659. Certified mail may be sent to: Department of Health and Family Services, Radiation Protection Section, 1 West Wilson St, Room 150, Madison, WI 53702-0007. Requests may be sent by facsimile to 608-267-3695.

HFS 157.93 General licenses. (1) COMMON OR CONTRACT CARRIER. A general license is issued to any common or contract carrier not exempt under s. HFS 157.92 (2) 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 under the applicable requirements, appropriate to the mode of transport, of the U.S. department of transportation 49 CFR 170 to 189 relating to loading and storage of packages, placarding of the transporting vehicle and incident reporting. Notification of an incident shall be filed with the department as prescribed in 49 CFR 170 to 189, in addition to notification made to the U.S. department of transportation or other agencies.

(2) PRIVATE CARRIER. A general license is ~~hereby~~ issued to any private carrier to transport radioactive material, provided the transportation is under the applicable requirements, appropriate to the mode of transport, of the U.S. department of transportation insofar as the requirements relate to the loading and storage of packages, placarding of the transporting vehicle and incident reporting. Notification of an incident shall be filed with~~, or made to~~, the department as prescribed in 49 CFR 170 to 189~~, regardless of and~~ in addition to notification made to the U.S. department of transportation or other agencies.

(3) EXEMPTION. A person who transports radioactive material under the general licenses in subs. (1) or (2) is exempt from the requirements of subchs. III and X only for the purposes of transporting radioactive material.

(4) NUCLEAR REGULATORY COMMISSION-APPROVED PACKAGES. (a) A general license is ~~hereby~~ issued to any licensee 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 nuclear regulatory commission.

(b) The general license issued in par. (a) applies only to a licensee who meets all the following criteria:

1. Has a copy of the specific license, certificate of compliance, or other approval by the nuclear regulatory commission of the package and has the drawings and other documents referenced in the approval relating to the use and maintenance of the packaging and to the actions to be taken prior to shipment.

2. Complies with the terms and conditions of the license, certificate, or other approval by the nuclear regulatory commission, as applicable, and the applicable requirements of this subsection.

3. Prior to the licensee's first use of the package, has registered with the nuclear regulatory commission.

4. Has a quality assurance program that complies with s. HFS 157.94 (6).

(c) The general license in par. (a) applies only when the package approval authorizes use of the package under this general license.

(d) For a Type B or fissile material package, the design of which was approved by the nuclear regulatory commission before April 1, 1996, the general license issued in par. (a) is subject to the additional restrictions of sub. (5).

(5) PREVIOUSLY APPROVED PACKAGE. (a) A Type B package previously approved by the nuclear regulatory commission, but not designated as B(U) or B(M) in the identification number of the nuclear regulatory commission certificate of compliance, may be used under the general license of sub. (4) if the packaging meets all the following conditions:

1. Fabrication of the packaging was satisfactorily completed before August 31, 1986, as demonstrated by application of its model number in accordance with nuclear regulatory commission regulations at 10 CFR 71.85(c).

2. A package used for a shipment to a location outside the United States is subject to multilateral approval, as defined in US department of transportation regulations at 49 CFR 173.403.

3. A serial number that uniquely identifies each packaging which conforms to the approved design is assigned to, and legibly and durably marked on, the outside of each packaging.

(b) A Type B(U) package, a Type B(M) package, a low specific activity material package or a fissile material package, previously approved by the nuclear regulatory commission but without the designation "-85" in the identification number of the nuclear regulatory commission certificate of compliance, may be used under the general license of sub. (4) if the packaging meets all the following additional conditions:

1. Fabrication of the package is satisfactorily completed by April 1, 1999, as demonstrated by application of its model number in accordance with nuclear regulatory commission regulations at 10 CFR 71.85(c).

2. A package used for a shipment to a location outside the United States is subject to multilateral approval except approved under special arrangement in accordance with US department of transportation regulations at 49 CFR 173.403.

3. A serial number that uniquely identifies each packaging and which conforms to the approved design is assigned to and legibly and durably marked on the outside of each packaging.

(6) US DEPARTMENT OF TRANSPORTATION SPECIFICATION CONTAINER. (a) A general license is issued to any licensee 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.

(b) The general license issued in par. (a) applies only to a licensee who meets all the following criteria:

1. Has a copy of the specification for the container.

2. Complies with the terms and conditions of the specification and the applicable requirements of this subchapter.

3. Has a quality assurance program that complies with s. HFS 157.94 (6).

(c) The general license issued in par. (a) 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.

(7) USE OF FOREIGN APPROVED PACKAGE. (a) A general license is issued to any licensee to transport, or to deliver to a carrier for transport, licensed material in a package whose design has been approved in a foreign national competent authority certificate and which has been revalidated by the US department of transportation as meeting the applicable requirements of 49 CFR 171.12.

(b) The general license in par. (a) applies only to international shipments.

(c) The general license in par. (a) applies only to a licensee who meet all the following criteria:

1. Has a copy of the applicable certificate, the revalidation, and the drawings and other documents referenced in the certificate relating to the use and maintenance of the packaging and to the actions to be taken prior to shipment.

2. Complies with the terms and conditions of the certificate and revalidation, and with the requirements of this subchapter.

3. ~~The licensee~~ Has a quality assurance program approved by the nuclear regulatory commission.

HFS 157.94 Operating controls and procedures. (1) ROUTINE DETERMINATIONS. Prior to each shipment of licensed material, a licensee shall determine all the following:

(a) The package is proper for the contents to be shipped.

(b) The package is in unimpaired physical condition except for superficial defects such as marks or dents.

(c) Each closure device of the packaging, including any required gasket, is properly installed and secured and free of defects.

(d) Any system for containing liquid is adequately sealed and has adequate space or other specified provision for expansion of the liquid.

(e) Any pressure relief device is operable and set under written procedures established by the carrier or licensee.

(f) The package has been loaded and closed under written procedures established by the carrier or licensee.

(g) For fissile material, any moderator or neutron absorber, if required, is present and in proper condition.

~~(g)~~ **(h)** Any structural part of the package that ~~can~~ **may** be used to lift or tie down a package during transport is rendered inoperable unless it satisfies design requirements specified by the ~~U.S. nuclear regulatory commission~~**NRC**.

~~(h)~~**(i)** The level of removable radioactive contamination on the external surfaces of each package offered for shipment is as low as reasonably achievable and does not exceed the levels specified in 49 CFR 173.443.

~~(i)~~**(j)** External radiation levels around the package and around the vehicle do not exceed the limits specified in 49 CFR 173.441.

(k) Accessible package surface temperatures will not exceed the limits specified in 10 CFR 71.43(g) at any time during transportation.

(2) AIR TRANSPORT OF PLUTONIUM. Notwithstanding the provisions of any general licenses and notwithstanding any exemptions stated directly in this section or included indirectly by citation of the U.S. department of transportation regulations, a licensee may not transport or deliver plutonium in any form by air, or deliver to a carrier for air transport, except under any of the following conditions:

(a) The plutonium is contained in a medical device designed for individual human application.

(b) The plutonium is contained in a material in which the specific activity is not greater than 70 becquerel per gram (0.002 μCi/g) of material and in which the radioactivity is essentially uniformly distributed.

(c) The plutonium is shipped in a single package containing no more than an A_2 quantity of plutonium in any isotope or form and is shipped as provided in s. HFS 157.92 (3).

(d) The plutonium is shipped in a package specifically authorized in a certificate of compliance issued by the nuclear regulatory commission for the shipment of plutonium by air, and the licensee requires, through special arrangement with the carrier, compliance with 49 CFR 175.704.

(3) SHIPMENT RECORDS. A licensee shall maintain for a period of 3 years after shipment a record of each shipment of licensed material not exempt under s. HFS 157.92 (2), showing all of the following:

(a) Identification of the packaging by model number and serial number.

(b) Verification that the packaging, as shipped, had no significant defect.

(c) Volume and identification of coolant.

(d) Type and quantity of licensed material in each package and the total quantity of each shipment.

(e) Date of the shipment.

(f) Name and address of the transferee.

(g) Address to which the shipment was made.

(h) Results of the determinations required by sub. (1) and by the conditions of the package approval.

Note: The approval of packaging and the conditions or limitations of that approval are reserved solely to the NRC.

(4) REPORTS. A licensee shall provide a written report to the department within 30 days of any of the following:

(a) Any instance in which there is significant reduction in the effectiveness of any packaging during use.

(b) Details of any defects with safety significance in the packaging after first use, and the means employed to repair the defects and prevent their recurrence.

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

(5) ADVANCE NOTIFICATION OF TRANSPORT OF NUCLEAR WASTE. (a) Prior to the transport of any nuclear waste meeting the criteria in par. (b) 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 the transport to the governor, or governor's designee, and to the department.

Note: Notification of transport of nuclear waste may be sent to: Division of Emergency Management, 2400 Wright Street, Madison, Wisconsin, 53704. Notification may also be made by: telephone at 608-242-3232; or fax at 608-242-3247. The telephone number of the 24-hour duty officer is 1-800-943-0003.

(b) Advance notification is required under any of the following conditions:

1. The nuclear waste is required to be in Type B packaging for transportation.

2. The nuclear waste is being transported through Wisconsin en route to a disposal facility or to a collection point for transport to a disposal facility.

3. The quantity of licensed material in a single package exceeds any of the following criteria:

a. Three thousand times the A_1 value of the radionuclides as specified in Appendix O, Table VI for special form radioactive material.

b. Three thousand times the A_2 value of the radionuclides as specified in Appendix O, Table VI for normal form radioactive material.

c. One thousand terabecquerel (27,000 Ci).

(c) Each advance notification required by par.(a) shall contain all the following information:

1. The name, address and telephone number of the shipper, carrier and receiver of the shipment.

2. A description of the nuclear waste contained in the shipment as required under 49 CFR 172.202 and 172.203.

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

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

5. The destination of the shipment and the 7-day period during which arrival of the shipment is estimated to occur.

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

(d) The notification required by par. (a) shall be made in writing to the office of the 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 or facsimile shall reach the office of the governor, or governor's designee, and the department 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.

(e) A licensee shall notify the governor, or governor's designee, and the department of any changes to schedule information provided under par. (a). Notification shall be by telephone or facsimile to a designated responsible individual in the office of the governor, or governor's designee, and to the department. A licensee shall retain for 3 years a record of the name of the individual contacted.

(f) A licensee who cancels a nuclear waste shipment for which advance notification has been sent shall send to the governor, or governor's designee, and to the department a cancellation notice identifying the advance notification that is being canceled. A copy of the notice shall be retained by the licensee for 3 years.

(6) QUALITY ASSURANCE REQUIREMENTS. (a) Unless exempted by the department, a licensee shall establish, maintain and execute a quality assurance program to verify that deficiencies, deviations and defective material and equipment relating to the shipment of packages containing radioactive material are promptly identified and corrected.

(b) A licensee shall identify the material and components to be covered by the quality assurance program.

(c) A licensee shall document the quality assurance program by written procedures or instructions and shall carry out the program under those procedures throughout the period during which packaging is used.

(d) Prior to the use of any package for the shipment of radioactive material, a licensee shall obtain approval of its quality assurance program from the department.

(e) A licensee shall maintain written records to demonstrate compliance with the quality assurance program. Records of quality assurance pertaining to the use of a package for shipment of radioactive material shall be retained for a period of 3 years after shipment.

(7) 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 have credible values that will cause the maximum neutron multiplication.

(8) PRELIMINARY DETERMINATIONS. Prior to the first use of any packaging for the shipment of radioactive material a licensee shall do all the following:

(a) Ascertain that there are no defects that could significantly reduce the effectiveness of the packaging.

(b) Where the maximum normal operating pressure will exceed 35 kilopascal (5 lb/in^2) gauge, test the containment system 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.

(c) Determine that the packaging has been fabricated in accordance with the design approved by the nuclear regulatory commission.

(d) Conspicuously and durably mark the packaging with its model number, serial number, gross weight, and a package identification number as assigned by the nuclear regulatory commission.

Subchapter XIV – Radioactivity in Community Water Systems

HFS 157.95 Exemptions. A community water system is exempt from the provisions of this subchapter if all of the following apply:

(1) The community water system consists solely of distribution and storage facilities.

(2) The community water system does not include collection and treatment facilities.

(3) The community water system obtains all water from, but is not owned or operated by, a public water system to which the rules of this subchapter apply.

(4) The community water system does not sell water to any person.

(5) The community water system is not a carrier that conveys passengers in interstate commerce.

HFS 157.96 Requirements. (1) MAXIMUM CONTAMINANT LEVELS. (a) *Alpha activity.* 1. The maximum contaminant level for radium-226 and radium-228 in community water systems is 5 pCi/L.

2. The maximum contaminant level for gross alpha particle activity in community water systems is15 pCi/L, including radium-226, but excluding radon and uranium.

(b) *Beta particle and photon radioactivity from man-made radionuclides in community water systems.* 1. The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water may not produce an annual dose equivalent to the total body or any internal organ greater than 0.04 millisievert (4 millirem).

2. Except for the radionuclides listed in Table HFS 157.96A, the concentration of man-made radionuclides causing 0.04 millisievert (4 millirem) total body or organ dose equivalents shall be calculated on the basis of a 2-liter per day drinking water intake using the 168 hour data listed in "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air or Water for Occupational Exposure", National Council on Radiation Protection and Measurements Report No. 22. If 2 or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any organ may not exceed 0.04 millisievert (4 millirem).

Note: The publication "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air or Water for Occupational Exposure" in the National Council on Radiation Protection and Measurements Report No. 22, is the same document as Handbook 69 published by the National Bureau of Standards and which the Department received permission from the Attorney General and the Revisor of Statutes on March 22, 1982 to incorporate into ch. HSS 157 by reference. The reference is no longer available through the federal government and the National Bureau of Standards no longer exists. However, the document may be consulted at the Department's Radiation Protection Section at 1 W. Wilson St. in Madison, WI or the Revisor of Statutes Bureau or the Secretary of State's Office and may be ordered from: NCRP, 7910 Woodmont Avenue, Suite 800, Bethesda MD, 20814.

TABLE HFS 157.96A

AVERAGE ANNUAL CONCENTRATIONS ASSUMED TO PRODUCE A TOTAL BODY OR ORGAN DOSE OF 4 MILLISIEVERT (4 MILLIREM)/YEAR

Radionuclide	Critical Organ	pCi per liter
Tritium	Total body	20,000
Strontium-90	Bone marrow	8

(2) ANALYTICAL METHODS FOR RADIOACTIVITY IN WATER. (a) *Standard radionuclide.* The following methods used to measure radionuclides and specified in "Prescribed Procedures for Measurement of Radioactivity in Drinking Water" EPA-600/4-80-032 shall be used to determine compliance with sub. (1), except in cases where alternative methods have been approved under sub. (4):

1. Gross Alpha and Beta - Method 900.

2. Gross Radium Alpha – Method 900.1.

3. Radium-226 – Method 903.1.

4. Radioactive Strontium Method 905.

5. Tritium – Method 906.

6. Radioactive Cesium Method 901.

7. Uranium – Method 908 or 908.1.

Note: The publication "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA-600 4-80-32, is on file in the Revisor of Statutes Bureau and the Secretary of State's Office and is available on-line at http://www.epa.gov/safewater/methods/rads.html.

(b) *Other radionuclides.* When the identification and measurement of radionuclides other than those listed in par. (a) is required, the following references shall be used, except in cases where alternative methods have been approved under sub. (4):

1. Procedures for Radiochemical Analysis of Nuclear Reactor Aqueous Solutions, H. L. Krieger and S. Gold, EPA-R4-73-014, May 1973.

2. Section 4.5.4 of the Health and Safety Laboratory Procedure Manual pertaining to testing water, ERDA-HASL 300, 28th Edition.

Note: 1. The Procedures for Radiochemical Analysis of Nuclear Reactor Aqueous Solutions, H. L. Krieger and S. Gold, EPA-R4-73-014, May 1973, is available upon written request to: Department of Health and Family Services, Radiation Protection Section, PO Box 2659, Madison WI 53701-2659.

2. The Health and Safety Laboratory Procedure Manual ERDA-HASL 300, 28th Edition, 1997, is available on-line at www.eml.doe.gov/publications/procman/ or by ordering from: The Environmental Measurements Labatory (EML), 201 Varick St, NY,NY 10014-4811.

(c) *Sensitivity.* 1. For the purpose of monitoring radioactivity concentrations in drinking water, the required sensitivity of the radioanalysis is defined in terms of a detection limit. The detection limit shall be that concentration that may be counted with a precision of plus or minus 100 percent at the 95 percent confidence level, where 1.96 is the standard deviation of the net counting rate of the sample.

~~1~~2. To determine compliance with sub. (1) (a) 1., the detection limit may not exceed one pCi/L. To determine compliance with sub. (1) (a) 2., the detection limit may not exceed 3 pCi/L.

23. To determine compliance with sub. (1) (b), the detection limits may not exceed the concentrations listed in Table HFS 157.96B.

TABLE HFS 157.96B

DETECTION LIMITS FOR MAN-MADE BETA PARTICLE AND PHOTON EMITTERS

Radionuclide	Detection Limit
Tritium	1,000 pCi/L
Strontium-89	10 pCi/L
Strontium-90	2 pCi/L
Iodine-131	1 pCi/L
Cesium-134	10 pCi/L
Gross beta	4 pCi/L
Other radionuclides	1/10 of the applicable limit

(d) *Compliance.* To judge compliance with the maximum contaminant levels listed in sub. (1), averages of data shall be used and shall be rounded to the same number of significant figures as the maximum contaminant level for the substance in question.

(3) MONITORING FREQUENCY IN COMMUNITY WATER SYSTEMS. (a) *Monitoring requirements for gross alpha particle activity, radium-226 and radium-228.* 1. Compliance with sub. (1) (a) shall be based on the analysis of an annual composite of 4 consecutive quarterly samples or the average of the analyses of 4 samples obtained at quarterly intervals.

a. A gross alpha particle activity measurement may be substituted for the required radium-226 and radium-228 analyses provided that the measured gross alpha particle activity does not exceed 5 pCi/L at a confidence level of 95 percent, where 1.96 is the standard deviation of the net counting rate of the sample. In localities where radium-228 may be present in drinking water, the department may require radium-226 or radium-228 analyses or analyses of both when the gross alpha particle activity exceeds 2 pCi/L.

b. When the gross alpha particle activity exceeds 5 pCi/L, the same or an equivalent sample shall be analyzed for radium-228.

2. A supplier of water shall monitor water supplies at least once every 4 years following the procedure required by subd. 1. At the discretion of the department, when the record taken in conformance with subd. 1. establishes that the average annual concentration is less than half the maximum contaminant levels established by sub. (1) (a), analysis of a single sample may be substituted for the quarterly sampling procedure required by subd. 1.

a. When ordered by the department, more frequent monitoring shall be conducted in the vicinity of mining or other operations that may contribute alpha particle radioactivity to either surface or groundwater sources of drinking water.

b. A supplier of water shall monitor in conformance with subd. 1. within one year of the introduction of a new water source for a community water system. More frequent monitoring shall be conducted when ordered by the department if possible contamination or changes in the distribution system or treatment processing occur that may increase the concentration of radioactivity in finished water.

c. A community water system using 2 or more sources having different concentrations of radioactivity shall monitor source water and water from a free-flowing tap when required by the department.

d. Monitoring for compliance with sub. (2) (a) need not include radium-228 except when required by the department, provided that the average annual concentration of radium-228 has been assayed at least once using the quarterly sampling procedure required by subd. 1.

e. A supplier of water shall conduct annual monitoring of any community water system in which the radium-226 concentration exceeds 3 pCi/L, when required by the department.

3. If the average annual maximum contaminant level for gross alpha particle activity or total radium as set forth in sub. (1) (a) is exceeded, the supplier of a community water system shall give notice to the department under sub. (7) and notify the public as required by sub. (8). Monitoring at quarterly intervals shall be continued until the annual average concentration no longer exceeds the maximum contaminant level or until a monitoring schedule as a condition to a variance, exemption or enforcement action is no longer ~~effective~~ **in effect**.

(b) *Monitoring requirements for man-made radioactivity in community water systems.* 1. Community water systems using surface water sources and serving more than 100,000 persons and any other community water systems as are designated by the department shall be monitored for compliance with sub. (1) (b) by analysis of a composite of 4 consecutive quarterly samples or analysis of 4 quarterly samples. Compliance with sub. (1) (b) may be assumed without further analysis if the average annual concentration of gross beta particle activity is less than 50 pCi/L and if the average annual concentrations of tritium and strontium-90 are less than those listed in Table 157.96A, provided that if both radionuclides are present, the sum of their annual dose equivalents to bone marrow does not exceed 4 millirem.

a. If the gross beta particle activity exceeds 50 pCi/L, an analysis of the sample shall be performed to identify the major radioactive constituents present. The appropriate organ and total body doses shall be calculated to determine compliance with sub. (1) (b).

b. A supplier of water shall conduct additional monitoring, as required by the department, to determine the concentration of man-made radioactivity in principal watersheds designated by the department.

c. At the discretion of the department, a supplier of water utilizing only groundwaters may be required to monitor for man-made radioactivity.

2. After the initial analysis required by subd. 1., a supplier of water shall monitor at least every 4 years following the procedure given in subd. 1.

3. The supplier of any community water system designated by the department as utilizing water subject to contamination by effluents from nuclear facilities shall initiate quarterly monitoring for gross beta particle and iodine-131 radioactivity and annual monitoring for strontium-90 and tritium.

a. Quarterly monitoring for gross beta particle activity shall be based on the analysis of monthly samples or the analysis of a composite of 3 monthly samples. If the gross beta particle activity exceeds 50 pCi/L, an analysis of the sample shall be performed to identify the major radioactive constituents present and the appropriate organ and total body doses shall be calculated to determine compliance with sub. (1) (b).

b. For iodine-131, a composite of 5 consecutive daily samples shall be analyzed once each calendar quarter. As required by the department, more frequent monitoring shall be conducted when iodine-131 is identified in the finished water.

c. Annual monitoring for strontium-90 and tritium shall be conducted by means of the analysis of a composite of 4 consecutive quarterly samples or analysis of 4 quarterly samples.

d. Data obtained by the direct monitoring of water supplies in the areas surrounding nuclear facilities may be utilized by the supplier where the department determines such data is applicable to a particular community water system.

4. If the average annual maximum contaminant level for man-made radioactivity specified in sub. (1) (b) is exceeded, the operator of a community water system shall give notice to the department under sub. (7) and to the public as required by sub. (8). Monitoring at monthly intervals shall be continued until the concentration no longer exceeds the maximum contaminant level or until a monitoring schedule as a condition to a variance, exemption or enforcement action becomes effective.

(4) ALTERNATIVE ANALYTICAL TECHNIQUES. With the written permission of the department concurred in by the administrator of the U.S. environmental protection agency, an alternative analytical technique may be employed. An alternative technique shall be acceptable only if it is substantially equivalent to the prescribed test in sub. (1) in both precision and accuracy as it relates to the determination of compliance with any maximum contaminant level. The use of the alternative analytical technique ~~shall~~ **may** not decrease the frequency of monitoring required by sub. (3).

(5) APPROVED LABORATORIES. For the purpose of determining compliance with this section, samples shall be considered only if the samples have been analyzed by a laboratory approved by the department.

(6) MONITORING OF CONSECUTIVE PUBLIC WATER SYSTEMS. When a public water system supplies water to one or more other public water systems, the department of natural resources may modify the monitoring requirements imposed by this section if the interconnection of the systems justifies treating them as a single system for monitoring purposes. Any modified monitoring shall be conducted under a schedule specified by the department of natural resources and concurred in by the administrator of the U.S. environmental protection agency.

(7) REPORTING REQUIREMENTS. (a) *Routine reports.* Except where a shorter reporting period is specified in this section, a supplier of water shall report the results of a test, measurement or analysis required to be made under this section to the department within 40 days following the test, measurement or analysis.

(b) *Noncompliance reporting.* A supplier of water shall report to the department within 48 hours noncompliance with any ~~drinking water rule set forth in~~ **provision of** this section, including failure to comply with monitoring requirements.

(c) *Exceptions.* A supplier of water is not required to report analytical results to the department when the department performs the analysis.

(8) PUBLIC NOTIFICATION. Public notification shall be provided as prescribed in s. NR 809.81.

(9) RECORD MAINTENANCE. A supplier of water shall maintain records as prescribed in s. NR 809.82.

(10) VARIANCE AND EXEMPTIONS. Variances and exemptions may be granted from any requirement regarding a maximum contaminant level for radioactivity as prescribed in ss. NR 809.90 and 809.91.

Subchapter XV – Registration of Radioactive Materials

HFS 157.97 Exemptions. (1) If a person utilizes ~~naturally-occurring-or-accelerator-produced-radioactive-materials~~ **NARM** in quantities less than those listed in Appendix B, the person ~~shall be~~ **is** exempt from the registration requirement and associated fee listed in this subchapter.

(2) If a person is licensed by the department to possess, receive, use, transfer, own, or acquire naturally-occurring or accelerator-produced radioactive materials, the person is exempt from the registration requirement and associated fee listed in this subchapter.

(3) If a person is licensed by an agreement state or licensing state on or after July 1, 2003, to possess, receive, use, transfer, own or acquire naturally-occurring or accelerator-produced radioactive materials, the person is exempt from the registration requirement and associated fee listed in this subchapter.

(4) If a person is exempt by the department for reasons other than those specified in subs. (1) to (3), the person ~~shall be~~ **is** exempt from the registration requirement and associated fee listed in this subchapter.

HFS 157.98 Registration. (1) DEFINITION. In this section, "the year of registration" means the period from January 1 to December 31 following the year in which the registration fee under sub. (2) is received by the department.

(2) REGISTRATION APPLICATION. **Except as provided in sub. (4),** no person may operate an ionizing radiation installation if the person has not been issued a notice of registration by the department by January 1 of each year. Application for registration shall be made on a form furnished by the department. An application for registration shall be accompanied by the fee required under subs. (3) and (4), as applicable, and submitted to the department by December 31, prior to the year of registration.

Note: An application for registration may be obtained by writing the Department at: Department of Health and Family Services, Radiation Protection Section, P.O. Box 2659, Madison WI 53701-2659, or may be downloaded from the Department website: http://www.dhfs.state.wi.us/licensing.htm.

(3) REGISTRATION FEE. (a) A medical, veterinary, industrial, academic, research project or other site having radioactive materials in any quantity shall pay to the department, an annual registration fee of $36 for each site.

(b) Following receipt of the registration fee, the department shall issue to the person in control a notice of registration.

(4) PENALTY FEE. If the annual registration fee is not paid by December 31 prior to the year of registration, the installation shall pay the department a penalty fee of $25, in addition to the registration fee, before being issued a new notice of registration.

(5) AMENDMENT REQUIREMENTS. A person in control shall notify the department of any change in registration information within 30 days of the change. A fee is not required to record a change in registration information.

SECTION 2. Chapter HSS 157 is repealed.

The repeal, subchapters I, III, IV, V, VIII through XV and all Appendices contained in this chapter shall take effect on the first day of the month following publication in the Wisconsin Administrative Register, as provided in s. 227.22 (2), Stats. Subchapters II, VI and VII shall take effect 30 days after signature by the Governor of an agreement transferring regulatory authority over byproduct, source and special nuclear material to the State of Wisconsin.

Wisconsin Department of Health
and Family Services

Dated:

By: _____
Phyllis J. Dubé
Secretary

SEAL:

APPENDIX A

EXEMPT CONCENTRATIONS

Element (atomic number)	Radionuclide	Column I Gas concentration μCi/ml 1/	Column II Liquid and solid concentration μCi/ml 2/
Antimony (51)	Sb-122		$3X10^{-4}$
	Sb-124		$2X10^{-4}$
	Sb-125		$1X10^{-3}$
Argon (18)	Ar-37	$1X10^{-3}$	
	Ar-41	$4X10^{-7}$	
Arsenic (33)	As-73		$5X10^{-3}$
	As-74		$5X10^{-4}$
	As-76		$2X10^{-4}$
	As-77		$8X10^{-4}$
Barium (56)	Ba-131		$2X10^{-3}$
	Ba-140		$3X10^{-4}$
Beryllium (4)	Be-7		$2X10^{-2}$
Bismuth (83)	Bi-206		$4X10^{-4}$
Bromine (35)	Br-82	$4X10^{-7}$	$3X10^{-3}$
Cadmium (48)	Cd-109		$2X10^{-3}$
	Cd-115m		$3X10^{-4}$
	Cd-115		$3X10^{-4}$
Calcium (20)	Ca-45		$9X10^{-5}$
	Ca-47		$5X10^{-4}$
Carbon (6)	C-14	$1X10^{-6}$	$8X10^{-3}$
Cerium (58)	Ce-141		$9X10^{-4}$
	Ce-143		$4X10^{-4}$
	Ce-144		$1X10^{-4}$
Cesium (55)	Cs-131		$2X10^{-2}$
	Cs-134m		$6X10^{-2}$
	Cs-134		$9X10^{-5}$
Chlorine (17)	Cl-38	$9X10^{-7}$	$4X10^{-3}$
Chromium (24)	Cr-51		$2X10^{-2}$
Cobalt (27)	Co-57		$5X10^{-3}$
	Co-58		$1X10^{-3}$
	Co-60		$5X10^{-4}$

1/ Values are given in Column I only for those materials normally used as gases.
2/ μCi/g for solids

Element (atomic number)	Radionuclide	Column I Gas concentration µCi/ml 1/	Column II Liquid and solid concentration µCi/ml 2/
Copper (29)	Cu-64		$3X10^{-3}$
Dysprosium (66)	Dy-165		$4X10^{-3}$
	Dy-166		$4X10^{-4}$
Erbium (68)	Er-169		$9X10^{-4}$
	Er-171		$1X10^{-3}$
Europium (63)	Eu-152(9.2 h)		$6X10^{-4}$
	Eu-155		$2X10^{-3}$
Fluorine (9)	F-18	$2X10^{-6}$	$8X10^{-3}$
Gadolinium (64)	Gd-153		$2X10^{-3}$
	Gd-159		$8X10^{-4}$
Gallium (31)	Ga-72		$4X10^{-4}$
Germanium (32)	Ge-71		$2X10^{-2}$
Gold (79)	Au-196		$2X10^{-3}$
	Au-198		$5X10^{-4}$
	Au-199		$2X10^{-3}$
Hafnium (72)	Hf-181		$7X10^{-4}$
Hydrogen (1)	H-3	$5X10^{-6}$	$3X10^{-2}$
Indium (49)	In-113m		$1X10^{-2}$
	In-114m		$2X10^{-4}$
Iodine (53)	I-126	$3X10^{-9}$	$2X10^{-5}$
	I-131	$3X10^{-9}$	$2X10^{-5}$
	I-132	$8X10^{-8}$	$6X10^{-4}$
	I-133	$1X10^{-8}$	$7X10^{-5}$
	I-134	$2X10^{-7}$	$1X10^{-3}$
Iridium (77)	Ir-190		$2X10^{-3}$
	Ir-192		$4X10^{-4}$
	Ir-194		$3X10^{-4}$
Iron (26)	Fe-55		$8X10^{-3}$
	Fe-59		$6X10^{-4}$
Krypton (36)	Kr-85m	$1X10^{-6}$	
	Kr-85	$3X10^{-6}$	
Lanthanum (57)	La-140		$2X10^{-4}$
Lead (82)	Pb-203		$4X10^{-3}$
Lutetium (71)	Lu-177		$1X10^{-3}$

1/ Values are given in Column I only for those materials normally used as gases.
2/ µCi/g for solids.

Element (atomic number)	Radionuclide	Column I Gas concentration μCi/ml 1/	Column II Liquid and solid concentration μCi/ml 2/
Manganese (25)	Mn-52		$3X10^{-4}$
	Mn-54		$1X10^{-3}$
	Mn-56		$1X10^{-3}$
Mercury (80)	Hg-197m		$2X10^{-3}$
	Hg-197		$3X10^{-3}$
	Hg-203		$2X10^{-4}$
Molybdenum (42)	Mo-99		$2X10^{-3}$
Neodymium (60)	Nd-147		$6X10^{-4}$
	Nd-149		$3X10^{-3}$
Nickel (28)	Ni-65		$1X10^{-3}$
Niobium (Columbium) (41)	Nb-95		$1X10^{-3}$
	Nb-97		$9X10^{-3}$
Osmium (76)	Os-185		$7X10^{-4}$
	Os-191m		$3X10^{-2}$
	Os-191		$2X10^{-3}$
	Os-193		$6X10^{-4}$
Palladium (46)	Pd-103		$3X10^{-3}$
	Pd-109		$9X10^{-4}$
Phosphorus (15)	P-32		$2X10^{-4}$
Platinum (78)	Pt-191		$1X10^{-3}$
	Pt-193m		$1X10^{-2}$
	Pt-197m		$1X10^{-2}$
	Pt-197		$1X10^{-3}$
Potassium (19)	K-42		$3X10^{-3}$
Praseodymium (59)	Pr-142		$3X10^{-4}$
	Pr-143		$5X10^{-4}$
Promethium (61)	Pm-147		$2X10^{-3}$
	Pm-149		$4X10^{-4}$
Rhenium (75)	Re-183		$6X10^{-3}$
	Re-186		$9X10^{-4}$
	Re-188		$6X10^{-4}$
Rhodium (45)	Rh-103m		$1X10^{-1}$
	Rh-105		$1X10^{-3}$
Rubidium (37)	Rb-86		$7X10^{-4}$

1/ Values are given in Column I only for those materials normally used as gases.
2/ μCi/g for solids.

Element (atomic number)	Radionuclide	Column I Gas concentration µCi/ml 1/	Column II Liquid and solid concentration µCi/ml 2/
Ruthenium (44)	Ru-97		$4X10^{-3}$
	Ru-103		$8X10^{-4}$
	Ru-105		$1X10^{-3}$
	Ru-106		$1X10^{-4}$
Samarium (62)	Sm-153		$8X10^{-4}$
Scandium (21)	Sc-46		$4X10^{-4}$
	Sc-47		$9X10^{-4}$
	Sc-48		$3X10^{-4}$
Selenium (34)	Se-75		$3X10^{-3}$
Silicon (14)	Si-31		$9X10^{-3}$
Silver (47)	Ag-105		$1X10^{-3}$
	Ag-110m		$3X10^{-4}$
	Ag-111		$4X10^{-4}$
Sodium (11)	Na-24		$2X10^{-3}$
Strontium (38)	Sr-85		$1X10^{-3}$
	Sr-89		$1X10^{-4}$
	Sr-91		$7X10^{-4}$
	Sr-92		$7X10^{-4}$
Sulfur (16)	S-35	$9X10^{-8}$	$6X10^{-4}$
Tantalum (73)	Ta-182		$4X10^{-4}$
Technetium (43)	Tc-96m		$1X10^{-1}$
	Tc-96		$1X10^{-3}$
Tellurium (52)	Te-125m		$2X10^{-3}$
	Te-127m		$6X10^{-4}$
	Te-127		$3X10^{-3}$
	Te-129m		$3X10^{-4}$
	Te-131m		$6X10^{-4}$
	Te-132		$3X10^{-4}$
Terbium (65)	Tb-160		$4X10^{-4}$
Thallium (81)	Tl-200		$4X10^{-3}$
	Tl-201		$3X10^{-3}$
	Tl-202		$1X10^{-3}$
	Tl-204		$1X10^{-3}$
Thulium (69)	Tm-170		$5X10^{-4}$
	Tm-171		$5X10^{-3}$

1/ Values are given in Column I only for those materials normally used as gases.
2/ µCi/g for solids.

Element (atomic number)	Radionuclide	Column I Gas concentration µCi/ml 1/	Column II Liquid and solid concentration µCi/ml 2/
Tin (50)	Sn-113		$9X10^{-4}$
	Sn-125		$2X10^{-4}$
Tungsten (Wolfram) (74)	W-181		$4X10^{-3}$
	W-187		$7X10^{-4}$
Vanadium (23)	V-48		$3X10^{-4}$
Xenon (54)	Xe-131m	$4X10^{-6}$	
	Xe-133	$3X10^{-6}$	
	Xe-135	$1X10^{-6}$	
Ytterbium (70)	Yb-175		$1X10^{-3}$
Yttrium (39)	Y-90		$2X10^{-4}$
	Y-91m		$3X10^{-2}$
	Y-91		$3X10^{-4}$
	Y-92		$6X10^{-4}$
	Y-93		$3X10^{-4}$
Zinc (30)	Zn-65		$1X10^{-3}$
	Zn-69m		$7X10^{-4}$
	Zn-69		$2X10^{-2}$
Zirconium (40)	Zr-95		$6X10^{-4}$
	Zr-97		$2X10^{-4}$
Beta- and gamma-emitting radioactive material not listed above with half-life of less than 3 years.		$1X10^{-10}$	$1X10^{-6}$

Note 1:Many radionuclides transform into other radionuclides. In expressing the concentrations in Appendix A, the activity stated is that of the parent radionuclide and takes into account the radioactive decay products.

Note 2:For purposes of s. HFS 157.09 (2) where there is involved a combination of radionuclides, the limit for the combination should be derived as follows: Determine for each radionuclide in the product the ratio between the radioactivity concentration present in the product and the exempt radioactivity concentration established in Appendix A for the specific radionuclide when not in combination. The sum of such ratios may not exceed "1".

1/ Values are given in Column I only for those materials normally used as gases.

2/ µCi/g for solids.

Example: $\frac{\text{Concentration of Radionuclide A in Product}}{\text{Exempt concentration of Radionuclide A}} +$

$\frac{\text{Concentration of Radionuclide B in Product}}{\text{Exempt concentration of Radionuclide B}} \leq 1$

Note 3:To convert μCi/ml to SI units of megabecquerels per liter multiply the above values by 37.

Example: Zirconium (40) Zr-97 (2×10^{-4} μCi/ml multiplied by 37 is equivalent to 74×10^{-4} MBq/l).

APPENDIX B

EXEMPT QUANTITIES

Radioactive Material	Microcuries
Antimony-122 (Sb 122)	100
Antimony-124 (Sb 124)	10
Antimony-125 (Sb 125)	10
Arsenic-73 (As 73)	100
Arsenic-74 (As 74)	10
Arsenic-76 (As 76)	10
Arsenic-77 (As 77)	100
Barium-131 (Ba 131)	10
Barium-133 (Ba 133)	10
Barium-140 (Ba 140)	10
Bismuth-210 (Bi 210)	1
Bromine-82 (Br 82)	10
Cadmium-109 (Cd 109)	10
Cadmium-115m (Cd 115m)	10
Cadmium-115 (Cd 115)	100
Calcium-45 (Ca 45)	10
Calcium-47 (Ca 47)	10
Carbon-14 (C 14)	100
Cerium-141 (Ce 141)	100
Cerium-143 (Ce 143)	100
Cerium-144 (Ce 144)	1
Cesium-129 (Cs 129)	100
Cesium-131 (Cs 131)	1,000
Cesium-134m (Cs 134m)	100
Cesium-134 (Cs 134)	1
Cesium-135 (Cs 135)	10
Cesium-136 (Cs 136)	10
Cesium-137 (Cs 137)	10
Chlorine-36 (Cl 36)	10
Chlorine-38 (Cl 38)	10
Chromium-51 (Cr 51)	1,000
Cobalt-57 (Co 57)	100
Cobalt-58m (Co 58m)	10
Cobalt-58 (Co 58)	10
Cobalt-60 (Co 60)	1
Copper-64 (Cu 64)	100
Dysprosium-165 (Dy 165)	10
Dysprosium-166 (Dy 166)	100
Erbium-169 (Er 169)	100
Erbium-171 (Er 171)	100

Radioactive Material	Microcuries
Europium-152 (Eu 152)9.2h	100
Europium-152 (Eu 152)13 yr	1
Europium-154 (Eu 154)	1
Europium-155 (Eu 155)	10
Fluorine-18 (F 18)	1,000
Gadolinium-153 (Gd 153)	10
Gadolinium-159 (Gd 159)	100
Gallium-67 (Ga 67)	100
Gallium-72 (Ga 72)	10
Germanium-68 (Ge 68)	10
Germanium-71 (Ge 71)	100
Gold-195 (Au 195)	10
Gold-198 (Au 198)	100
Gold-199 (Au 199)	100
Hafnium-181 (Hf 181)	10
Holmium-166 (Ho 166)	100
Hydrogen-3 (H 3)	1,000
Indium-111 (In 111)	100
Indium-113m (In 113m)	100
Indium-114m (In 114m)	10
Indium-115m (In 115m)	100
Indium-115 (In 115)	10
Iodine-123 (I 123)	100
Iodine-125 (I 125)	1
Iodine-126 (I 126)	1
Iodine-129 (I 129)	0.1
Iodine-131 (I 131)	1
Iodine-132 (I 132)	10
Iodine-133 (I 133)	1
Iodine-134 (I 134)	10
Iodine-135 (I 135)	10
Iridium-192 (Ir 192)	10
Iridium-194 (Ir 194)	100
Iron-52 (Fe 52)	10
Iron-55 (Fe 55)	100
Iron-59 (Fe 59)	10
Krypton-85 (Kr 85)	100
Krypton-87 (Kr 87)	10
Lanthanum-140 (La 140)	10
Lutetium-177 (Lu 177)	100
Manganese-52 (Mn 52)	10
Manganese-54 (Mn 54)	10
Manganese-56 (Mn 56)	10
Mercury-197m (Hg 197m)	100

Radioactive Material	Microcuries
Mercury-197 (Hg 197)	100
Mercury-203 (Hg 203)	10
Molybdenum-99 (Mo 99)	100
Neodymium-147 (Nd 147)	100
Neodymium-149 (Nd 149)	100
Nickel-59 (Ni 59)	100
Nickel-63 (Ni 63)	10
Nickel-65 (Ni 65)	100
Niobium-93m (Nb 93m)	10
Niobium-95 (Nb 95)	10
Niobium-97 (Nb 97)	10
Osmium-185 (Os 185)	10
Osmium-191m (Os 191m)	100
Osmium-191 (Os 191)	100
Osmium-193 (Os 193)	100
Palladium-103 (Pd 103)	100
Palladium-109 (Pd 109)	100
Phosphorus-32 (P 32)	10
Platinum-191 (Pt 191)	100
Platinum-193m (Pt 193m)	100
Platinum-193 (Pt 193)	100
Platinum-197m (Pt 197m)	100
Platinum-197 (Pt 197)	100
Polonium-210 (Po 210)	0.1
Potassium-42 (K 42)	10
Potassium-43 (K 43)	10
Praseodymium-142 (Pr 142)	100
Praseodymium-143 (Pr 143)	100
Promethium-147 (Pm 147)	10
Promethium-149 (Pm 149)	10
Rhenium-186 (Re 186)	100
Rhenium-188 (Re 188)	100
Rhodium-103m (Rh 103m)	100
Rhodium-105 (Rh 105)	100
Rubidium-81 (Rb 81)	10
Rubidium-86 (Rb 86)	10
Rubidium-87 (Rb 87)	10
Ruthenium-97 (Ru 97)	100
Ruthenium-103 (Ru 103)	10
Ruthenium-105 (Ru 105)	10
Ruthenium-106 (Ru 106)	1
Samarium-151 (Sm 151)	10
Samarium-153 (Sm 153)	100
Scandium-46 (Sc 46)	10

Radioactive Material	Microcuries
Scandium-47 (Sc 47)	100
Scandium-48 (Sc 48)	10
Selenium-75 (Se 75)	10
Silicon-31 (Si 31)	100
Silver-105 (Ag 105)	10
Silver-110m (Ag 110m)	1
Silver-111 (Ag 111)	100
Sodium-22 (Na 22)	10
Sodium-24 (Na 24)	10
Strontium-85 (Sr 85)	10
Strontium-89 (Sr 89)	1
Strontium-90 (Sr 90)	0.1
Strontium-91 (Sr 91)	10
Strontium-92 (Sr 92)	10
Sulphur-35 (S 35)	100
Tantalum-182 (Ta 182)	10
Technetium-96 (Tc 96)	10
Technetium-97m (Tc 97m)	100
Technetium-97 (Tc 97)	100
Technetium-99m (Tc 99m)	100
Technetium-99 (Tc 99)	10
Tellurium-125m (Te 125m)	10
Tellurium-127m (Te 127m)	10
Tellurium-127 (Te 127)	100
Tellurium-129m (Te 129m)	10
Tellurium-129 (Te 129)	100
Tellurium-131m (Te 131m)	10
Tellurium-132 (Te 132)	10
Terbium-160 (Tb 160)	10
Thallium-200 (Tl 200)	100
Thallium-201 (Tl 201)	100
Thallium-202 (Tl 202)	100
Thallium-204 (Tl 204)	10
Thulium-170 (Tm 170)	10
Thulium-171 (Tm 171)	10
Tin-113 (Sn 113)	10
Tin-125 (Sn 125)	10
Tungsten-181 (W 181)	10
Tungsten-185 (W 185)	10
Tungsten-187 (W 187)	100
Vanadium-48 (V 48)	10
Xenon-131m (Xe 131m)	1,000
Xenon-133 (Xe 133)	100
Xenon-135 (Xe 135)	100

Radioactive Material	Microcuries
Ytterbium-175 (Yb 175)	100
Yttrium-87 (Y 87)	10
Yttrium-88 (Y 88)	10
Yttrium-90 (Y 90)	10
Yttrium-91 (Y 91)	10
Yttrium-92 (Y 92)	100
Yttrium-93 (Y 93)	100
Zinc-65 (Zn 65)	10
Zinc-69m (Zn 69m)	100
Zinc-69 (Zn 69)	1,000
Zirconium-93 (Zr 93)	10
Zirconium-95 (Zr 95)	10
Zirconium-97 (Zr 97)	10
Any radioactive material not listed above other than alpha-emitting radioactive material	0.1

Note 1: Where there is a combination of radionuclides, the limit for the combination should be derived as follows:

Determine the amount of each radionuclide possessed and 1,000 times the amount in Appendix B for each of those radionuclides when not in combination. The sum of the ratios of those quantities may not exceed 1.

Example:

$$\frac{\text{Amt. of Radionuclide A possessed}}{\text{1000 x Appendix B quantity for Radionuclide A}} + \frac{\text{Amt. of Radionuclide B possessed}}{\text{1000 x Appendix B quantity for Radionuclide B}} \leq 1$$

Note 2: To convert microcuries (μCi) to SI units of kilobecquerels (kBq), multiply the above values by 37.

Example: Zirconium-97 (10 μCi multiplied by 37 is equivalent to 370 kBq).

APPENDIX C

LIMITS FOR BROAD LICENSES

Radioactive Material	Type B License Column I curies	Type C License Column II curies
Antimony-122	1	0.01
Antimony-124	1	0.01
Antimony-125	1	0.01
Arsenic-73	10	0.1
Arsenic-74	1	0.01
Arsenic-76	1	0.01
Arsenic-77	10	0.1
Barium-131	10	0.1
Barium-140	1	0.01
Beryllium-7	10	0.1
Bismuth-210	0.1	0.001
Bromine-82	10	0.1
Cadmium-109	1	0.01
Cadmium-115m	1	0.01
Cadmium-115	10	0.1
Calcium-45	1	0.01
Calcium-47	10	0.1
Carbon-14	100	1.
Cerium-141	10	0.1
Cerium-143	10	0.1
Cerium-144	0.1	0.001
Cesium-131	100	1.
Cesium-134m	100	1.
Cesium-134	0.1	0.001
Cesium-135	1	0.01
Cesium-136	10	0.1
Cesium-137	0.1	0.001
Chlorine-36	1	0.01
Chlorine-38	100	1.
Chromium-51	100	1.
Cobalt-57	10	0.1
Cobalt-58m	100	1.
Cobalt-58	1	0.01
Cobalt-60	0.1	0.001
Copper-64	10	0.1
Dysprosium-165	100	1.
Dysprosium-166	10	0.1

Radioactive Material	Type B License Column I curies	Type C License Column II curies
Erbium-169	10	0.1
Erbium-171	10	0.1
Europium-152 (9.2 h)	10	0.1
Europium-152 (13 y)	0.1	0.001
Europium-154	0.1	0.001
Europium-155	1	0.01
Fluorine-18	100	1.
Gadolinium-153	1	0.01
Gadolinium-159	10	0.1
Gallium-72	10	0.1
Germanium-71	100	1.
Gold-198	10	0.1
Gold-199	10	0.1
Hafnium-181	1	0.01
Holmium-166	10	0.1
Hydrogen-3	100	1.
Indium-113m	100	1.
Indium-114m	1	0.01
Indium-115m	100	1.
Indium-115	1	0.01
Iodine-125	0.1	0.001
Iodine-126	0.1	0.001
Iodine-129	0.1	0.001
Iodine-131	0.1	0.001
Iodine-132	10	0.1
Iodine-133	1	0.01
Iodine-134	10	0.1
Iodine-135	1	0.01
Iridium-192	1	0.01
Iridium-194	10	0.1
Iron-55	10	0.1
Iron-59	1	0.01
Krypton-85	100	1.
Krypton-87	10	0.1
Lanthanum-140	1	0.01
Lutetium-177	10	0.1
Manganese-52	1	0.01
Manganese-54	1	0.01
Manganese-56	10	0.1
Mercury-197m	10	0.1
Mercury-197	10	0.1
Mercury-203	1	0.01

Radioactive Material	Type B License Column I curies	Type C License Column II curies
Molybdenum-99	10	0.1
Neodymium-147	10	0.1
Neodymium-149	10	0.1
Nickel-59	10	0.1
Nickel-63	1	0.01
Nickel-65	10	0.1
Niobium-93m	1	0.01
Niobium-95	1	0.01
Niobium-97	100	1.
Osmium-185	1	0.01
Osmium-191m	100	1.
Osmium-191	10	0.1
Osmium-193	10	0.1
Palladium-103	10	0.1
Palladium-109	10	0.1
Phosphorus-32	1	0.01
Platinum-191	10	0.1
Platinum-193m	100	1.
Platinum-193	10	0.1
Platinum-197m	100	1.
Platinum-197	10	0.1
Polonium-210	0.01	0.0001
Potassium-42	1	0.01
Praseodymium-142	10	0.1
Praseodymium-143	10	0.1
Promethium-147	1	0.01
Promethium-149	10	0.1
Radium-226	0.01	0.0001
Rhenium-186	10	0.1
Rhenium-188	10	0.1
Rhodium-103m	1,000	10.
Rhodium-105	10	0.1
Rubidium-86	1	0.01
Rubidium-87	1	0.01
Ruthenium-97	100	1.
Ruthenium-103	1	0.01
Ruthenium-105	10	0.1
Ruthenium-106	0.1	0.001
Samarium-151	1	0.01
Samarium-153	10	0.1
Scandium-46	1	0.01
Scandium-47	10	0.1

Radioactive Material	Type B License Column I curies	Type C License Column II curies
Scandium-48	1	0.01
Selenium-75	1	0.01
Silicon-31	10	0.1
Silver-105	1	0.01
Silver-110m	0.1	0.001
Silver-111	10	0.1
Sodium-22	0.1	0.001
Sodium-24	1	0.01
Strontium-85m	1,000	10.
Strontium-85	1	0.01
Strontium-89	1	0.01
Strontium-90	0.01	0.0001
Strontium-91	10	0.1
Strontium-92	10	0.1
Sulphur-35	10	0.1
Tantalum-182	1	0.01
Technetium-96	10	0.1
Technetium-97m	10	0.1
Technetium-97	10	0.1
Technetium-99m	100	1.
Technetium-99	1	0.01
Tellurium-125m	1	0.01
Tellurium-127m	1	0.01
Tellurium-127	10	0.1
Tellurium-129m	1	0.01
Tellurium-129	100	1.
Tellurium-131m	10	0.1
Tellurium-132	1	0.01
Terbium-160	1	0.01
Thallium-200	10	0.1
Thallium-201	10	0.1
Thallium-202	10	0.1
Thallium-204	1	0.01
Thulium-170	1	0.01
Thulium-171	1	0.01
Tin-113	1	0.01
Tin-125	1	0.01
Tungsten-181	1	0.01
Tungsten-185	1	0.01
Tungsten-187	10	0.1
Vanadium-48	1	0.01
Xenon-131m	1,000	10.
Xenon-133	100	1.
Xenon-135	100	1.

Radioactive Material	Type B License Column I curies	Type C License Column II curies
Ytterbium-175	10	0.1
Yttrium-90	1	0.01
Yttrium-91	1	0.01
Yttrium-92	10	0.1
Yttrium-93	1	0.01
Zinc-65	1	0.01
Zinc-69m	10	0.1
Zinc-69	100	1.
Zirconium-93	1	0.01
Zirconium-95	1	0.01
Zirconium-97	1	0.01
Any radioactive material other than source material, special nuclear material, or alpha emitting radioactive material not listed above.	0.1	0.001

Note 1: To convert curies (Ci) to SI units of gigabecquerels (GBq), multiply the above values by 37.

Example: Zirconium-97 (Col. II) (0.01 Ci multiplied by 37 is equivalent to 0.37 GBq).

APPENDIX D
ASSIGNED PROTECTION FACTORS FOR RESPIRATORS[a]

	Operating mode	Assigned Protection Factors
I. Air Purifying Respirators [Particulate1A[b] only]1A[c]:		
Filtering facepiece disposabled	Negative Pressure	([d])
Facepiece, half [e]	Negative Pressure	10
Facepiece, full	Negative Pressure	100
Facepiece, half	Powered air-purifying respirators	50
Facepiece, full	Powered air-purifying respirators	1000
Helmet/hood	Powered air-purifying respirators	1000
Facepiece, loose-fitting	Powered air-purifying respirators	25
II. Atmosphere supplying respirators [particulate, gases and vapors1A[f]]:		
1. Air-line respirator:		
Facepiece, half	Demand	10
Facepiece, half	Continuous Flow	50
Facepiece, half	Pressure Demand	50
Facepiece, full	Demand	100
Facepiece, full	Continuous Flow	1000
Facepiece, full	Pressure Demand	1000
Helmet/hood	Continuous Flow	1000
Facepiece, loose-fitting	Continuous Flow	25
Suit	Continuous Flow	([g])
2. Self-contained breathing Apparatus (SCBA):		
Facepiece, full	Demand	100
Facepiece, full	Pressure Demand	10,000
Facepiece, full	Demand, Recirculating	100
Facepiece, full	Positive Pressure Recirculating	10,000
III. Combination Respirators:		
Any combination of air-purifying and atmosphere-supplying respirators	(1) Assigned protection factor for type and mode of operation as listed above.	

[a] These assigned protection factors apply only in a respiratory protection program that meets the requirements of subchapter III of this chapter. The protection factors are applicable only to airborne radiological hazards and may not be appropriate to circumstances when chemical or other respiratory hazards exist instead of, or in addition to, radioactive hazards. Selection and use of respirators for such circumstances must also comply with U.S. Department of Labor regulations.

Radioactive contaminants for which the concentration values in Column 3 of Appendix E are based on internal dose due to inhalation may, in addition, present external exposure hazards at

higher concentrations. Under these circumstances, limitations on occupancy may have to be governed by external dose limits.

[b] Air purifying respirators with APF <100 must be equipped with particulate filters that are at least 95 percent efficient. Air purifying respirators with APF = 100 must be equipped with particulate filters that are at least 99 percent efficient. Air purifying respirators with APFs >100 must be equipped with particulate filters that are at least 99.97 percent efficient.

[c] A licensee may apply to the department for the use of an APF greater than 1 for sorbent cartridges as protection against airborne radioactive gases and vapors, for example, radioiodine.

[d] A licensee may permit individuals who have not been medically screened or fit tested on the device to use this type of respirator, provided that no credit be taken for their use in estimating intake or dose. It is also recognized that it is difficult to perform an effective positive or negative pressure pre-use user seal check on this type of device. All other respiratory protection program requirements listed in s. HFS 157.27 (3) apply. An assigned protection factor has not been assigned for these devices. However, an APF equal to 10 may be used if the licensee demonstrates a fit factor of at least 100 by use of a validated or evaluated, qualitative or quantitative fit test.

[e] Under-chin type only. No distinction is made in this Appendix between elastomeric half-masks with replaceable cartridges and those designed with the filter medium as an integral part of the facepiece, for example, disposable or reusable disposable. Both types are acceptable so long as the seal area of the latter contains some substantial type of seal-enhancing material such as rubber or plastic, the 2 or more suspension straps are adjustable, the filter medium is at least 95 percent efficient and all other requirements of subchapter III of this chapter are met.

[f] The assigned protection factors for gases and vapors are not applicable to radioactive contaminants that present an absorption or submersion hazard. For tritium oxide vapor, approximately one-third of the intake occurs by absorption through the skin so that an overall protection factor of 3 is appropriate when atmosphere-supplying respirators are used to protect against tritium oxide. Exposure to radioactive noble gases is not considered a significant respiratory hazard, and protective actions for these contaminants should be based on external submersion dose considerations.

[g] No National Institute of Occupational Safety and Health approval schedule is currently available for atmosphere supplying suits. This equipment may be used in an acceptable respiratory protection program as long as all the other minimum program requirements, with the exception of fit testing, are met.

Note: See s. HFS 157.27 (3).

[h] A licensee should implement institutional controls to assure that these devices are not used in areas immediately dangerous to life or health.

[i] This type of respirator may be used as an emergency device in unknown concentrations for protection against inhalation hazards. External radiation hazards and other limitations to permitted exposure such as skin absorption shall be taken into account in these circumstances. This device may not be used by any individual who experiences perceptible outward leakage of breathing gas while wearing the device.

APPENDIX E

ANNUAL LIMITS ON INTAKE (ALI) AND DERIVED AIR CONCENTRATIONS (DAC) OF RADIONUCLIDES FOR OCCUPATIONAL EXPOSURE; EFFLUENT CONCENTRATIONS; CONCENTRATIONS FOR RELEASE TO SANITARY SEWERAGE

Introduction

For each radionuclide, Table I indicates the chemical form which is to be used for selecting the appropriate ALI or DAC value. The ALIs and DACs for inhalation are given for an aerosol with an activity median aerodynamic diameter (AMAD) of 1 μ(micron), and for the D, W and Y classes of radioactive material, which refer to their retention in the pulmonary region of the lung. This classification applies to a range of clearance half-times for D if less than 10 days, for W from 10 to 100 days, and for Y greater than 100 days. The D, W or Y class given in the column headed "Class" applies only to the inhalation ALIs and DACs given in Table I, column 2 and 3. Table II provides concentration limits for airborne and liquid effluents released to the general environment. Table III provides concentration limits for discharges to sanitary sewerage.

Note: The values in Tables I, II, and III are presented in the computer "E" notation. In this notation a value of 6E-02 represents a value of 6×10^{-2} or 0.06, 6E+2 represents 6×10^{2} or 600, and 6E+0 represents 6×10^{0} or 6.

Table I "Occupational Values"

Note that the columns in Table I of this appendix captioned "Oral Ingestion ALI," "Inhalation ALI" and "DAC" are applicable to occupational exposure to radioactive material.

The ALIs in this appendix are the annual intakes of given radionuclide by "reference man" which would result in either (1) a committed effective dose equivalent of 0.05 Sv (5 rem), stochastic ALI, or (2) a committed dose equivalent of 0.5 Sv (50 rem) to an organ or tissue, non-stochastic ALI. The stochastic ALIs were derived to result in a risk, due to irradiation of organs and tissues, comparable to the risk associated with deep dose equivalent to the whole body of 0.05 Sv (5 rem). The derivation includes multiplying the committed dose equivalent to an organ or tissue by a weighting factor, w_T. This weighting factor is the proportion of the risk of stochastic effects resulting from irradiation of the organ or tissue, T, to the total risk of stochastic effects when the whole body is irradiated uniformly. The values of w_T are listed under the definition of weighting factor in s. HFS 157.03. The non-stochastic ALIs were derived to avoid non-stochastic effects, such as prompt damage to tissue or reduction in organ function.

Note: A description of the reference man is contained in the International Commission on Radiological Protection report, ICRP Publication 23, Reference Man: Anatomical Physiological and Metabolic Characteristics, Pergamon Press, Oxford (1975). The publication may be ordered from the web-site http://www.icrp.org/ordering.htm.

A value of $w_T = 0.06$ is applicable to each of the 5 organs or tissues in the "remainder" category receiving the highest dose equivalents, and the dose equivalents of all other remaining tissues may be disregarded. The following portions of the GI tract -- stomach, small intestine, upper large intestine, and lower large intestine -- are to be treated as 4 separate organs.

Note that the dose equivalents for an extremity, skin and lens of the eye are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

When an ALI is defined by the stochastic dose limit, this value alone is given. When an ALI is determined by the non-stochastic dose limit to an organ, the organ or tissue to which the limit applies is shown, and the ALI for the stochastic limit is shown in parentheses. Abbreviated organ or tissue designations are used:

LLI wall = lower large intestine wall;
St wall = stomach wall;
Blad wall = bladder wall; and
Bone surf = bone surface.

The use of the ALIs listed first, the more limiting of the stochastic and non-stochastic ALIs, will ensure that non-stochastic effects are avoided and that the risk of stochastic effects is limited to an acceptably low value. If, in a particular situation involving a radionuclide for which the non-stochastic ALI is limiting, use of that non-stochastic ALI is considered unduly conservative, the licensee may use the stochastic ALI to determine the committed effective dose equivalent. However, the licensee shall also ensure that the 0.5 Sv (50 rem) dose equivalent limit for any organ or tissue is not exceeded by the sum of the external deep dose equivalent plus the internal committed dose equivalent to that organ, not the effective dose. For the case where there is no external dose contribution, this would be demonstrated if the sum of the fractions of the nonstochastic ALIs that contribute to the committed dose equivalent to the organ receiving the highest dose does not exceed unity, that is, intake of each radionuclide/$ALI_{ns} \leq 1.0$. If there is an external deep dose equivalent contribution of H_d, then this sum must be less than $1 - (H_d/50)$, instead of ≤ 1.0.

Note that the dose equivalents for an extremity, skin, and lens of the eye are not considered in computing the committed effective dose equivalent, but are subject to limits that must be met separately.

The derived air concentration (DAC) values are derived limits intended to control chronic occupational exposures. The relationship between the DAC and the ALI is given by:

$$\text{DAC} = \text{ALI in } \mu\text{Ci}/(2000 \text{ hours per working year} \times 60 \text{ minutes/hour} \times 2 \times 10^4 \text{ ml per minute}) = [\text{ALI}/2.4 \times 10^9] \ \mu\text{Ci/ml},$$

where 2×10^4 ml is the volume of air breathed per minute at work by reference man under working conditions of light work.

The DAC values relate to 1 of 2 modes of exposure: either external submersion or the internal committed dose equivalents resulting from inhalation of radioactive materials. DACs based upon submersion are for immersion in a semi-infinite cloud of uniform concentration and apply to each radionuclide separately.

The ALI and DAC values include contributions to exposure by the single radionuclide named and any in-growth of daughter radionuclides produced in the body by decay of the parent. However, intakes that include both the parent and daughter radionuclides should be treated by the general method appropriate for mixtures.

The values of ALI and DAC do not apply directly when the individual both ingests and inhales a radionuclide, when the individual is exposed to a mixture of radionuclides by either inhalation or ingestion or both or when the individual is exposed to both internal and external irradiation. See s. HFS 157.22 (2). When an individual is exposed to radioactive materials that fall under several of the translocation classifications of the same radionuclide, such as Class D, Class W or Class Y, the exposure may be evaluated as if it were a mixture of different radionuclides.

It should be noted that the classification of a compound as Class D, W, or Y is based on the chemical form of the compound and does not take into account the radiological half-life of different radionuclides. For this reason, values are given for Class D, W, and Y compounds, even for very short-lived radionuclides.

Table II "Effluent Concentrations"

The columns in Table II of this appendix captioned "Effluents," "Air" and "Water" are applicable to the assessment and control of dose to the public, particularly in the implementation of the provisions of s. HFS 157.23 (2). The concentration values given in Columns 1 and 2 of Table II are equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose equivalent of 0.5 mSv (0.05 rem).

Consideration of non-stochastic limits has not been included in deriving the air and water effluent concentration limits because non-stochastic effects are presumed not to occur at or below the dose levels established for individual members of the public. For radionuclides, where the non-stochastic limit was governing in deriving the occupational DAC, the stochastic ALI was used in deriving the corresponding airborne effluent limit in Table II. For this reason, the DAC and airborne effluent limits are not always proportional.

The air concentration values listed in Table II, Column 1 were derived by one of 2 methods. For those radionuclides for which the stochastic limit is governing, the occupational stochastic inhalation ALI was divided by 2.4×10^9 ml, relating the inhalation ALI to the DAC, as explained above, and then divided by a factor of 300. The factor of 300 includes the following components: a factor of 50 to relate the 0,05 Sv (5 rem) annual occupational dose limit to the 1 mSv (0.1 rem) limit for members of the public, a factor of 3 to adjust for the difference in exposure time and the inhalation rate for a worker and that for members of the public; and a factor of 2 to adjust the occupational values, derived for adults, so that they are applicable to other age groups.

For those radionuclides for which submersion, that is external dose, is limiting, the occupational DAC in Table I, Column 3 was divided by 219. The factor of 219 is composed of a factor of 50, as described above, and a factor of 4.38 relating occupational exposure for 2,000 hours of a 8,760 hour full-time exposure per year. Note that an additional factor of 2 for age considerations is not warranted in the submersion case.

The water concentrations were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^7. The factor of 7.3×10^7 ml includes the following components: the factors of 50 and 2 described above and a factor of 7.3×10^5 ml which is the annual water intake of reference man.

Note 2 of this appendix provides groupings of radionuclides which are applicable to unknown mixtures of radionuclides. These groupings, including occupational inhalation ALIs and DACs, air and water effluent concentrations and releases to sewer, require demonstrating that the most limiting radionuclides in successive classes are absent. The limit for the unknown mixture is defined when the presence of one of the listed radionuclides cannot be definitely excluded as being present either from knowledge of the radionuclide composition of the source or from actual measurements.

Table III "Releases to Sewers"

The monthly average concentrations for release to sanitary sewerage are applicable to the provisions in s. HFS 157.30 (3). The concentration values were derived by taking the most restrictive occupational stochastic oral ingestion ALI and dividing by 7.3×10^6 ml. The factor of 7.3×10^6 ml is composed of a factor of 7.3×10^5 ml, the annual water intake by reference man, and a factor of 10, such that the concentrations, if the sewage released by the licensee were the only source of water ingested by a reference man during a year, would result in a committed effective dose equivalent of 5 mSv (0.5 rem).

List of Elements

Name	Symbol	Atomic Number	Name	Symbol	Atomic Number
Actinium	Ac	89	Copper	Cu	29
Aluminum	A	13	Curium	Cm	96
Americium	Am	95	Dysprosium	Dy	66
Antimony	Sb	51	Einsteinium	Es	99
Argon	Ar	18	Erbium	Er	68
Arsenic	As	33	Europium	Eu	63
Astatine	At	85	Fermium	Fm	100
Barium	Ba	56	Fluorine	F	9
Berkelium	Bk	97	Francium	Fr	87
Beryllium	Be	4	Gadolinium	Gd	64
Bismuth	Bi	83	Gallium	Ga	31
Bromine	Br	35	Germanium	Ge	32
Cadmium	Cd	48	Gold	Au	79
Calcium	Ca	20	Hafnium	Hf	72
Californium	Cf	98	Holmium	Ho	67
Carbon	C	6	Hydrogen	H	1

List of Elements *(Continued)*

Name	Symbol	Atomic Number
Cerium	Ce	58
Cesium	Cs	55
Chlorine	Cl	17
Chromium	Cr	24
Cobalt	Co	27
Lanthanum	La	57
Lead	Pb	82
Lutetium	Lu	71
Magnesium	Mg	12
Manganese	Mn	25
Mendelevium	Md	101
Mercury	Hg	80
Molybdenum	Mo	42
Neodymium	Nd	60
Neptunium	Np	93
Nickel	Ni	28
Niobium	Nb	41
Osmium	Os	76
Palladium	Pd	46
Phosphorus	P	15
Platinum	Pt	78
Plutonium	Pu	94
Polonium	Po	84
Potassium	K	19
Praseodymium	Pr	59
Promethium	Pm	61
Protactinium	Pa	91
Radium	Ra	88
Radon	Rn	86
Rhenium	Re	75
Rhodium	Rh	45
Rubidium	Rb	37
Ruthenium	Ru	44
Samarium	Sm	62
Scandium	Sc	21
Selenium	Se	34
Silicon	Si	14
Silver	Ag	47
Sodium	Na	11
Strontium	Sr	38
Sulfur	S	16
Tantalum	Ta	73
Technetium	Tc	43
Tellurium	Te	52
Terbium	Tb	65
Thallium	Tl	81
Thorium	Th	90
Thulium	Tm	69
Tin	Sn	50
Indium	In	49
Iodine	I	53
Iridium	Ir	77
Iron	Fe	26
Krypton	Kr	36
Titanium	Ti	22
Tungsten	W	74
Uranium	U	92
Vanadium	V	23
Xenon	Xe	54
Ytterbium	Yb	70
Yttrium	Y	39
Zinc	Zn	30

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage

Atomic No	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
1	Hydrogen-3	Water, DAC includes skin absorption	8E+4	8E+4	2E-5	1E-7	1E-3	1E-2
		Gas (HT or T_2) Submersion[a]: Use above values as HT and T_2 oxidize in air and in the body to HTO						
4	Beryllium-7	W, all compounds except those given for Y	4E+4	2E+4	9E-6	3E-8	6E-4	6E-3
		Y, oxides, halides, and nitrates	-	2E+4	8E-6	3E-8	-	-
4	Beryllium-10	W, see ^{7}Be	1E+3 LLI wall (1E+3)	2E+2 -	6E-8 -	2E-10 -	- 2E-5	- 2E-4
		Y, see ^{7}Be	-	1E+1	6E-9	2E-11	-	-
6	Carbon-11[b]	Monoxide	-	1E+6	5E-4	2E-6	-	-
		Dioxide	-	6E+5	3E-4	9E-7	-	-
		Compounds	4E+5	4E+5	2E-4	6E-7	6E-3	6E-2
6	Carbon-14	Monoxide	-	2E+6	7E-4	2E-6	-	-
		Dioxide	-	2E+5	9E-5	3E-7	-	-
		Compounds	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4
9	Fluorine-18[b]	D, fluorides of H, Li, Na, K, Rb, Cs, and Fr	5E+4 St wall (5E+4)	7E+4 -	3E-5 -	1E-7 -	- 7E-4	- 7E-3
		W, fluorides of Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, As, Sb, Bi, Fe, Ru, Os, Co, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, V, Nb, Ta, Mn, Tc, and Re	-	9E+4	4E-5	1E-7	-	-
		Y, lanthanum fluoride	-	8E+4	3E-5	1E-7	-	-
11	Sodium-22	D, all compounds	4E+2	6E+2	3E-7	9E-10	6E-6	6E-5
11	Sodium-24	D, all compounds	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
12	Magnesium-28	D, all compounds except those given for W	7E+2	2E+3	7E-7	2E-9	9E-6	9E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	-	1E+3	5E-7	2E-9	-	-
13	Aluminum-26	D, all compounds except those given for W	4E+2	6E+1	3E-8	9E-11	6E-6	6E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	-	9E+1	4E-8	1E-10	-	-
14	Silicon-31	D, all compounds except those given for W and Y	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, oxides, hydroxides, carbides, and nitrates	-	3E+4	1E-5	5E-8	-	-
		Y, aluminosilicate glass	-	3E+4	1E-5	4E-8	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
14	Silicon-32	D, see ^{31}Si	2E+3	2E+2	1E-7	3E-10	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4
		W, see ^{31}Si	1E+2	5E-8	2E-10	-	-	-
		Y, see ^{31}Si	-	5E+0	2E-9	7E-12	-	-
15	Phosphorus-32	D, all compounds except phosphates given for W	6E+2	9E+2	4E-7	1E-9	9E-6	9E-5
		W, phosphates of Zn^{2+}, S^{3+}, Mg^{2+}, Fe^{3+}, Bi^{3+}, and lanthanides	-	4E+2	2E-7	5E-10	-	-
15	Phosphorus-33	D, see ^{32}P	6E+3	8E+3	4E-6	1E-8	8E-5	8E-4
		W, see ^{32}P	-	3E+3	1E-6	4E-9	-	-
16	Sulfur-35	Vapor	-	1E+4	6E-6	2E-8	-	-
		D, sulfides and sulfates except those given for W	1E+4	2E+4	7E-6	2E-8	-	-
			LLI wall (8E+3)	-	-	-	1E-4	1E-3
		W, elemental sulfur, sulfides of Sr, Ba, Ge, Sn, Pb, As, Sb, Bi, Cu, Ag, Au, Zn, Cd, Hg, W, and Mo Sulfates of Ca, Sr, Ba, Ra, As, Sb, and Bi	6E+3 -	2E+3	9E-7	3E-9	-	-
17	Chlorine-36	D, chlorides of H, Li, Na, K, Rb, Cs, and Fr	2E+3	2E+3	1E-6	3E-9	2E-5	2E-4
		W, chlorides of lanthanides, Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, Ge, Sn, Pb, As, Sb, Bi, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Mn, Tc, and Re	-	2E+2	1E-7	3E-10	-	-
17	Chlorine-38[b]	D, see ^{36}Cl	2E+4	4E+4	2E-5	6E-8	-	-
			St wall (3E+4)	-	-	-	3E-4	3E-3
		W, see ^{36}Cl	-	5E+4	2E-5	6E-8	-	-
17	Chlorine-39[b]	D, see ^{36}Cl	2E+4	5E+4	2E-5	7E-8	-	-
			St wall (4E+4)	-	-	-	5E-4	5E-3
		W, see ^{36}Cl	-	6E+4	2E-5	8E-8	-	-
18	Argon-37	Submersion[b]	-	-	1E+0	6E-3	-	-
18	Argon-39	Submersion[b]	-	-	2E-4	8E-7	-	-
18	Argon-41	Submersion[b]	-	-	3E-6	1E-8	-	-
19	Potassium-40	D, all compounds	3E+2	4E+2	2E-7	6E-10	4E-6	4E-5
19	Potassium-42	D, all compounds	5E+3	5E+3	2E-6	7E-9	6E-5	6E-4
19	Potassium-43	D, all compounds	6E+3	9E+3	4E-6	1E-8	9E-5	9E-4
19	Potassium-44[b]	D, all compounds	2E+4	7E+4	3E-5	9E-8	-	-
			St wall (4E+4)	-	-	-	5E-4	5E-3

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
19	Potassium-45[b]	D, all compounds	3E+4	1E+5	5E-5	2E-7	-	-
			St wall (5E+4)	-	-	-	7E-4	7E-3
20	Calcium-41	W, all compounds	3E+3	4E+3	2E-6	-	-	-
			Bone surf (4E+3)	Bone surf (4E+3)	-	5E-9	6E-5	6E-4
20	Calcium-45	W, all compounds	2E+3	8E+2	4E-7	1E-9	2E-5	2E-4
20	Calcium-47	W, all compounds	8E+2	9E+2	4E-7	1E-9	1E-5	1E-4
21	Scandium-43	Y, all compounds	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
21	Scandium-44m	Y, all compounds	5E+2	7E+2	3E-7	1E-9	7E-6	7E-5
21	Scandium-44	Y, all compounds	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
21	Scandium-46	Y, all compounds	9E+2	2E+2	1E-7	3E-10	1E-5	1E-4
21	Scandium-47	Y, all compounds	2E+3	3E+3	1E-6	4E-9	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4
21	Scandium-48	Y, all compounds	8E+2	1E+3	6E-7	2E-9	1E-5	1E-4
21	Scandium-49[b]	Y, all compounds	2E+4	5E+4	2E-5	8E-8	3E-4	3E-3
22	Titanium-44	D, all compounds except those given for W and Y	3E+2	1E+1	5E-9	2E-11	4E-6	4E-5
		W, oxides, hydroxides, carbides, halides, and nitrates	-	3E+1	1E-8	4E-11	-	-
		Y, $SrTiO$	-	6E+0	2E-9	8E-12	-	-
22	Titanium-45	D, see ^{44}Ti	9E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{44}Ti	-	4E+4	1E-5	5E-8	-	-
		Y, see ^{44}Ti	-	3E+4	1E-5	4E-8	-	-
23	Vanadium-47[b]	D, all compounds except those given for W	3E+4	8E+4	3E-5	1E-7	-	-
			St wall (3E+4)	-	-	-	4E-4	4E-3
		W, oxides, hydroxides, carbides, and halides	-	1E+5	4E-5	1E-7	-	-
23	Vanadium-48	D, see ^{47}V	6E+2	1E+3	5E-7	2E-9	9E-6	9E-5
		W, see ^{47}V	-	6E+2	3E-7	9E-10	-	-
23	Vanadium-49	D, see ^{47}V	7E+4	3E+4	1E-5	-	-	-
			LLI wall (9E+4)	Bone surf (3E+4)	-	5E-8	1E-3	1E-2
		W, see ^{47}V	-	2E+4	8E-6	2E-8	-	-
24	Chromium-48	D, all compounds except those given for W and Y	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, halides and nitrates	-	7E+3	3E-6	1E-8	-	-
		Y, oxides and hydroxides	-	7E+3	3E-6	1E-8	-	-
24	Chromium-49[b]	D, see ^{48}Cr	3E+4	8E+4	4E-5	1E-7	4E-4	4E-3
		W, see ^{48}Cr	-	1E+5	4E-5	1E-7	-	-
		Y, see ^{48}Cr	-	9E+4	4E-5	1E-7	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
24	Chromium-51	D, see ^{48}Cr	4E+4	5E+4	2E-5	6E-8	5E-4	5E-3
		W, see ^{48}Cr	-	2E+4	1E-5	3E-8	-	-
		Y, see ^{48}Cr	-	2E+4	8E-6	3E-8	-	-
25	Manganese-51[b]	D, all compounds except those given for W	2E+4	5E+4	2E-5	7E-8	3E-4	3E-3
		W, oxides, hydroxides, halides, and nitrates	-	6E+4	3E-5	8E-8	-	-
25	Manganese-52m[b]	D, see ^{51}Mn	3E+4 St wall (4E+4)	9E+4	4E-5	1E-7	-	-
		W, see ^{51}Mn	-	- 1E+5	- 4E-5	- 1E-7	5E-4 -	5E-3 -
25	Manganese-52	D, see ^{51}Mn	7E+2	1E+3	5E-7	2E-9	1E-5	1E-4
		W, see ^{51}Mn	-	9E+2	4E-7	1E-9	-	-
25	Manganese-53	D, see ^{51}Mn	5E+4	1E+4 Bone surf (2E+4)	5E-6	-	7E-4	7E-3
		W, see ^{51}Mn	- -	- 1E+4	- 5E-6	3E-8 2E-8	- -	- -
25	Manganese-54	D, see ^{51}Mn	2E+3	9E+2	4E-7	1E-9	3E-5	3E-4
		W, see ^{51}Mn	-	8E+2	3E-7	1E-9	-	-
25	Manganese-56	D, see ^{51}Mn	5E+3	2E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{51}Mn	-	2E+4	9E-6	3E-8	-	-
26	Iron-52	D, all compounds except those given for W	9E+2	3E+3	1E-6	4E-9	1E-5	1E-4
		W, oxides, hydroxides, and halides	-	2E+3	1E-6	3E-9	-	-
26	Iron-55	D, see ^{52}Fe	9E+3	2E+3	8E-7	3E-9	1E-4	1E-3
		W, see ^{52}Fe	-	4E+3	2E-6	6E-9	-	-
26	Iron-59	D, see ^{52}Fe	8E+2	3E+2	1E-7	5E-10	1E-5	1E-4
		W, see ^{52}Fe	-	5E+2	2E-7	7E-10	-	-
26	Iron-60	D, see ^{52}Fe	3E+1	6E+0	3E-9	9E-12	4E-7	4E-6
		W, see ^{52}Fe	-	2E+1	8E-9	3E-11	-	-
27	Cobalt-55	W, all compounds except those given for Y	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, oxides, hydroxides, halides, and nitrates	-	3E+3	1E-6	4E-9	-	-
27	Cobalt-56	W, see ^{55}Co	5E+2	3E+2	1E-7	4E-10	6E-6	6E-5
		Y, see ^{55}Co	4E+2	2E+2	8E-8	3E-10	-	-
27	Cobalt-57	W, see ^{55}Co	8E+3	3E+3	1E-6	4E-9	6E-5	6E-4
		Y, see ^{55}Co	4E+3	7E+2	3E-7	9E-10	-	-
27	Cobalt-58m	W, see ^{55}Co	6E+4	9E+4	4E-5	1E-7	8E-4	8E-3
		Y, see ^{55}Co	-	6E+4	3E-5	9E-8	-	-
27	Cobalt-58	W, see ^{55}Co	2E+3	1E+3	5E-7	2E-9	2E-5	2E-4
		Y, see ^{55}Co	1E+3	7E+2	3E-7	1E-9	-	-
27	Cobalt-60m[b]	W, see ^{55}Co	1E+6 St wall (1E+6)	4E+6	2E-3	6E-6	-	-
		Y, see ^{55}Co	-	- 3E+6	- 1E-3	- 4E-6	2E-2 -	2E-1 -

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
27	Cobalt-60	W, see ^{55}Co	5E+2	2E+2	7E-8	2E-10	3E-6	3E-5
		Y, see ^{55}Co	2E+2	3E+1	1E-8	5E-11	-	-
27	Cobalt-61[b]	W, see ^{55}Co	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		Y, see ^{55}Co	2E+4	6E+4	2E-5	8E-8	-	-
27	Cobalt-62m[b]	W, see ^{55}Co	4E+4	2E+5	7E-5	2E-7	-	-
			St wall (5E+4)	-	-	-	7E-4	7E-3
		Y, see ^{55}Co	-	2E+5	6E-5	2E-7	-	-
28	Nickel-56	D, all compounds except those given for W	1E+3	2E+3	8E-7	3E-9	2E-5	2E-4
		W, oxides, hydroxides, and carbides	-	1E+3	5E-7	2E-9	-	-
		Vapor	-	1E+3	5E-7	2E-9	-	-
28	Nickel-57	D, see ^{56}Ni	2E+3	5E+3	2E-6	7E-9	2E-5	2E-4
		W, see ^{56}Ni	-	3E+3	1E-6	4E-9	-	-
		Vapor	-	6E+3	3E-6	9E-9	-	-
28	Nickel-59	D, see ^{56}Ni	2E+4	4E+3	2E-6	5E-9	3E-4	3E-3
		W, see ^{56}Ni	-	7E+3	3E-6	1E-8	-	-
		Vapor	-	2E+3	8E-7	3E-9	-	-
28	Nickel-63	D, see ^{56}Ni	9E+3	2E+3	7E-7	2E-9	1E-4	1E-3
		W, see ^{56}Ni	-	3E+3	1E-6	4E-9	-	-
		Vapor	-	8E+2	3E-7	1E-9	-	-
28	Nickel-65	D, see ^{56}Ni	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{56}Ni	-	3E+4	1E-5	4E-8	-	-
		Vapor	-	2E+4	7E-6	2E-8	-	-
28	Nickel-66	D, see ^{56}Ni	4E+2	2E+3	7E-7	2E-9	-	-
			LLI wall (5E+2)	-	-	-	6E-6	6E-5
		W, see ^{56}Ni	-	6E+2	3E-7	9E-10	-	-
		Vapor	-	3E+3	1E-6	4E-9	-	-
29	Copper-60[b]	D, all compounds except those given for W and Y	3E+4	9E+4	4E-5	1E-7	-	-
			St wall (3E+4)	-	-	-	4E-4	4E-3
		W, sulfides, halides, and nitrates	-	1E+5	5E-5	2E-7	-	-
		Y, oxides and hydroxides	-	1E+5	4E-5	1E-7	-	-
29	Copper-61	D, see ^{60}Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{60}Cu	-	4E+4	2E-5	6E-8	-	-
		Y, see ^{60}Cu	-	4E+4	1E-5	5E-8	-	-
29	Copper-64	D, see ^{60}Cu	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{60}Cu	-	2E+4	1E-5	3E-8	-	-
		Y, see ^{60}Cu	-	2E+4	9E-6	3E-8	-	-
29	Copper-67	D, see ^{60}Cu	5E+3	8E+3	3E-6	1E-8	6E-5	6E-4
		W, see ^{60}Cu	-	5E+3	2E-6	7E-9	-	-
		Y, see ^{60}Cu	-	5E+3	2E-6	6E-9	-	-
30	Zinc-62	Y, all compounds	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
30	Zinc-63[b]	Y, all compounds	2E+4	7E+4	3E-5	9E-8	-	-
			St wall (3E+4)	-	-	-	3E-4	3E-3

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
30	Zinc-65	Y, all compounds	4E+2	3E+2	1E-7	4E-10	5E-6	5E-5
30	Zinc-69m	Y, all compounds	4E+3	7E+3	3E-6	1E-8	6E-5	6E-4
30	Zinc-69[b]	Y, all compounds	6E+4	1E+5	6E-5	2E-7	8E-4	8E-3
30	Zinc-71m	Y, all compounds	6E+3	2E+4	7E-6	2E-8	8E-5	8E-4
30	Zinc-72	Y, all compounds	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
31	Gallium-65[b]	D, all compounds except those given for W	5E+4 St wall (6E+4)	2E+5	7E-5	2E-7	-	-
		W, oxides, hydroxides, carbides, halides, and nitrates	-	-	-	-	9E-4	9E-3
			-	2E+5	8E-5	3E-7	-	-
31	Gallium-66	D, see ^{65}Ga	1E+3	4E+3	1E-6	5E-9	1E-5	1E-4
		W, see ^{65}Ga	-	3E+3	1E-6	4E-9	-	-
31	Gallium-67	D, see ^{65}Ga	7E+3	1E+4	6E-6	2E-8	1E-4	1E-3
		W, see ^{65}Ga	-	1E+4	4E-6	1E-8	-	-
31	Gallium-68[b]	D, see ^{65}Ga	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{65}Ga	-	5E+4	2E-5	7E-8	-	-
31	Gallium-70[b]	D, see ^{65}Ga	5E+4 St wall (7E+4)	2E+5	7E-5	2E-7	-	-
		W, see ^{65}Ga	-	- 2E+5	- 8E-5	- 3E-7	1E-3 -	1E-2 -
31	Gallium-72	D, see ^{65}Ga	1E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{65}Ga	-	3E+3	1E-6	4E-9	-	-
31	Gallium-73	D, see ^{65}Ga	5E+3	2E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{65}Ga	-	2E+4	6E-6	2E-8	-	-
32	Germanium-66	D, all compounds except those given for W	2E+4	3E+4	1E-5	4E-8	3E-4	3E-3
		W, oxides, sulfides, and halides	-	2E+4	8E-6	3E-8	-	-
32	Germanium-67[b]	D, see ^{66}Ge	3E+4 St wall (4E+4)	9E+4	4E-5	1E-7	-	-
		W, see ^{66}Ge	-	- 1E+5	- 4E-5	- 1E-7	6E-4 -	6E-3 -
32	Germanium-68	D, see ^{66}Ge	5E+3	4E+3	2E-6	5E-9	6E-5	6E-4
		W, see ^{66}Ge	-	1E+2	4E-8	1E-10	-	-
32	Germanium-69	D, see ^{66}Ge	1E+4	2E+4	6E-6	2E-8	2E-4	2E-3
		W, see ^{66}Ge	-	8E+3	3E-6	1E-8	-	-
32	Germanium-71	D, see ^{66}Ge	5E+5	4E+5	2E-4	6E-7	7E-3	7E-2
		W, see ^{66}Ge	-	4E+4	2E-5	6E-8	-	-
32	Germanium-75[b]	D, see ^{66}Ge	4E+4 St wall (7E+4)	8E+4	3E-5	1E-7	-	-
		W, see ^{66}Ge	-	- 8E+4	- 4E-5	- 1E-7	9E-4 -	9E-3 -

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
32	Germanium-77	D, see ^{66}Ge	9E+3	1E+4	4E-6	1E-8	1E-4	1E-3
		W, see ^{66}Ge	-	6E+3	2E-6	8E-9	-	-
32	Germanium-78[b]	D, see ^{66}Ge	2E+4	2E+4	9E-6	3E-8	-	-
			St wall (2E+4)	-	-	-	3E-4	3E-3
		W, see ^{66}Ge	-	2E+4	9E-6	3E-8	-	-
33	Arsenic-69[b]	W, all compounds	3E+4	1E+5	5E-5	2E-7	-	-
			St wall (4E+4)	-	-	-	6E-4	6E-3
33	Arsenic-70[b]	W, all compounds	1E+4	5E+4	2E-5	7E-8	2E-4	2E-3
33	Arsenic-71	W, all compounds	4E+3	5E+3	2E-6	6E-9	5E-5	5E-4
33	Arsenic-72	W, all compounds	9E+2	1E+3	6E-7	2E-9	1E-5	1E-4
33	Arsenic-73	W, all compounds	8E+3	2E+3	7E-7	2E-9	1E-4	1E-3
33	Arsenic-74	W, all compounds	1E+3	8E+2	3E-7	1E-9	2E-5	2E-4
33	Arsenic-76	W, all compounds	1E+3	1E+3	6E-7	2E-9	1E-5	1E-4
33	Arsenic-77	W, all compounds	4E+3	5E+3	2E-6	7E-9	-	-
			LLI wall (5E+3)	-	-	-	6E-5	6E-4
33	Arsenic-78[b]	W, all compounds	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
34	Selenium-70[b]	D, all compounds except those given for W	2E+4	4E+4	2E-5	5E-8	1E-4	1E-3
		W, oxides, hydroxides, carbides, and elemental Se	1E+4	4E+4	2E-5	6E-8	-	-
34	Selenium-73m[b]	D, see ^{70}Se	6E+4	2E+5	6E-5	2E-7	4E-4	4E-3
		W, see ^{70}Se	3E+4	1E+5	6E-5	2E-7	-	-
34	Selenium-73	D, see ^{70}Se	3E+3	1E+4	5E-6	2E-8	4E-5	4E-4
		W, see ^{70}Se	-	2E+4	7E-6	2E-8	-	-
34	Selenium-75	D, see ^{70}Se	5E+2	7E+2	3E-7	1E-9	7E-6	7E-5
		W, see ^{70}Se	-	6E+2	3E-7	8E-10	-	-
34	Selenium-79	D, see ^{70}Se	6E+2	8E+2	3E-7	1E-9	8E-6	8E-5
		W, see ^{70}Se	-	6E+2	2E-7	8E-10	-	-
34	Selenium-81m[b]	D, see ^{70}Se	4E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		W, see ^{70}Se	2E+4	7E+4	3E-5	1E-7	-	-
34	Selenium-81[b]	D, see ^{70}Se	6E+4	2E+5	9E-5	3E-7	-	-
			St wall (8E+4)	-	-	-	1E-3	1E-2
		W, see ^{70}Se	-	2E+5	1E-4	3E-7	-	-
34	Selenium-83[b]	D, see ^{70}Se	4E+4	1E+5	5E-5	2E-7	4E-4	4E-3
		W, see ^{70}Se	3E+4	1E+5	5E-5	2E-7	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
35	Bromine-74m[b]	D, bromides of H, Li, Na, K, Rb, Cs, and Fr	1E+4	4E+4	2E-5	5E-8	-	-
			St wall (2E+4)	-	-	-	3E-4	3E-3
		W, bromides of lanthanides, Be, Mg, Ca, Sr, Ba, Ra, Al, Ga, In, Tl, Ge, Sn, Pb, As, Sb, Bi, Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, Cu, Ag, Au, Zn, Cd, Hg, Sc, Y, Ti, Zr, Hf, V, Nb, Ta, Mn, Tc, and Re	-	4E+4	2E-5	6E-8	-	-
35	Bromine-74[b]	D, see ^{74m}Br	2E+4	7E+4	3E-5	1E-7	-	-
			St wall (4E+4)	-	-	-	5E-4	5E-3
		W, see ^{74m}Br	-	8E+4	4E-5	1E-7	-	-
35	Bromine-75[b]	D, see ^{74m}Br	3E+4	5E+4	2E-5	7E-8	-	-
			St wall (4E+4)	-	-	-	5E-4	5E-3
		W, see ^{74m}Br	-	5E+4	2E-5	7E-8	-	-
35	Bromine-76	D, see ^{74m}Br	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
		W, see ^{74m}Br	-	4E+3	2E-6	6E-9	-	-
35	Bromine-77	D, see ^{74m}Br	2E+4	2E+4	1E-5	3E-8	2E-4	2E-3
		W, see ^{74m}Br	-	2E+4	8E-6	3E-8	-	-
35	Bromine-80m	D, see ^{74m}Br	2E+4	2E+4	7E-6	2E-8	3E-4	3E-3
		W, see ^{74m}Br	-	1E+4	6E-6	2E-8	-	-
35	Bromine-80[b]	D, see ^{74m}Br	5E+4	2E+5	8E-5	3E-7	-	-
			St wall (9E+4)	-	-	-	1E-3	1E-2
		W, see ^{74m}Br	-	2E+5	9E-5	3E-7	-	-
35	Bromine-82	D, see ^{74m}Br	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
		W, see ^{74m}Br	-	4E+3	2E-6	5E-9	-	-
35	Bromine-83	D, see ^{74m}Br	5E+4	6E+4	3E-5	9E-8	-	-
			St wall (7E+4)	-	-	-	9E-4	9E-3
		W, see ^{74m}Br	-	6E+4	3E-5	9E-8	-	-
35	Bromine-84[b]	D, see ^{74m}Br	2E+4	6E+4	2E-5	8E-8	-	-
			St wall (3E+4)	-	-	-	4E-4	4E-3
		W, see ^{74m}Br	-	6E+4	3E-5	9E-8	-	-
36	Krypton-74[b]	Submersion[b]	-	-	3E-6	1E-8	-	-
36	Krypton-76	Submersion[b]	-	-	9E-6	4E-8	-	-
36	Krypton-77[b]	Submersion[b]	-	-	4E-6	2E-8	-	-
36	Krypton-79	Submersion[b]	-	-	2E-5	7E-8	-	-
36	Krypton-81	Submersion[b]	-	-	7E-4	3E-6	-	-
36	Krypton-83m[b]	Submersion[b]	-	-	1E-2	5E-5	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col 1 Oral Ingestion ALI (μCi)	Col 2 Inhalation ALI (μCi)	Col 3 DAC (μCi/ml)	Col 1 Air (μCi/ml)	Col 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
36	Krypton-85m	Submersion[a]	-	-	2E-5	1E-7	-	-
36	Krypton-85	Submersion[a]	-	-	1E-4	7E-7	-	-
36	Krypton-87[b]	Submersion[a]	-	-	5E-6	2E-8	-	-
36	Krypton-88	Submersion[a]	-	-	2E-6	9E-9	-	-
37	Rubidium-79[b]	D, all compounds	4E+4	1E+5	5E-5	2E-7	-	-
			St wall (6E+4)	-	-	-	8E-4	8E-3
37	Rubidium-81m[b]	D, all compounds	2E+5	3E+5	1E-4	5E-7	-	-
			St wall (3E+5)	-	-	-	4E-3	4E-2
37	Rubidium-81	D, all compounds	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
37	Rubidium-82m	D, all compounds	1E+4	2E+4	7E-6	2E-8	2E-4	2E-3
37	Rubidium-83	D, all compounds	6E+2	1E+3	4E-7	1E-9	9E-6	9E-5
37	Rubidium-84	D, all compounds	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-86	D, all compounds	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
37	Rubidium-87	D, all compounds	1E+3	2E+3	6E-7	2E-9	1E-5	1E-4
37	Rubidium-88[b]	D, all compounds	2E+4	6E+4	3E-5	9E-8	-	-
			St wall (3E+4)	-	-	-	4E-4	4E-3
37	Rubidium-89[b]	D, all compounds	4E+4	1E+5	6E-5	2E-7	-	-
			St wall (6E+4)	-	-	-	9E-4	9E-3
38	Strontium-80[b]	D, all soluble compounds except $SrTiO_3$	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		Y, all insoluble compounds and $SrTiO_3$	-	1E+4	5E-6	2E-8	-	-
38	Strontium-81[b]	D, see ^{90}Sr	3E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		Y, see ^{90}Sr	2E+4	8E+4	3E-5	1E-7	-	-
38	Strontium-82	D, see ^{90}Sr	3E+2	4E+2	2E-7	6E-10	-	-
			LLI wall (2E+2)	-	-	-	3E-6	3E-5
		Y, see ^{90}Sr	2E+2	9E+1	4E-8	1E-10	-	-
38	Strontium-83	D, see ^{90}Sr	3E+3	7E+3	3E-6	1E-8	3E-5	3E-4
		Y, see ^{90}Sr	2E+3	4E+3	1E-6	5E-9	-	-
38	Strontium-85m[b]	D, see ^{90}Sr	2E+5	6E+5	3E-4	9E-7	3E-3	3E-2
		Y, see ^{90}Sr	-	8E+5	4E-4	1E-6	-	-
38	Strontium-85	D, see ^{90}Sr	3E+3	3E+3	1E-6	4E-9	4E-5	4E-4
		Y, see ^{90}Sr	-	2E+3	6E-7	2E-9	-	-
38	Strontium-87m	D, see ^{90}Sr	5E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		Y, see ^{90}Sr	4E+4	2E+5	6E-5	2E-7	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
38	Strontium-89	D, see ^{80}Sr	6E+2	8E+2	4E-7	1E-9	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
		Y, see ^{80}Sr	5E+2	1E+2	6E-8	2E-10	-	-
38	Strontium-90	D, see ^{80}Sr	3E+1	2E+1	8E-9	-	-	-
			Bone surf (4E+1)	Bone surf (2E+1)	-	3E-11	5E-7	5E-6
		Y, see ^{80}Sr	-	4E+0	2E-9	6E-12	-	-
38	Strontium-91	D, see ^{80}Sr	2E+3	6E+3	2E-6	8E-9	2E-5	2E-4
		Y, see ^{80}Sr	-	4E+3	1E-6	5E-9	-	-
38	Strontium-92	D, see ^{80}Sr	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{80}Sr	-	7E+3	3E-6	9E-9	-	-
39	Yttrium-86m[b]	W, all compounds except those given for Y	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
		Y, oxides and hydroxides	-	5E+4	2E-5	8E-8	-	-
39	Yttrium-86	W, see ^{86m}Y	1E+3	3E+3	1E-6	5E-9	2E-5	2E-4
		Y, see ^{86m}Y	-	3E+3	1E-6	5E-9	-	-
39	Yttrium-87	W, see ^{86m}Y	2E+3	3E+3	1E-6	5E-9	3E-5	3E-4
		Y, see ^{86m}Y	-	3E+3	1E-6	5E-9	-	-
39	Yttrium-88	W, see ^{86m}Y	1E+3	3E+2	1E-7	3E-10	1E-5	1E-4
		Y, see ^{86m}Y	-	2E+2	1E-7	3E-10	-	-
39	Yttrium-90m	W, see ^{86m}Y	8E+3	1E+4	5E-6	2E-8	1E-4	1E-3
		Y, see ^{86m}Y	-	1E+4	5E-6	2E-8	-	-
39	Yttrium-90	W, see ^{86m}Y	4E+2	7E+2	3E-7	9E-10	-	-
			LLI wall (5E+2)	-	-	-	7E-6	7E-5
		Y, see ^{86m}Y	-	6E+2	3E-7	9E-10	-	-
39	Yttrium-91m[b]	W, see ^{86m}Y	1E+5	2E+5	1E-4	3E-7	2E-3	2E-2
		Y, see ^{86m}Y	-	2E+5	7E-5	2E-7	-	-
39	Yttrium-91	W, see ^{86m}Y	5E+2	2E+2	7E-8	2E-10	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
		Y, see ^{86m}Y	-	1E+2	5E-8	2E-10	-	-
39	Yttrium-92	W, see ^{86m}Y	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{86m}Y	-	8E+3	3E-6	1E-8	-	-
39	Yttrium-93	W, see ^{86m}Y	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, see ^{86m}Y	-	2E+3	1E-6	3E-9	-	-
39	Yttrium-94[b]	W, see ^{86m}Y	2E+4	8E+4	3E-5	1E-7	-	-
			St wall (3E+4)	-	-	-	4E-4	4E-3
		Y, see ^{86m}Y	-	8E+4	3E-5	1E-7	-	-
39	Yttrium-95[b]	W, see ^{86m}Y	4E+4	2E+5	6E-5	2E-7	-	-
			St wall (5E+4)	-	-	-	7E-4	7E-3
		Y, see ^{86m}Y	-	1E+5	6E-5	2E-7	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

			Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col 1	Col 2	Col 3	Col. 1	Col 2	
Atomic No	Radionuclide	Class	Oral Ingestion ALI (μCi)	Inhalation ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
40	Zirconium-86	D, all compounds except those given for W and Y	1E+3	4E+3	2E-6	6E-9	2E-5	2E-4
		W, oxides, hydroxides, halides, and nitrates	-	3E+3	1E-6	4E-9	-	-
		Y, carbide	-	2E+3	1E-6	3E-9	-	-
40	Zirconium-88	D, see ^{86}Zr	4E+3	2E+2	9E-8	3E-10	5E-5	5E-4
		W, see ^{86}Zr	-	5E+2	2E-7	7E-10	-	-
		Y, see ^{86}Zr	-	3E+2	1E-7	4E-10	-	-
40	Zirconium-89	D, see ^{86}Zr	2E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{86}Zr	-	2E+3	1E-6	3E-9	-	-
		Y, see ^{86}Zr	-	2E+3	1E-6	3E-9	-	-
40	Zirconium-93	D, see ^{86}Zr	1E+3 Bone surf (3E+3)	6E+0 Bone surf (2E+1)	3E-9	-	-	-
		W, see ^{86}Zr	-	2E+1 Bone surf (6E+1)	-	2E-11	4E-5	4E-4
		Y, see ^{86}Zr	-	6E+1 Bone surf (7E+1)	2E-8	9E-11	-	-
40	Zirconium-95	D, see ^{86}Zr	1E+3	1E+2 Bone surf (3E+2)	5E-8	-	2E-5	2E-4
		W, see ^{86}Zr	-	4E+2	2E-7	4E-10	-	-
		Y, see ^{86}Zr	-	3E+2	1E-7	5E-10	-	-
40	Zirconium-97	D, see ^{86}Zr	6E+2	2E+3	8E-7	4E-10	-	-
		W, see ^{86}Zr	-	1E+3	6E-7	3E-9	9E-6	9E-5
		Y, see ^{86}Zr	-	1E+3	5E-7	2E-9	-	-
41	Niobium-88[b]	W, all compounds except those given for Y	5E+4 St wall (7E+4)	2E+5	9E-5	3E-7	-	-
		Y, oxides and hydroxides	-	2E+5	9E-5	3E-7	1E-3	1E-2
41	Niobium-89[b] (66 min)	W, see ^{88}Nb	1E+4	4E+4	2E-5	6E-8	1E-4	1E-3
		Y, see ^{88}Nb	-	4E+4	2E-5	5E-8	-	-
41	Niobium-89 (122 min)	W, see ^{88}Nb	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		Y, see ^{88}Nb	-	2E+4	6E-6	2E-8	-	-
41	Niobium-90	W, see ^{88}Nb	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		Y, see ^{88}Nb	-	2E+3	1E-6	3E-9	-	-
41	Niobium-93m	W, see ^{88}Nb	9E+3 LLI wall (1E+4)	2E+3	8E-7	3E-9	-	-
		Y, see ^{88}Nb	-	2E+2	7E-8	2E-10	2E-4	2E-3
41	Niobium-94	W, see ^{88}Nb	9E+2	2E+2	8E-8	3E-10	1E-5	1E-4
		Y, see ^{88}Nb	-	2E+1	6E-9	2E-11	-	-
41	Niobium-95m	W, see ^{88}Nb	2E+3 LLI wall (2E+3)	3E+3	1E-6	4E-9	-	-
		Y, see ^{88}Nb	-	2E+3	9E-7	3E-9	3E-5	3E-4

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
41	Niobium-95	W, see ^{88}Nb	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
		Y, see ^{88}Nb	-	1E+3	5E-7	2E-9	-	-
41	Niobium-96	W, see ^{88}Nb	1E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		Y, see ^{88}Nb	-	2E+3	1E-6	3E-9	-	-
41	Niobium-97[b]	W, see ^{88}Nb	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		Y, see ^{88}Nb	-	7E+4	3E-5	1E-7	-	-
41	Niobium-98[b]	W, see ^{88}Nb	1E+4	5E+4	2E-5	8E-8	2E-4	2E-3
		Y, see ^{88}Nb	-	5E+4	2E-5	7E-8	-	-
42	Molybdenum-90	D, all compounds except those given for Y	4E+3	7E+3	3E-6	1E-8	3E-5	3E-4
		Y, oxides, hydroxides, and MoS_2	2E+3	5E+3	2E-6	6E-9	-	-
42	Molybdenum-93m	D, see ^{90}Mo	9E+3	2E+4	7E-6	2E-8	6E-5	6E-4
		Y, see ^{90}Mo	4E+3	1E+4	6E-6	2E-8	-	-
42	Molybdenum-93	D, see ^{90}Mo	4E+3	5E+3	2E-6	8E-9	5E-5	5E-4
		Y, see ^{90}Mo	2E+4	2E+2	8E-8	2E-10	-	-
42	Molybdenum-99	D, see ^{90}Mo	2E+3 LLI wall (1E+3)	3E+3 -	1E-6 -	4E-9 -	- -	- -
		Y, see ^{90}Mo	1E+3	1E+3	6E-7	2E-9	2E-5 -	2E-4 -
42	Molybdenum-101[b]	D, see ^{90}Mo	4E+4 St wall (5E+4)	1E+5 -	6E-5 -	2E-7 -	- 7E-4	- 7E-3
		Y, see ^{90}Mo	-	1E+5	6E-5	2E-7	-	-
43	Technetium-93m[b]	D, all compounds except those given for W	7E+4	2E+5	6E-5	2E-7	1E-3	1E-2
		W, oxides, hydroxides, halides, and nitrates	-	3E+5	1E-4	4E-7	-	-
43	Technetium-93	D, see ^{93m}Tc	3E+4	7E+4	3E-5	1E-7	4E-4	4E-3
		W, see ^{93m}Tc	-	1E+5	4E-5	1E-7	-	-
43	Technetium-94m[b]	D, see ^{93m}Tc	2E+4	4E+4	2E-5	6E-8	3E-4	3E-3
		W, see ^{93m}Tc	-	6E+4	2E-5	8E-8	-	-
43	Technetium-94	D, see ^{93m}Tc	9E+3	2E+4	8E-6	3E-8	1E-4	1E-3
		W, see ^{93m}Tc	-	2E+4	1E-5	3E-8	-	-
43	Technetium-95m	D, see ^{93m}Tc	4E+3	5E+3	2E-6	8E-9	5E-5	5E-4
		W, see ^{93m}Tc	-	2E+3	8E-7	3E-9	-	-
43	Technetium-95	D, see ^{93m}Tc	1E+4	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{93m}Tc	-	2E+4	8E-6	3E-8	-	-
43	Technetium-96m[b]	D, see ^{93m}Tc	2E+5	3E+5	1E-4	4E-7	2E-3	2E-2
		W, see ^{93m}Tc	-	2E+5	1E-4	3E-7	-	-
43	Technetium-96	D, see ^{93m}Tc	2E+3	3E+3	1E-6	5E-9	3E-5	3E-4
		W, see ^{93m}Tc	-	2E+3	9E-7	3E-9	-	-
43	Technetium-97m	D, see ^{93m}Tc	5E+3	7E+3 St wall (7E+3)	3E-6 -	- 1E-8	6E-5 -	6E-4 -
		W, see ^{93m}Tc	-	1E+3	5E-7	2E-9	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
43	Technetium-97	D, see ^{93m}Tc	4E+4	5E+4	2E-5	7E-8	5E-4	5E-3
		W, see ^{93m}Tc	-	6E+3	2E-6	8E-9	-	-
43	Technetium-98	D, see ^{93m}Tc	1E+3	2E+3	7E-7	2E-9	1E-5	1E-4
		W, see ^{93m}Tc	-	3E+2	1E-7	4E-10	-	-
43	Technetium-99m	D, see ^{93m}Tc	8E+4	2E+5	6E-5	2E-7	1E-3	1E-2
		W, see ^{93m}Tc	-	2E+5	1E-4	3E-7	-	-
43	Technetium-99	D, see ^{93m}Tc	4E+3	5E+3 St wall (6E+3)	2E-6 -	- 8E-9	6E-5 -	6E-4 -
		W, see ^{93m}Tc	-	7E+2	3E-7	9E-10	-	-
43	Technetium-101[b]	D, see ^{93m}Tc	9E+4 St wall (1E+5)	3E+5 -	1E-4 -	5E-7 -	- 2E-3	- 2E-2
		W, see ^{93m}Tc	-	4E+5	2E-4	5E-7	-	-
43	Technetium-104[b]	D, see ^{93m}Tc	2E+4 St wall (3E+4)	7E+4 -	3E-5 -	1E-7 -	- 4E-4	- 4E-3
		W, see ^{93m}Tc	-	9E+4	4E-5	1E-7	-	-
44	Ruthenium-94[b]	D, all compounds except those given for W and Y	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, halides	-	6E+4	3E-5	9E-8	-	-
		Y, oxides and hydroxides	-	6E+4	2E-5	8E-8	-	-
44	Ruthenium-97	D, see ^{94}Ru	8E+3	2E+4	8E-6	3E-8	1E-4	1E-3
		W, see ^{94}Ru	-	1E+4	5E-6	2E-8	-	-
		Y, see ^{94}Ru	-	1E+4	5E-6	2E-8	-	-
44	Ruthenium-103	D, see ^{94}Ru	2E+3	2E+3	7E-7	2E-9	3E-5	3E-4
		W, see ^{94}Ru	-	1E+3	4E-7	1E-9	-	-
		Y, see ^{94}Ru	-	6E+2	3E-7	9E-10	-	-
44	Ruthenium-105	D, see ^{94}Ru	5E+3	1E+4	6E-6	2E-8	7E-5	7E-4
		W, see ^{94}Ru	-	1E+4	6E-6	2E-8	-	-
		Y, see ^{94}Ru	-	1E+4	5E-6	2E-8	-	-
44	Ruthenium-106	D, see ^{94}Ru	2E+2 LLI wall (2E+2)	9E+1 -	4E-8 -	1E-10 -	- 3E-6	- 3E-5
		W, see ^{94}Ru	-	5E+1	2E-8	8E-11	-	-
		Y, see ^{94}Ru	-	1E+1	5E-9	2E-11	-	-
45	Rhodium-99m	D, all compounds except those given for W and Y	2E+4	6E+4	2E-5	8E-8	2E-4	2E-3
		W, halides	-	8E+4	3E-5	1E-7	-	-
		Y, oxides and hydroxides	-	7E+4	3E-5	9E-8	-	-
45	Rhodium-101m	D, see ^{99m}Rh	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, see ^{99m}Rh	-	8E+3	4E-6	1E-8	-	-
		Y, see ^{99m}Rh	-	8E+3	3E-6	1E-8	-	-
45	Rhodium-101	D, see ^{99m}Rh	2E+3	5E+2	2E-7	7E-10	3E-5	3E-4
		W, see ^{99m}Rh	-	8E+2	3E-7	1E-9	-	-
		Y, see ^{99m}Rh	-	2E+2	6E-8	2E-10	-	-
45	Rhodium-99	D, see ^{99m}Rh	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{99m}Rh	-	2E+3	9E-7	3E-9	-	-
		Y, see ^{99m}Rh	-	2E+3	8E-7	3E-9	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
45	Rhodium-100	D, see ^{99m}Rh	2E+3	5E+3	2E-6	7E-9	2E-5	2E-4
		W, see ^{99m}Rh	-	4E+3	2E-6	6E-9	-	-
		Y, see ^{99m}Rh	-	4E+3	2E-6	5E-9	-	-
45	Rhodium-102m	D, see ^{99m}Rh	1E+3 LLI wall (1E+3)	5E+2	2E-7	7E-10	-	-
		W, see ^{99m}Rh	-	4E+2	2E-7	5E-10	2E-5	2E-4
		Y, see ^{99m}Rh	-	1E+2	5E-8	2E-10	-	-
45	Rhodium-102	D, see ^{99m}Rh	6E+2	9E+1	4E-8	1E-10	8E-6	8E-5
		W, see ^{99m}Rh	-	2E+2	7E-8	2E-10	-	-
		Y, see ^{99m}Rh	-	6E+1	2E-8	8E-11	-	-
45	Rhodium-103m[b]	D, see ^{99m}Rh	4E+5	1E+6	5E-4	2E-6	6E-3	6E-2
		W, see ^{99m}Rh	-	1E+6	5E-4	2E-6	-	-
		Y, see ^{99m}Rh	-	1E+6	5E-4	2E-6	-	-
45	Rhodium-105	D, see ^{99m}Rh	4E+3 LLI wall (4E+3)	1E+4	5E-6	2E-8	-	-
		W, see ^{99m}Rh	-	6E+3	3E-6	9E-9	5E-5	5E-4
		Y, see ^{99m}Rh	-	6E+3	2E-6	8E-9	-	-
45	Rhodium-106m	D, see ^{99m}Rh	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, see ^{99m}Rh	-	4E+4	2E-5	5E-8	-	-
		Y, see ^{99m}Rh	-	4E+4	1E-5	5E-8	-	-
45	Rhodium-107[b]	D, see ^{99m}Rh	7E+4 St wall (9E+4)	2E+5	1E-4	3E-7	-	-
		W, see ^{99m}Rh	-	3E+5	1E-4	4E-7	1E-3	1E-2
		Y, see ^{99m}Rh	-	3E+5	1E-4	3E-7	-	-
46	Palladium-100	D, all compound44s except those given for W and4 Y	1E+3	1E+3	6E-7	2E-9	2E-5	2E-4
		W, nitrates	-	1E+3	5E-7	2E-9	-	-
		Y, oxides and hydroxides	-	1E+3	6E-7	2E-9	-	-
46	Palladium-101	D, see ^{100}Pd	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{100}Pd	-	3E+4	1E-5	5E-8	-	-
		Y, see ^{100}Pd	-	3E+4	1E-5	4E-8	-	-
46	Palladium-103	D, see ^{100}Pd	6E+3 LLI wall (7E+3)	6E+3	3E-6	9E-9	-	-
		W, see ^{100}Pd	-	4E+3	2E-6	6E-9	1E-4	1E-3
		Y, see ^{100}Pd	-	4E+3	1E-6	5E-9	-	-
46	Palladium-107	D, see ^{100}Pd	3E+4 LLI wall (4E+4)	2E+4 Kidneys (2E+4)	9E-6	-	-	-
		W, see ^{100}Pd	-	7E+3	3E-6	3E-8	5E-4	5E-3
		Y, see ^{100}Pd	-	4E+2	2E-7	1E-8	-	-
						6E-10	-	-
46	Palladium-109	D, see ^{100}Pd	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
		W, see ^{100}Pd	-	5E+3	2E-6	8E-9	-	-
		Y, see ^{100}Pd	-	5E+3	2E-6	6E-9	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
47	Silver-102[b]	D, all compounds except those given for W and Y	5E+4 St wall (6E+4)	2E+5 -	8E-5 -	2E-7 -	- 9E-4	- 9E-3
		W, nitrates and sulfides	-	2E+5	9E-5	3E-7	-	-
		Y, oxides and hydroxides	-	2E+5	8E-5	3E-7	-	-
47	Silver-103[b]	D, see ^{102}Ag	4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
		W, see ^{102}Ag	-	1E+5	5E-5	2E-7	-	-
		Y, see ^{102}Ag	-	1E+5	5E-5	2E-7	-	-
47	Silver-104m[b]	D, see ^{102}Ag	3E+4	9E+4	4E-5	1E-7	4E-4	4E-3
		W, see ^{102}Ag	-	1E+5	5E-5	2E-7	-	-
		Y, see ^{102}Ag	-	1E+5	5E-5	2E-7	-	-
47	Silver-104[b]	D, see ^{102}Ag	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{102}Ag	-	1E+5	6E-5	2E-7	-	-
		Y, see ^{102}Ag	-	1E+5	6E-5	2E-7	-	-
47	Silver-105	D, see ^{102}Ag	3E+3	1E+3	4E-7	1E-9	4E-5	4E-4
		W, see ^{102}Ag	-	2E+3	7E-7	2E-9	-	-
		Y, see ^{102}Ag	-	2E+3	7E-7	2E-9	-	-
47	Silver-106m	D, see ^{102}Ag	8E+2	7E+2	3E-7	1E-9	1E-5	1E-4
		W, see ^{102}Ag	-	9E+2	4E-7	1E-9	-	-
		Y, see ^{102}Ag	-	9E+2	4E-7	1E-9	-	-
47	Silver-106[b]	D, see ^{102}Ag	6E+4 St wall (6E+4)	2E+5 -	8E-5 -	3E-7 -	- 9E-4	- 9E-3
		W, see ^{102}Ag	-	2E+5	9E-5	3E-7	-	-
		Y, see ^{102}Ag	-	2E+5	8E-5	3E-7	-	-
47	Silver-108m	D, see ^{102}Ag	6E+2	2E+2	8E-8	3E-10	9E-6	9E-5
		W, see ^{102}Ag	-	3E+2	1E-7	4E-10	-	-
		Y, see ^{102}Ag	-	2E+1	1E-8	3E-11	-	-
47	Silver-110m	D, see ^{102}Ag	5E+2	1E+2	5E-8	2E-10	6E-6	6E-5
		W, see ^{102}Ag	-	2E+2	8E-8	3E-10	-	-
		Y, see ^{102}Ag	-	9E+1	4E-8	1E-10	-	-
47	Silver-111	D, see ^{102}Ag	9E+2 LLI wall (1E+3)	2E+3 Liver (2E+3)	6E-7 -	- 2E-9	- 2E-5	- 2E-4
		W, see ^{102}Ag	-	9E+2	4E-7	1E-9	-	-
		Y, see ^{102}Ag	-	9E+2	4E-7	1E-9	-	-
47	Silver-112	D, see ^{102}Ag	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{102}Ag	-	1E+4	4E-6	1E-8	-	-
		Y, see ^{102}Ag	-	9E+3	4E-6	1E-8	-	-
47	Silver-115[b]	D, see ^{102}Ag	3E+4 St wall (3E+4)	9E+4 -	4E-5 -	1E-7 -	- 4E-4	- 4E-3
		W, see ^{102}Ag	-	9E+4	4E-5	1E-7	-	-
		Y, see ^{102}Ag	-	8E+4	3E-5	1E-7	-	-
48	Cadmium-104[b]	D, all compounds except those given for W and Y	2E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		W, sulfides, halides, and nitrates	-	1E+5	5E-5	2E-7	-	-
		Y, oxides and hydroxides	-	1E+5	5E-5	2E-7	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
48	Cadmium-107	D, see ^{104}Cd	2E+4	5E+4	2E-5	8E-8	3E-4	3E-3
		W, see ^{104}Cd	-	6E+4	2E-5	8E-8	-	-
		Y, see ^{104}Cd	-	5E+4	2E-5	7E-8	-	-
48	Cadmium-109	D, see ^{104}Cd	3E+2 Kidneys (4E+2)	4E+1 Kidneys (5E+1)	1E-8	-	-	-
		W, see ^{104}Cd	-	1E+2 Kidneys (1E+2)	5E-8	7E-11 -	6E-6 -	6E-5 -
		Y, see ^{104}Cd	- -	1E+2	5E-8	2E-10 2E-10	- -	- -
48	Cadmium-113m	D, see ^{104}Cd	2E+1 Kidneys (4E+1)	2E+0 Kidneys (4E+0)	1E-9	-	-	-
		W, see ^{104}Cd	-	8E+0 Kidneys (1E+1)	4E-9	5E-12 -	5E-7 -	5E-6 -
		Y, see ^{104}Cd	- -	1E+1	5E-9	2E-11 2E-11	- -	- -
48	Cadmium-113	D, see ^{104}Cd	2E+1 Kidneys (3E+1)	2E+0 Kidneys (3E+0)	9E-10	-	-	-
		W, see ^{104}Cd	-	8E+0 Kidneys (1E+1)	3E-9	5E-12 -	4E-7 -	4E-6 -
		Y, see ^{104}Cd	- -	1E+1	6E-9	2E-11 2E-11	- -	- -
48	Cadmium-115m	D, see ^{104}Cd	3E+2	5E+1 Kidneys (8E+1)	2E-8	-	4E-6	4E-5
		W, see ^{104}Cd	-	1E+2	5E-8	1E-10	-	-
		Y, see ^{104}Cd	-	1E+2	6E-8	2E-10	-	-
48	Cadmium-115	D, see ^{104}Cd	9E+2 LLI wall (1E+3)	1E+3	6E-7	2E-9	-	-
		W, see ^{104}Cd	-	1E+3	5E-7	-	1E-5	1E-4
		Y, see ^{104}Cd	-	1E+3	6E-7	2E-9	-	-
48	Cadmium-117m	D, see ^{104}Cd	5E+3	1E+4	5E-6	2E-9	-	-
		W, see ^{104}Cd	-	2E+4	7E-6	2E-8	6E-5	6E-4
		Y, see ^{104}Cd	-	1E+4	6E-6	2E-8	-	-
48	Cadmium-117	D, see ^{104}Cd	5E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		W, see ^{104}Cd	-	2E+4	7E-6	2E-8	-	-
		Y, see ^{104}Cd	-	1E+4	6E-6	2E-8	-	-
49	Indium-109	D, all compounds except those given for W	2E+4	4E+4	2E-5	6E-8	3E-4	3E-3
		W, oxides, hydroxides, halides, and nitrates	-	6E+4	3E-5	9E-8	-	-
49	Indium-110[b] (69 1 mn)	D, see ^{109}In	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{109}In	-	6E+4	2E-5	8E-8	-	-
49	Indium-110 (4.9 h)	D, see ^{109}In	5E+3	2E+4	7E-6	2E-8	7E-5	7E-4
		W, see ^{109}In	-	2E+4	8E-6	3E-8	-	-
49	Indium-111	D, see ^{109}In	4E+3	6E+3	3E-6	9E-9	6E-5	6E-4
		W, see ^{109}In	-	6E+3	3E-6	9E-9	-	-
49	Indium-112[b]	D, see ^{109}In	2E+5	6E+5	3E-4	9E-7	2E-3	2E-2
		W, see ^{109}In	-	7E+5	3E-4	1E-6	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
49	Indium-113m[b]	D, see ^{109}In	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
		W, see ^{109}In	-	2E+5	8E-5	3E-7	-	-
49	Indium-114m	D, see ^{109}In	3E+2	6E+1	3E-8	9E-11	-	-
			LLI wall (4E+2)	-	-	-	5E-6	5E-5
		W, see ^{109}In	-	1E+2	4E-8	1E-10	-	-
49	Indium-115m	D, see ^{109}In	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{109}In	-	5E+4	2E-5	7E-8	-	-
49	Indium-115	D, see ^{109}In	4E+1	1E+0	6E-10	2E-12	5E-7	5E-6
		W, see ^{109}In	-	5E+0	2E-9	8E-12	-	-
49	Indium-116m[b]	D, see ^{109}In	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{109}In	-	1E+5	5E-5	2E-7	-	-
49	Indium-117m[b]	D, see ^{109}In	1E+4	3E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{109}In	-	4E+4	2E-5	6E-8	-	-
49	Indium-117[b]	D, see ^{109}In	6E+4	2E+5	7E-5	2E-7	8E-4	8E-3
		W, see ^{109}In	-	2E+5	9E-5	3E-7	-	-
49	Indium-119m[b]	D, see ^{109}In	4E+4	1E+5	5E-5	2E-7	-	-
			St wall (5E+4)	-	-	-	7E-4	7E-3
		W, see ^{109}In	-	1E+5	6E-5	2E-7	-	-
50	Tin-110	D, all compounds except those given for W	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
		W, sulfides, oxides, hydroxides, halides, nitrates, and stannic phosphate	-	1E+4	5E-6	2E-8	-	-
50	Tin-111[b]	D, see ^{110}Sn	7E+4	2E+5	9E-5	3E-7	1E-3	1E-2
		W, see ^{110}Sn	-	3E+5	1E-4	4E-7	-	-
50	Tin-113	D, see ^{110}Sn	2E+3	1E+3	5E-7	2E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
		W, see ^{110}Sn	-	5E+2	2E-7	8E-10	-	-
50	Tin-117m	D, see ^{110}Sn	2E+3	1E+3	5E-7	-	-	-
			LLI wall (2E+3)	Bone surf (2E+3)	-	3E-9	3E-5	3E-4
		W, see ^{110}Sn	-	1E+3	6E-7	2E-9	-	-
50	Tin-119m	D, see ^{110}Sn	3E+3	2E+3	1E-6	3E-9	-	-
			LLI wall (4E+3)	-	-	-	6E-5	6E-4
		W, see ^{110}Sn	-	1E+3	4E-7	1E-9	-	-
50	Tin-121m	D, see ^{110}Sn	3E+3	9E+2	4E-7	1E-9	-	-
			LLI wall (4E+3)	-	-	-	5E-5	5E-4
		W, see ^{110}Sn	-	5E+2	2E-7	8E-10	-	-
50	Tin-121	D, see ^{110}Sn	6E+3	2E+4	6E-6	2E-8	-	-
			LLI wall (6E+3)	-	-	-	8E-5	8E-4
		W, see ^{110}Sn	-	1E+4	5E-6	2E-8	-	-
50	Tin-123m[b]	D, see ^{110}Sn	5E+4	1E+5	5E-5	2E-7	7E-4	7E-3
		W, see ^{110}Sn	-	1E+5	6E-5	2E-7	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
50	Tin-123	D, see ^{110}Sn	5E+2	6E+2	3E-7	9E-10	-	-
			LLI wall (6E+2)	-	-	-	9E-6	9E-5
		W, see ^{110}Sn	-	2E+2	7E-8	2E-10	-	-
50	Tin-125	D, see ^{110}Sn	4E+2	9E+2	4E-7	1E-9	-	-
			LLI wall (5E+2)	-	-	-	6E-6	6E-5
		W, see ^{110}Sn	-	4E+2	1E-7	5E-10	-	-
50	Tin-126	D, see ^{110}Sn	3E+2	6E+1	2E-8	8E-11	4E-6	4E-5
		W, see ^{110}Sn	-	7E+1	3E-8	9E-11	-	-
50	Tin-127	D, see ^{110}Sn	7E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		W, see ^{110}Sn	-	2E+4	8E-6	3E-8	-	-
50	Tin-128[b]	D, see ^{110}Sn	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, see ^{110}Sn	-	4E+4	1E-5	5E-8	-	-
51	Antimony-115[b]	D, all compounds except those given for W	8E+4	2E+5	1E-4	3E-7	1E-3	1E-2
		W, oxides, hydroxides, halides, sulfides, sulfates, and nitrates	-	3E+5	1E-4	4E-7	-	-
51	Antimony-116m[b]	D, see ^{115}Sb	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
		W, see ^{115}Sb	-	1E+5	6E-5	2E-7	-	-
51	Antimony-116[b]	D, see ^{115}Sb	7E+4	3E+5	1E-4	4E-7	-	-
			St wall (9E+4)	-	-	-	1E-3	1E-2
		W, see ^{115}Sb	-	3E+5	1E-4	5E-7	-	-
51	Antimony-117	D, see ^{115}Sb	7E+4	2E+5	9E-5	3E-7	9E-4	9E-3
		W, see ^{115}Sb	-	3E+5	1E-4	4E-7	-	-
51	Antimony-118m	D, see ^{115}Sb	6E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		W, see ^{115}Sb	5E+3	2E+4	9E-6	3E-8	-	-
51	Antimony-119	D, see ^{115}Sb	2E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{115}Sb	2E+4	3E+4	1E-5	4E-8	-	-
51	Antimony-120[b] (16 min)	D, see ^{115}Sb	1E+5	4E+5	2E-4	6E-7	-	-
			St wall (2E+5)	-	-	-	2E-3	2E-2
		W, see ^{115}Sb	-	5E+5	2E-4	7E-7	-	-
51	Antimony-120 (5 76 d)	D, see ^{115}Sb	1E+3	2E+3	9E-7	3E-9	1E-5	1E-4
		W, see ^{115}Sb	9E+2	1E+3	5E-7	2E-9	-	-
51	Antimony-122	D, see ^{115}Sb	8E+2	2E+3	1E-6	3E-9	-	-
			LLI wall (8E+2)	-	-	-	1E-5	1E-4
		W, see ^{115}Sb	7E+2	1E+3	4E-7	2E-9	-	-
51	Antimony-124m[b]	D, see ^{115}Sb	3E+5	8E+5	4E-4	1E-6	3E-3	3E-2
		W, see ^{115}Sb	2E+5	6E+5	2E-4	8E-7	-	-
51	Antimony-124	D, see ^{115}Sb	6E+2	9E+2	4E-7	1E-9	7E-6	7E-5
		W, see ^{115}Sb	5E+2	2E+2	1E-7	3E-10	-	-
51	Antimony-125	D, see ^{115}Sb	2E+3	2E+3	1E-6	3E-9	3E-5	3E-4
		W, see ^{115}Sb	-	5E+2	2E-7	7E-10	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
51	Antimony-126m[b]	D, see ^{115}Sb	5E+4 St wall (7E+4)	2E+5 -	8E-5 -	3E-7 -	- 9E-4	- 9E-3
		W, see ^{115}Sb	-	2E+5	8E-5	3E-7	-	-
51	Antimony-126	D, see ^{115}Sb	6E+2	1E+3	5E-7	2E-9	7E-6	7E-5
		W, see ^{115}Sb	5E+2	5E+2	2E-7	7E-10	-	-
51	Antimony-127	D, see ^{115}Sb	8E+2 LLI wall (8E+2)	2E+3 -	9E-7 -	3E-9 -	- 1E-5	- 1E-4
		W, see ^{115}Sb	7E+2	9E+2	4E-7	1E-9	-	-
51	Antimony-128[b] (10 4 min)	D, see ^{115}Sb	8E+4 St wall (1E+5)	4E+5 -	2E-4 -	5E-7 -	- 1E-3	- 1E-2
		W, see ^{115}Sb	-	4E+5	2E-4	6E-7	-	-
51	Antimony-128 (9 01 h)	D, see ^{115}Sb	1E+3	4E+3	2E-6	6E-9	2E-5	2E-4
		W, see ^{115}Sb	-	3E+3	1E-6	5E-9	-	-
51	Antimony-129	D, see ^{115}Sb	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		W, see ^{115}Sb	-	9E+3	4E-6	1E-8	-	-
51	Antimony-130[b]	D, see ^{115}Sb	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		W, see ^{115}Sb	-	8E+4	3E-5	1E-7	-	-
51	Antimony-131[b]	D, see ^{115}Sb	1E+4 Thyroid (2E+4)	2E+4 Thyroid (4E+4)	1E-5 -	- 6E-8	- 2E-4	- 2E-3
		W, see ^{115}Sb	-	2E+4 Thyroid (4E+4)	1E-5 -	6E-8	- -	- -
52	Tellurium-116	D, all compounds except those given for W	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, oxides, hydroxides, and nitrates	-	3E+4	1E-5	4E-8	-	-
52	Tellurium-121m	D, see ^{116}Te	5E+2 Bone surf (7E+2)	2E+2 Bone surf (4E+2)	8E-8 -	- 5E-10	- 1E-5	- 1E-4
		W, see ^{116}Te	-	4E+2	2E-7	6E-10	-	-
52	Tellurium-121	D, see ^{116}Te	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
		W, see ^{116}Te	-	3E+3	1E-6	4E-9	-	-
52	Tellurium-123m	D, see ^{116}Te	6E+2 Bone surf (1E+3)	2E+2 Bone surf (5E+2)	9E-8 -	- 8E-10	- 1E-5	- 1E-4
		W, see ^{116}Te	-	5E+2	2E-7	8E-10	-	-
52	Tellurium-123	D, see ^{116}Te	5E+2 Bone surf (1E+3)	2E+2 Bone surf (5E+2)	8E-8 -	- 7E-10	- 2E-5	- 2E-4
		W, see ^{116}Te	-	4E+2 Bone surf (1E+3)	2E-7 -	- 2E-9	- -	- -
52	Tellurium-125m	D, see ^{116}Te	1E+3 Bone surf (1E+3)	4E+2 Bone surf (1E+3)	2E-7 -	- 1E-9	- 2E-5	- 2E-4
		W, see ^{116}Te	-	7E+2	3E-7	1E-9	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
52	Tellurium-127m	D, see ^{116}Te	6E+2	3E+2 Bone surf	1E-7	-	9E-6	9E-5
			-	(4E+2)	-	6E-10	-	-
		W, see ^{116}Te	-	3E+2	1E-7	4E-10	-	-
52	Tellurium-127	D, see ^{116}Te	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{116}Te	-	2E+4	7E-6	2E-8	-	-
52	Tellurium-129m	D, see ^{116}Te	5E+2	6E+2	3E-7	9E-10	7E-6	7E-5
		W, see ^{116}Te	-	2E+2	1E-7	3E-10	-	-
52	Tellurium-129[b]	D, see ^{116}Te	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
		W, see ^{116}Te	-	7E+4	3E-5	1E-7	-	-
52	Tellurium-131m	D, see ^{116}Te	3E+2 Thyroid (6E+2)	4E+2 Thyroid (1E+3)	2E-7	-	-	-
		W, see ^{116}Te	-	4E+2 Thyroid	- 2E-7	2E-9 -	8E-6 -	8E-5 -
			-	(9E+2)	-	1E-9	-	-
52	Tellurium-131[b]	D, see ^{116}Te	3E+3 Thyroid (6E+3)	5E+3 Thyroid (1E+4)	2E-6	-	-	-
		W, see ^{116}Te	-	5E+3 Thyroid	- 2E-6	2E-8 -	8E-5 -	8E-4 -
			-	(1E+4)	-	2E-8	-	-
52	Tellurium-132	D, see ^{116}Te	2E+2 Thyroid (7E+2)	2E+2 Thyroid (8E+2)	9E-8 -	-	-	-
		W, see ^{116}Te	-	2E+2 Thyroid	9E-8	1E-9 -	9E-6 -	9E-5 -
			-	(6E+2)	-	9E-10	-	-
52	Tellurium-133m[b]	D, see ^{116}Te	3E+3 Thyroid (6E+3)	5E+3 Thyroid (1E+4)	2E-6 -	-	-	-
		W, see ^{116}Te	-	5E+3 Thyroid	2E-6	2E-8 -	9E-5 -	9E-4 -
			-	(1E+4)	-	2E-8	-	-
52	Tellurium-133[b]	D, see ^{116}Te	1E+4 Thyroid (3E+4)	2E+4 Thyroid (6E+4)	9E-6 -	-	-	-
		W, see ^{116}Te	-	2E+4 Thyroid	9E-6	8E-8 -	4E-4 -	4E-3 -
			-	(6E+4)	-	8E-8	-	-
52	Tellurium-134[b]	D, see ^{116}Te	2E+4 Thyroid (2E+4)	2E+4 Thyroid (5E+4)	1E-5 -	-	-	-
		W, see ^{116}Te	-	2E+4 Thyroid	1E-5	7E-8 -	3E-4 -	3E-3 -
			-	(5E+4)	-	7E-8	-	-
53	Iodine-120m[b]	D, all compounds	1E+4 Thyroid (1E+4)	2E+4 -	9E-6 -	3E-8 -	- 2E-4	- 2E-3
53	Iodine-120[b]	D, all compounds	4E+3 Thyroid (8E+3)	9E+3 Thyroid (1E+4)	4E-6 -	- 2E-8	- 1E-4	- 1E-3

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
53	Iodine-121	D, all compounds	1E+4 Thyroid (3E+4)	2E+4 Thyroid (5E+4)	8E-6 -	- 7E-8	- 4E-4	- 4E-3
53	Iodine-123	D, all compounds	3E+3 Thyroid (1E+4)	6E+3 Thyroid (2E+4)	3E-6 -	- 2E-8	- 1E-4	- 1E-3
53	Iodine-124	D, all compounds	5E+1 Thyroid (2E+2)	8E+1 Thyroid (3E+2)	3E-8 -	- 4E-10	- 2E-6	- 2E-5
53	Iodine-125	D, all compounds	4E+1 Thyroid (1E+2)	6E+1 Thyroid (2E+2)	3E-8 -	- 3E-10	- 2E-6	- 2E-5
53	Iodine-126	D, all compounds	2E+1 Thyroid (7E+1)	4E+1 Thyroid (1E+2)	1E-8 -	- 2E-10	- 1E-6	- 1E-5
53	Iodine-128[b]	D, all compounds	4E+4 St wall (6E+4)	1E+5 -	5E-5 -	2E-7 -	- 8E-4	- 8E-3
53	Iodine-129	D, all compounds	5E+0 Thyroid (2E+1)	9E+0 Thyroid (3E+1)	4E-9 -	- 4E-11	- 2E-7	- 2E-6
53	Iodine-130	D, all compounds	4E+2 Thyroid (1E+3)	7E+2 Thyroid (2E+3)	3E-7 -	- 3E-9	- 2E-5	- 2E-4
53	Iodine-131	D, all compounds	3E+1 Thyroid (9E+1)	5E+1 Thyroid (2E+2)	2E-8 -	- 2E-10	- 1E-6	- 1E-5
53	Iodine-132m[b]	D, all compounds	4E+3 Thyroid (1E+4)	8E+3 Thyroid (2E+4)	4E-6 -	- 3E-8	- 1E-4	- 1E-3
53	Iodine-132	D, all compounds	4E+3 Thyroid (9E+3)	8E+3 Thyroid (1E+4)	3E-6 -	- 2E-8	- 1E-4	- 1E-3
53	Iodine-133	D, all compounds	1E+2 Thyroid (5E+2)	3E+2 Thyroid (9E+2)	1E-7 -	- 1E-9	- 7E-6	- 7E-5
53	Iodine-134[b]	D, all compounds	2E+4 Thyroid (3E+4)	5E+4 -	2E-5 -	6E-8 -	- 4E-4	- 4E-3
53	Iodine-135	D, all compounds	8E+2 Thyroid (3E+3)	2E+3 Thyroid (4E+3)	7E-7 -	- 6E-9	- 3E-5	- 3E-4
54	Xenon-120[b]	Submersion[a]	-	-	1E-5	4E-8	-	-
54	Xenon-121[b]	Submersion[a]	-	-	2E-6	1E-8	-	-
54	Xenon-122	Submersion[a]	-	-	7E-5	3E-7	-	-
54	Xenon-123	Submersion[a]	-	-	6E-6	3E-8	-	-
54	Xenon-125	Submersion[a]	-	-	2E-5	7E-8	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
54	Xenon-127	Submersion[b]	-	-	1E-5	6E-8	-	-
54	Xenon-129m	Submersion[b]	-	-	2E-4	9E-7	-	-
54	Xenon-131m	Submersion[b]	-	-	4E-4	2E-6	-	-
54	Xenon-133m	Submersion[b]	-	-	1E-4	6E-7	-	-
54	Xenon-133	Submersion[b]	-	-	1E-4	5E-7	-	-
54	Xenon-135m[b]	Submersion[b]	-	-	9E-6	4E-8	-	-
54	Xenon-135	Submersion[b]	-	-	1E-5	7E-8	-	-
54	Xenon-138[b]	Submersion[b]	-	-	4E-6	2E-8	-	-
55	Cesium-125[b]	D, all compounds	5E+4	1E+5	6E-5	2E-7	-	-
			St wall (9E+4)	-	-	-	1E-3	1E-2
55	Cesium-127	D, all compounds	6E+4	9E+4	4E-5	1E-7	9E-4	9E-3
55	Cesium-129	D, all compounds	2E+4	3E+4	1E-5	5E-8	3E-4	3E-3
55	Cesium-130[b]	D, all compounds	6E+4	2E+5	8E-5	3E-7	-	-
			St wall (1E+5)	-	-	-	1E-3	1E-2
55	Cesium-131	D, all compounds	2E+4	3E+4	1E-5	4E-8	3E-4	3E-3
55	Cesium-132	D, all compounds	3E+3	4E+3	2E-6	6E-9	4E-5	4E-4
55	Cesium-134m	D, all compounds	1E+5	1E+5	6E-5	2E-7	-	-
			St wall (1E+5)	-	-	-	2E-3	2E-2
55	Cesium-134	D, all compounds	7E+1	1E+2	4E-8	2E-10	9E-7	9E-6
55	Cesium-135m[b]	D, all compounds	1E+5	2E+5	8E-5	3E-7	1E-3	1E-2
55	Cesium-135	D, all compounds	7E+2	1E+3	5E-7	2E-9	1E-5	1E-4
55	Cesium-136	D, all compounds	4E+2	7E+2	3E-7	9E-10	6E-6	6E-5
55	Cesium-137	D, all compounds	1E+2	2E+2	6E-8	2E-10	1E-6	1E-5
55	Cesium-138[b]	D, all compounds	2E+4	6E+4	2E-5	8E-8	-	-
			St wall (3E+4)	-	-	-	4E-4	4E-3
56	Barium-126[b]	D, all compounds	6E+3	2E+4	6E-6	2E-8	8E-5	8E-4
56	Barium-128	D, all compounds	5E+2	2E+3	7E-7	2E-9	7E-6	7E-5
56	Barium-131m[b]	D, all compounds	4E+5	1E+6	6E-4	2E-6	-	-
			St wall (5E+5)	-	-	-	7E-3	7E-2
56	Barium-131	D, all compounds	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
56	Barium-133m	D, all compounds	2E+3	9E+3	4E-6	1E-8	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Col 2 Inhalation ALI (μCi)	Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
56	Barium-133	D, all compounds	2E+3	7E+2	3E-7	9E-10	2E-5	2E-4
56	Barium-135m	D, all compounds	3E+3	1E+4	5E-6	2E-8	4E-5	4E-4
56	Barium-139[b]	D, all compounds	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
56	Barium-140	D, all compounds	5E+2	1E+3	6E-7	2E-9	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
56	Barium-141[b]	D, all compounds	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
56	Barium-142[b]	D, all compounds	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
57	Lanthanum-131[b]	D, all compounds except those given for W	5E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		W, oxides and hydroxides	-	2E+5	7E-5	2E-7	-	-
57	Lanthanum-132	D, see ^{131}La	3E+3	1E+4	4E-6	1E-8	4E-5	4E-4
		W, see ^{131}La	-	1E+4	5E-6	2E-8	-	-
57	Lanthanum-135	D, see ^{131}La	4E+4	1E+5	4E-5	1E-7	5E-4	5E-3
		W, see ^{131}La	-	9E+4	4E-5	1E-7	-	-
57	Lanthanum-137	D, see ^{131}La	1E+4	6E+1 Liver	3E-8	-	2E-4	2E-3
			-	(7E+1)	-	1E-10	-	-
		W, see ^{131}La	-	3E+2	1E-7	-	-	-
			-	Liver (3E+2)	-	4E-10	-	-
57	Lanthanum-138	D, see ^{131}La	9E+2	4E+0	1E-9	5E-12	1E-5	1E-4
		W, see ^{131}La	-	1E+1	6E-9	2E-11	-	-
57	Lanthanum-140	D, see ^{131}La	6E+2	1E+3	6E-7	2E-9	9E-6	9E-5
		W, see ^{131}La	-	1E+3	5E-7	2E-9	-	-
57	Lanthanum-141	D, see ^{131}La	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
		W, see ^{131}La	-	1E+4	5E-6	2E-8	-	-
57	Lanthanum-142[b]	D, see ^{131}La	8E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{131}La	-	3E+4	1E-5	5E-8	-	-
57	Lanthanum-143[b]	D, see ^{131}La	4E+4	1E+5	4E-5	1E-7	-	-
			St wall (4E+4)	-	-	-	5E-4	5E-3
		W, see ^{131}La	-	9E+4	4E-5	1E-7	-	-
58	Cerium-134	W, all compounds except those given for Y	5E+2	7E+2	3E-7	1E-9	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
		Y, oxides, hydroxides, and fluorides	-	7E+2	3E-7	9E-10	-	-
58	Cerium-135	W, see ^{134}Ce	2E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		Y, see ^{134}Ce	-	4E+3	1E-6	5E-9	-	-
58	Cerium-137m	W, see ^{134}Ce	2E+3	4E+3	2E-6	6E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
		Y, see ^{134}Ce	-	4E+3	2E-6	5E-9	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
58	Cerium-137	W, see ^{134}Ce	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
		Y, see ^{134}Ce	-	1E+5	5E-5	2E-7	-	-
58	Cerium-139	W, see ^{134}Ce	5E+3	8E+2	3E-7	1E-9	7E-5	7E-4
		Y, see ^{134}Ce	-	7E+2	3E-7	9E-10	-	-
58	Cerium-141	W, see ^{134}Ce	2E+3 LLI wall (2E+3)	7E+2	3E-7	1E-9	-	-
		Y, see ^{134}Ce	-	- 6E+2	- 2E-7	- 8E-10	3E-5 -	3E-4 -
58	Cerium-143	W, see ^{134}Ce	1E+3 LLI wall (1E+3)	2E+3	8E-7	3E-9	-	-
		Y, see ^{134}Ce	-	- 2E+3	- 7E-7	- 2E-9	2E-5 -	2E-4 -
58	Cerium-144	W, see ^{134}Ce	2E+2 LLI wall (3E+2)	3E+1	1E-8	4E-11	-	-
		Y, see ^{134}Ce	-	- 1E+1	- 6E-9	- 2E-11	3E-6 -	3E-5 -
59	Praseodymium-136[b]	W, all compounds except those given for Y	5E+4 St wall (7E+4)	2E+5	1E-4	3E-7	-	-
		Y, oxides, hydroxides, carbides, and fluorides	-	2E+5	9E-5	3E-7	1E-3 -	1E-2 -
59	Praseodymium-137[b]	W, see ^{136}Pr	4E+4	2E+5	6E-5	2E-7	5E-4	5E-3
		Y, see ^{136}Pr	-	1E+5	6E-5	2E-7	-	-
59	Praseodymium-138m	W, see ^{136}Pr	1E+4	5E+4	2E-5	8E-8	1E-4	1E-3
		Y, see ^{136}Pr	-	4E+4	2E-5	6E-8	-	-
59	Praseodymium-139	W, see ^{136}Pr	4E+4	1E+5	5E-5	2E-7	6E-4	6E-3
		Y, see ^{136}Pr	-	1E+5	5E-5	2E-7	-	-
59	Praseodymium-142m[b]	W, see ^{136}Pr	8E+4	2E+5	7E-5	2E-7	1E-3	1E-2
		Y, see ^{136}Pr	-	1E+5	6E-5	2E-7	-	-
59	Praseodymium-142	W, see ^{136}Pr	1E+3	2E+3	9E-7	3E-9	1E-5	1E-4
		Y, see ^{136}Pr	-	2E+3	8E-7	3E-9	-	-
59	Praseodymium-143	W, see ^{136}Pr	9E+2 LLI wall (1E+3)	8E+2	3E-7	1E-9	-	-
		Y, see ^{136}Pr	-	- 7E+2	- 3E-7	- 9E-10	2E-5 -	2E-4 -
59	Praseodymium-144[b]	W, see ^{136}Pr	3E+4 St wall (4E+4)	1E+5	5E-5	2E-7	-	-
		Y, see ^{136}Pr	-	- 1E+5	- 5E-5	- 2E-7	6E-4 -	6E-3 -
59	Praseodymium-145	W, see ^{136}Pr	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		Y, see ^{136}Pr	-	8E+3	3E-6	1E-8	-	-
60	Neodymium-136[b]	W, all compounds except those given for Y	1E+4	6E+4	2E-5	8E-8	2E-4	2E-3
		Y, oxides, hydroxides, carbides, and fluorides	-	5E+4	2E-5	8E-8	-	-
60	Neodymium-138	W, see ^{136}Nd	2E+3	6E+3	3E-6	9E-9	3E-5	3E-4
		Y, see ^{136}Nd	-	5E+3	2E-6	7E-9	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
59	Praseodymium-147[b]	W, see ^{136}Pr	5E+4 St wall (8E+4)	2E+5	8E-5	3E-7	-	-
		Y, see ^{136}Pr	-	2E+5	8E-5	3E-7	1E-3 -	1E-2 -
60	Neodymium-139m	W, see ^{136}Nd	5E+3	2E+4	7E-6	2E-8	7E-5	7E-4
		Y, see ^{136}Nd	-	1E+4	6E-6	2E-8	-	-
60	Neodymium-139[b]	W, see ^{136}Nd	9E+4	3E+5	1E-4	5E-7	1E-3	1E-2
		Y, see ^{136}Nd	-	3E+5	1E-4	4E-7	-	-
60	Neodymium-141	W, see ^{136}Nd	2E+5	7E+5	3E-4	1E-6	2E-3	2E-2
		Y, see ^{136}Nd	-	6E+5	3E-4	9E-7	-	-
60	Neodymium-147	W, see ^{136}Nd	1E+3 LLI wall (1E+3)	9E+2	4E-7	1E-9	-	-
		Y, see ^{136}Nd	-	8E+2	4E-7	1E-9	2E-5 -	2E-4 -
60	Neodymium-149[b]	W, see ^{136}Nd	1E+4	3E+4	1E-5	4E-8	1E-4	1E-3
		Y, see ^{136}Nd	-	2E+4	1E-5	3E-8	-	-
60	Neodymium-151[b]	W, see ^{136}Nd	7E+4	2E+5	8E-5	3E-7	9E-4	9E-3
		Y, see ^{136}Nd	-	2E+5	8E-5	3E-7	-	-
61	Promethium-141[b]	W, all compounds except those given for Y	5E+4 St wall (6E+4)	2E+5	8E-5	3E-7	-	-
		Y, oxides, hydroxides, carbides, and fluorides	-	2E+5	7E-5	2E-7	8E-4 -	8E-3 -
61	Promethium-143	W, see ^{141}Pm	5E+3	6E+2	2E-7	8E-10	7E-5	7E-4
		Y, see ^{141}Pm	-	7E+2	3E-7	1E-9	-	-
61	Promethium-144	W, see ^{141}Pm	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		Y, see ^{141}Pm	-	1E+2	5E-8	2E-10	-	-
61	Promethium-145	W, see ^{141}Pm	1E+4	2E+2 Bone surf (2E+2)	7E-8	-	1E-4	1E-3
		Y, see ^{141}Pm	-	2E+2	8E-8	3E-10	-	-
61	Promethium-146	W, see ^{141}Pm	2E+3	5E+1	2E-8	7E-11	2E-5	2E-4
		Y, see ^{141}Pm	-	4E+1	2E-8	6E-11	-	-
61	Promethium-147	W, see ^{141}Pm	4E+3 LLI wall (5E+3)	1E+2 Bone surf (2E+2)	5E-8	-	-	-
		Y, see ^{141}Pm	-	1E+2	6E-8	3E-10 2E-10	7E-5 -	7E-4 -
61	Promethium-148m	W, see ^{141}Pm	7E+2	3E+2	1E-7	4E-10	1E-5	1E-4
		Y, see ^{141}Pm	-	3E+2	1E-7	5E-10	-	-
61	Promethium-148	W, see ^{141}Pm	4E+2 LLI wall (5E+2)	5E+2	2E-7	8E-10	-	-
		Y, see ^{141}Pm	-	5E+2	2E-7	- 7E-10	7E-6 -	7E-5 -
61	Promethium-149	W, see ^{141}Pm	1E+3 LLI wall (1E+3)	2E+3	8E-7	3E-9	-	-
		Y, see ^{141}Pm	-	2E+3	8E-7	- 2E-9	2E-5 -	2E-4 -

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
61	Promethium-150	W, see ^{141}Pm	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
		Y, see ^{141}Pm	-	2E+4	7E-6	2E-8	-	-
61	Promethium-151	W, see ^{141}Pm	2E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		Y, see ^{141}Pm	-	3E+3	1E-6	4E-9	-	-
62	Samarium-141m[b]	W, all compounds	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
62	Samarium-141[b]	W, all compounds	5E+4 St wall (6E+4)	2E+5	8E-5	2E-7	-	-
				-	-	-	8E-4	8E-3
62	Samarium-142[b]	W, all compounds	8E+3	3E+4	1E-5	4E-8	1E-4	1E-3
62	Samarium-145	W, all compounds	6E+3	5E+2	2E-7	7E-10	8E-5	8E-4
62	Samarium-146	W, all compounds	1E+1 Bone surf (3E+1)	4E-2 Bone surf (6E-2)	1E-11	-	-	-
					-	9E-14	3E-7	3E-6
62	Samarium-147	W, all compounds	2E+1 Bone surf (3E+1)	4E-2 Bone surf (7E-2)	2E-11	-	-	-
					-	1E-13	4E-7	4E-6
62	Samarium-151	W, all compounds	1E+4 LLI wall (1E+4)	1E+2 Bone surf (2E+2)	4E-8	-	-	-
					-	2E-10	2E-4	2E-3
62	Samarium-153	W, all compounds	2E+3 LLI wall (2E+3)	3E+3	1E-6	4E-9	-	-
				-	-	-	3E-5	3E-4
62	Samarium-155[b]	W, all compounds	6E+4 St wall (8E+4)	2E+5	9E-5	3E-7	-	-
				-	-	-	1E-3	1E-2
62	Samarium-156	W, all compounds	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
63	Europium-145	W, all compounds	2E+3	2E+3	8E-7	3E-9	2E-5	2E-4
63	Europium-146	W, all compounds	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
63	Europium-147	W, all compounds	3E+3	2E+3	7E-7	2E-9	4E-5	4E-4
63	Europium-148	W, all compounds	1E+3	4E+2	1E-7	5E-10	1E-5	1E-4
63	Europium-149	W, all compounds	1E+4	3E+3	1E-6	4E-9	2E-4	2E-3
63	Europium-150 (12 62 h)	W, all compounds	3E+3	8E+3	4E-6	1E-8	4E-5	4E-4
63	Europium-150 (34 2 y)	W, all compounds	8E+2	2E+1	8E-9	3E-11	1E-5	1E-4
63	Europium-152m	W, all compounds	3E+3	6E+3	3E-6	9E-9	4E-5	4E-4
63	Europium-152	W, all compounds	8E+2	2E+1	1E-8	3E-11	1E-5	1E-4
63	Europium-154	W, all compounds	5E+2	2E+1	8E-9	3E-11	7E-6	7E-5
63	Europium-155	W, all compounds	4E+3	9E+1 Bone surf (1E+2)	4E-8	-	5E-5	5E-4
			-		-	2E-10	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
63	Europium-156	W, all compounds	6E+2	5E+2	2E-7	6E-10	8E-6	8E-5
63	Europium-157	W, all compounds	2E+3	5E+3	2E-6	7E-9	3E-5	3E-4
63	Europium-158[b]	W, all compounds	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
64	Gadolinium-145[b]	D, all compounds except those given for W	5E+4 St wall (5E+4)	2E+5	6E-5	2E-7	-	-
		W, oxides, hydroxides, and fluorides	-	-	-	-	6E-4	6E-3
			-	2E+5	7E-5	2E-7	-	-
64	Gadolinium-146	D, see ^{145}Gd	1E+3	1E+2	5E-8	2E-10	2E-5	2E-4
		W, see ^{145}Gd	-	3E+2	1E-7	4E-10	-	-
64	Gadolinium-147	D, see ^{145}Gd	2E+3	4E+3	2E-6	6E-9	3E-5	3E-4
		W, see ^{145}Gd	-	4E+3	1E-6	5E-9	-	-
64	Gadolinium-148	D, see ^{145}Gd	1E+1 Bone surf (2E+1)	8E+3 Bone surf (2E-2)	3E-12 -	-	-	-
		W, see ^{145}Gd	-	3E-2 Bone surf (6E-2)	1E-11 -	2E-14 8E-14	3E-7 -	3E-6 -
64	Gadolinium-149	D, see ^{145}Gd	3E+3	2E+3	9E-7	3E-9	4E-5	4E-4
		W, see ^{145}Gd	-	2E+3	1E-6	3E-9	-	-
64	Gadolinium-151	D, see ^{145}Gd	6E+3 -	4E+2 Bone surf (6E+2)	2E-7 -	- 9E-10	9E-5 -	9E-4 -
		W, see ^{145}Gd	-	1E+3	5E-7	2E-9	-	-
64	Gadolinium-152	D, see ^{145}Gd	2E+1 Bone surf (3E+1)	1E-2 Bone surf (2E-2)	4E-12 -	-	-	-
		W, see ^{145}Gd	-	4E-2 Bone surf (8E-2)	2E-11 -	3E-14 1E-13	4E-7 -	4E-6 -
64	Gadolinium-153	D, see ^{145}Gd	5E+3 -	1E+2 Bone surf (2E+2)	6E-8 -	- 3E-10	6E-5 -	6E-4 -
		W, see ^{145}Gd	-	6E+2	2E-7	8E-10	-	-
64	Gadolinium-159	D, see ^{145}Gd	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{145}Gd	-	6E+3	2E-6	8E-9	-	-
65	Terbium-147[b]	W, all compounds	9E+3	3E+4	1E-5	5E-8	1E-4	1E-3
65	Terbium-149	W, all compounds	5E+3	7E+2	3E-7	1E-9	7E-5	7E-4
65	Terbium-150	W, all compounds	5E+3	2E+4	9E-6	3E-8	7E-5	7E-4
65	Terbium-151	W, all compounds	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
65	Terbium-153	W, all compounds	5E+3	7E+3	3E-6	1E-8	7E-5	7E-4
65	Terbium-154	W, all compounds	2E+3	4E+3	2E-6	6E-9	2E-5	2E-4
65	Terbium-155	W, all compounds	6E+3	8E+3	3E-6	1E-8	8E-5	8E-4
65	Terbium-156m (5.0 h)	W, all compounds	2E+4	3E+4	1E-5	4E-8	2E-4	2E-3

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col 1 Oral Ingestion ALI (μCi)	Col. 2 Inhalation ALI (μCi)	Col 3 DAC (μCi/ml)	Col 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
65	Terbium-156m (24 4 h)	W, all compounds	7E+3	8E+3	3E-6	1E-8	1E-4	1E-3
65	Terbium-156	W, all compounds	1E+3	1E+3	6E-7	2E-9	1E-5	1E-4
65	Terbium-157	W, all compounds	5E+4 LLI wall (5E+4)	3E+2 Bone surf (6E+2)	1E-7 -	- 8E-10	- 7E-4	- 7E-3
65	Terbium-158	W, all compounds	1E+3	2E+1	8E-9	3E-11	2E-5	2E-4
65	Terbium-160	W, all compounds	8E+2	2E+2	9E-8	3E-10	1E-5	1E-4
65	Terbium-161	W, all compounds	2E+3 LLI wall (2E+3)	2E+3 -	7E-7 -	2E-9 -	- 3E-5	- 3E-4
66	Dysprosium-155	W, all compounds	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
66	Dysprosium-157	W, all compounds	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
66	Dysprosium-159	W, all compounds	1E+4	2E+3	1E-6	3E-9	2E-4	2E-3
66	Dysprosium-165	W, all compounds	1E+4	5E+4	2E-5	6E-8	2E-4	2E-3
66	Dysprosium-166	W, all compounds	6E+2 LLI wall (8E+2)	7E+2 -	3E-7 -	1E-9 -	- 1E-5	- 1E-4
67	Holmium-155[b]	W, all compounds	4E+4	2E+5	6E-5	2E-7	6E-4	6E-3
67	Holmium-157[b]	W, all compounds	3E+5	1E+6	6E-4	2E-6	4E-3	4E-2
67	Holmium-159[b]	W, all compounds	2E+5	1E+6	4E-4	1E-6	3E-3	3E-2
67	Holmium-161	W, all compounds	1E+5	4E+5	2E-4	6E-7	1E-3	1E-2
67	Holmium-162m[b]	W, all compounds	5E+4	3E+5	1E-4	4E-7	7E-4	7E-3
67	Holmium-162[b]	W, all compounds	5E+5 St wall (8E+5)	2E+6 -	1E-3 -	3E-6 -	- 1E-2	- 1E-1
67	Holmium-164m[b]	W, all compounds	1E+5	3E+5	1E-4	4E-7	1E-3	1E-2
67	Holmium-164[b]	W, all compounds	2E+5 St wall (2E+5)	6E+5 -	3E-4 -	9E-7 -	- 3E-3	- 3E-2
67	Holmium-166m	W, all compounds	6E+2	7E+0	3E-9	9E-12	9E-6	9E-5
67	Holmium-166	W, all compounds	9E+2 LLI wall (9E+2)	2E+3 -	7E-7 -	2E-9 -	- 1E-5	- 1E-4
67	Holmium-167	W, all compounds	2E+4	6E+4	2E-5	8E-8	2E-4	2E-3
68	Erbium-161	W, all compounds	2E+4	6E+4	3E-5	9E-8	2E-4	2E-3
68	Erbium-165	W, all compounds	6E+4	2E+5	8E-5	3E-7	9E-4	9E-3
68	Erbium-169	W, all compounds	3E+3 LLI wall (4E+3)	3E+3 -	1E-6 -	4E-9 -	- 5E-5	- 5E-4

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col 1	Col 2	Col 3	Col 1	Col 2	
			Oral Ingestion	Inhalation				
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
68	Erbium-171	W, all compounds	4E+3	1E+4	4E-6	1E-8	5E-5	5E-4
68	Erbium-172	W, all compounds	1E+3	1E+3	6E-7	2E-9	-	-
			LLI wall (1E+3)	-	-	-	2E-5	2E-4
69	Thulium-162[b]	W, all compounds	7E+4	3E+5	1E-4	4E-7	-	-
			St wall (7E+4)	-	-	-	1E-3	1E-2
69	Thulium-166	W, all compounds	4E+3	1E+4	6E-6	2E-8	6E-5	6E-4
69	Thulium-167	W, all compounds	2E+3	2E+3	8E-7	3E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
69	Thulium-170	W, all compounds	8E+2	2E+2	9E-8	3E-10	-	-
			LLI wall (1E+3)	-	-	-	1E-5	1E-4
69	Thulium-171	W, all compounds	1E+4	3E+2	1E-7	-	-	-
			LLI wall (1E+4)	Bone surf (6E+2)	-	8E-10	2E-4	2E-3
69	Thulium-172	W, all compounds	7E+2	1E+3	5E-7	2E-9	-	-
			LLI wall (8E+2)	-	-	-	1E-5	1E-4
69	Thulium-173	W, all compounds	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
69	Thulium-175[b]	W, all compounds	7E+4	3E+5	1E-4	4E-7	-	-
			St wall (9E+4)	-	-	-	1E-3	1E-2
70	Ytterbium-162[b]	W, all compounds except those given for Y	7E+4	3E+5	1E-4	4E-7	1E-3	1E-2
		Y, oxides, hydroxides, and fluorides	-	3E+5	1E-4	4E-7	-	-
70	Ytterbium-166	W, see ^{162}Yb	1E+3	2E+3	8E-7	3E-9	2E-5	2E-4
		Y, see ^{162}Yb	-	2E+3	8E-7	3E-9	-	-
70	Ytterbium-167[b]	W, see ^{162}Yb	3E+5	8E+5	3E-4	1E-6	4E-3	4E-2
		Y, see ^{162}Yb	-	7E+5	3E-4	1E-6	-	-
70	Ytterbium-169	W, see ^{162}Yb	2E+3	8E+2	4E-7	1E-9	2E-5	2E-4
		Y, see ^{162}Yb	-	7E+2	3E-7	1E-9	-	-
70	Ytterbium-175	W, see ^{162}Yb	3E+3	4E+3	1E-6	5E-9	-	-
			LLI wall (3E+3)	-	-	-	4E-5	4E-4
		Y, see ^{162}Yb	-	3E+3	1E-6	5E-9	-	-
70	Ytterbium-177[b]	W, see ^{162}Yb	2E+4	5E+4	2E-5	7E-8	2E-4	2E-3
		Y, see ^{162}Yb	-	5E+4	2E-5	6E-8	-	-
70	Ytterbium-178[b]	W, see ^{162}Yb	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		Y, see ^{162}Yb	-	4E+4	2E-5	5E-8	-	-
71	Lutetium-169	W, all compounds except those given for Y	3E+3	4E+3	2E-6	6E-9	3E-5	3E-4
		Y, oxides, hydroxides, and fluorides	-	4E+3	2E-6	6E-9	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
71	Lutetium-170	W, see ^{169}Lu	1E+3	2E+3	9E-7	3E-9	2E-5	2E-4
		Y, see ^{169}Lu	-	2E+3	8E-7	3E-9	-	-
71	Lutetium-171	W, see ^{169}Lu	2E+3	2E+3	8E-7	3E-9	3E-5	3E-4
		Y, see ^{169}Lu	-	2E+3	8E-7	3E-9	-	-
71	Lutetium-172	W, see ^{169}Lu	1E+3	1E+3	5E-7	2E-9	1E-5	1E-4
		Y, see ^{169}Lu	-	1E+3	5E-7	2E-9	-	-
71	Lutetium-173	W, see ^{169}Lu	5E+3	3E+2 Bone surf	1E-7	-	7E-5	7E-4
			-	(5E+2)	-	6E-10	-	-
		Y, see ^{169}Lu	-	3E+2	1E-7	4E-10	-	-
71	Lutetium-174m	W, see ^{169}Lu	2E+3 LLI wall (3E+3)	2E+2 Bone surf (3E+2)	1E-7	-	-	-
		Y, see ^{169}Lu	-	2E+2	9E-8	5E-10 3E-10	4E-5 -	4E-4 -
71	Lutetium-176	W, see ^{169}Lu	7E+2	5E+0 Bone surf (1E+1)	2E-9 -	- 2E-11	1E-5 -	1E-4 -
		Y, see ^{169}Lu	-	8E+0	3E-9	1E-11	-	-
71	Lutetium-177m	W, see ^{169}Lu	7E+2	1E+2 Bone surf (1E+2)	5E-8 -	- 2E-10	1E-5 -	1E-4 -
		Y, see ^{169}Lu	-	8E+1	3E-8	1E-10	-	-
71	Lutetium-177	W, see ^{169}Lu	2E+3 LLI wall (3E+3)	2E+3 -	9E-7 -	3E-9 -	- 4E-5	- 4E-4
		Y, see ^{169}Lu	-	2E+3	9E-7	3E-9	-	-
71	Lutetium-178m[b]	W, see ^{169}Lu	5E+4 St wall (6E+4)	2E+5 -	8E-5 -	3E-7 -	- 8E-4	- 8E-3
		Y, see ^{169}Lu	-	2E+5	7E-5	2E-7	-	-
71	Lutetium-178[b]	W, see ^{169}Lu	4E+4 St wall (4E+4)	1E+5 -	5E-5 -	2E-7 -	- 6E-4	- 6E-3
		Y, see ^{169}Lu	-	1E+5	5E-5	2E-7	-	-
71	Lutetium-179	W, see ^{169}Lu	6E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		Y, see ^{169}Lu	-	2E+4	6E-6	3E-8	-	-
72	Hafnium-170	D, all compounds except those given for W	3E+3	6E+3	2E-6	8E-9	4E-5	4E-4
		W, oxides, hydroxides, carbides, and nitrates	-	5E+3	2E-6	6E-9	-	-
72	Hafnium-172	D, see ^{170}Hf	1E+3	9E+0 Bone surf (2E+1)	4E-9 -	- 3E-11	2E-5 -	2E-4 -
		W, see ^{170}Hf	-	4E+1 Bone surf (6E+1)	2E-8 -	- 8E-11	- -	- -
72	Hafnium-173	D, see ^{170}Hf	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{170}Hf	-	1E+4	5E-6	2E-8	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
72	Hafnium-175	D, see ^{170}Hf	3E+3	9E+2 Bone surf	4E-7	-	4E-5	4E-4
			-	(1E+3)	-	1E-9	-	-
		W, see ^{170}Hf	-	1E+3	5E-7	2E-9	-	-
72	Hafnium-177m[b]	D, see ^{170}Hf	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
		W, see ^{170}Hf	-	9E+4	4E-5	1E-7	-	-
72	Hafnium-178m	D, see ^{170}Hf	3E+2	1E+0 Bone surf	5E-10	-	3E-6	3E-5
			-	(2E+0)	-	3E-12	-	-
		W, see ^{170}Hf	-	5E+0 Bone surf	2E-9	-	-	-
			-	(9E+0)	-	1E-11	-	-
72	Hafnium-179m	D, see ^{170}Hf	1E+3	3E+2 Bone surf	1E-7	-	1E-5	1E-4
			-	(6E+2)	-	8E-10	-	-
		W, see ^{170}Hf	-	6E+2	3E-7	8E-10	-	-
72	Hafnium-180m	D, see ^{170}Hf	7E+3	2E+4	9E-6	3E-8	1E-4	1E-3
		W, see ^{170}Hf	-	3E+4	1E-5	4E-8	-	-
72	Hafnium-181	D, see ^{170}Hf	1E+3	2E+2 Bone surf	7E-8	-	2E-5	2E-4
			-	(4E+2)	-	6E-10	-	-
		W, see ^{170}Hf	-	4E+2	2E-7	6E-10	-	-
72	Hafnium-182m[b]	D, see ^{170}Hf	4E+4	9E+4	4E-5	1E-7	5E-4	5E-3
		W, see ^{170}Hf	-	1E+5	6E-5	2E-7	-	-
72	Hafnium-182	D, see ^{170}Hf	2E+2 Bone surf	8E-1 Bone surf	3E-10	-	-	-
			(4E+2)	(2E+0)	-	2E-12	5E-6	5E-5
		W, see ^{170}Hf	-	3E+0 Bone surf	1E-9	-	-	-
			-	(7E+0)	-	1E-11	-	-
72	Hafnium-183[b]	D, see ^{170}Hf	2E+4	5E+4	2E-5	6E-8	3E-4	3E-3
		W, see ^{170}Hf	-	6E+4	2E-5	8E-8	-	-
72	Hafnium-184	D, see ^{170}Hf	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		W, see ^{170}Hf	-	6E+3	3E-6	9E-9	-	-
73	Tantalum-172[b]	W, all compounds except those given for Y	4E+4	1E+5	5E-5	2E-7	5E-4	5E-3
		Y, elemental Ta, oxides, hydroxides, halides, carbides, nitrates, and nitrides	-	1E+5	4E-5	1E-7	-	-
71	Lutetium-174	W, see ^{169}Lu	5E+3	1E+2 Bone surf	5E-8	-	7E-5	7E-4
			-	(2E+2)	-	3E-10	-	-
		Y, see ^{169}Lu	-	2E+2	6E-8	2E-10	-	-
71	Lutetium-176m	W, see ^{169}Lu	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		Y, see ^{169}Lu	-	2E+4	9E-6	3E-8	-	-
73	Tantalum-173	W, see ^{172}Ta	7E+3	2E+4	8E-6	3E-8	9E-5	9E-4
		Y, see ^{172}Ta	-	2E+4	7E-6	2E-8	-	-
73	Tantalum-174[b]	W, see ^{172}Ta	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
		Y, see ^{172}Ta	-	9E+4	4E-5	1E-7	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
73	Tantalum-175	W, see ^{172}Ta	6E+3	2E+4	7E-6	2E-8	8E-5	8E-4
		Y, see ^{172}Ta	-	1E+4	6E-6	2E-8	-	-
73	Tantalum-176	W, see ^{172}Ta	4E+3	1E+4	5E-6	2E-8	5E-5	5E-4
		Y, see ^{172}Ta	-	1E+4	5E-6	2E-8	-	-
73	Tantalum-177	W, see ^{172}Ta	1E+4	2E+4	8E-6	3E-8	2E-4	2E-3
		Y, see ^{172}Ta	-	2E+4	7E-6	2E-8	-	-
73	Tantalum-178	W, see ^{172}Ta	2E+4	9E+4	4E-5	1E-7	2E-4	2E-3
		Y, see ^{172}Ta	-	7E+4	3E-5	1E-7	-	-
73	Tantalum-179	W, see ^{172}Ta	2E+4	5E+3	2E-6	8E-9	3E-4	3E-3
		Y, see ^{172}Ta	-	9E+2	4E-7	1E-9	-	-
73	Tantalum-180m	W, see ^{172}Ta	2E+4	7E+4	3E-5	9E-8	3E-4	3E-3
		Y, see ^{172}Ta	-	6E+4	2E-5	8E-8	-	-
73	Tantalum-180	W, see ^{172}Ta	1E+3	4E+2	2E-7	6E-10	2E-5	2E-4
		Y, see ^{172}Ta	-	2E+1	1E-8	3E-11	-	-
73	Tantalum-182m[b]	W, see ^{172}Ta	2E+5 St wall (2E+5)	5E+5	2E-4	8E-7	-	-
		Y, see ^{172}Ta	-	- 4E+5	- 2E-4	- 6E-7	3E-3 -	3E-2 -
73	Tantalum-182	W, see ^{172}Ta	8E+2	3E+2	1E-7	5E-10	1E-5	1E-4
		Y, see ^{172}Ta	-	1E+2	6E-8	2E-10	-	-
73	Tantalum-183	W, see ^{172}Ta	9E+2 LLI wall (1E+3)	1E+3	5E-7	2E-9	-	-
		Y, see ^{172}Ta	-	- 1E+3	- 4E-7	- 1E-9	2E-5 -	2E-4 -
73	Tantalum-184	W, see ^{172}Ta	2E+3	5E+3	2E-6	8E-9	3E-5	3E-4
		Y, see ^{172}Ta	-	5E+3	2E-6	7E-9	-	-
73	Tantalum-185[b]	W, see ^{172}Ta	3E+4	7E+4	3E-5	1E-7	4E-4	4E-3
		Y, see ^{172}Ta	-	6E+4	3E-5	9E-8	-	-
73	Tantalum-186[b]	W, see ^{172}Ta	5E+4 St wall (7E+4)	2E+5	1E-4	3E-7	-	-
		Y, see ^{172}Ta	-	- 2E+5	- 9E-5	- 3E-7	1E-3 -	1E-2 -
74	Tungsten-176	D, all compounds	1E+4	5E+4	2E-5	7E-8	1E-4	1E-3
74	Tungsten-177	D, all compounds	2E+4	9E+4	4E-5	1E-7	3E-4	3E-3
74	Tungsten-178	D, all compounds	5E+3	2E+4	8E-6	3E-8	7E-5	7E-4
74	Tungsten-179[b]	D, all compounds	5E+5	2E+6	7E-4	2E-6	7E-3	7E-2
74	Tungsten-181	D, all compounds	2E+4	3E+4	1E-5	5E-8	2E-4	2E-3
74	Tungsten-185	D, all compounds	2E+3 LLI wall (3E+3)	7E+3	3E-6	9E-9	-	-
				-	-	-	4E-5	4E-4
74	Tungsten-187	D, all compounds	2E+3	9E+3	4E-6	1E-8	3E-5	3E-4
74	Tungsten-188	D, all compounds	4E+2 LLI wall (5E+2)	1E+3	5E-7	2E-9	-	-
				-	-	-	7E-6	7E-5

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col 1 Oral Ingestion ALI (μCi)	Col 2 Inhalation ALI (μCi)	Col 3 Inhalation DAC (μCi/ml)	Col 1 Air (μCi/ml)	Col 2 Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
75	Rhenium-177[b]	D, all compounds except those given for W	9E+4	3E+5	1E-4	4E-7	-	-
			St wall (1E+5)	-	-	-	2E-3	2E-2
		W, oxides, hydroxides, and nitrates	-	4E+5	1E-4	5E-7	-	-
75	Rhenium-178[b]	D, see ^{177}Re	7E+4	3E+5	1E-4	4E-7	-	-
			St wall (1E+5)	-	-	-	1E-3	1E-2
		W, see ^{177}Re	-	3E+5	1E-4	4E-7	-	-
75	Rhenium-181	D, see ^{177}Re	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4
		W, see ^{177}Re	-	9E+3	4E-6	1E-8	-	-
75	Rhenium-182 (12.7 h)	D, see ^{177}Re	7E+3	1E+4	5E-6	2E-8	9E-5	9E-4
		W, see ^{177}Re	-	2E+4	6E-6	2E-8	-	-
75	Rhenium-182 (64 0 h)	D, see ^{177}Re	1E+3	2E+3	1E-6	3E-9	2E-5	2E-4
		W, see ^{177}Re	-	2E+3	9E-7	3E-9	-	-
75	Rhenium-184m	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{177}Re	-	4E+2	2E-7	6E-10	-	-
75	Rhenium-184	D, see ^{177}Re	2E+3	4E+3	1E-6	5E-9	3E-5	3E-4
		W, see ^{177}Re	-	1E+3	6E-7	2E-9	-	-
75	Rhenium-186m	D, see ^{177}Re	1E+3	2E+3	7E-7	-	-	-
			St wall (2E+3)	St wall (2E+3)	-	3E-9	2E-5	2E-4
		W, see ^{177}Re	-	2E+2	6E-8	2E-10	-	-
75	Rhenium-186	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
		W, see ^{177}Re	-	2E+3	7E-7	2E-9	-	-
75	Rhenium-187	D, see ^{177}Re	6E+5	8E+5	4E-4	-	8E-3	8E-2
			-	St wall (9E+5)	-	1E-6	-	-
		W, see ^{177}Re	-	1E+5	4E-5	1E-7	-	-
75	Rhenium-188m[b]	D, see ^{177}Re	8E+4	1E+5	6E-5	2E-7	1E-3	1E-2
		W, see ^{177}Re	-	1E+5	6E-5	2E-7	-	-
75	Rhenium-188	D, see ^{177}Re	2E+3	3E+3	1E-6	4E-9	2E-5	2E-4
		W, see ^{177}Re	-	3E+3	1E-6	4E-9	-	-
75	Rhenium-189	D, see ^{177}Re	3E+3	5E+3	2E-6	7E-9	4E-5	4E-4
		W, see ^{177}Re	-	4E+3	2E-6	6E-9	-	-
76	Osmium-180[b]	D, all compounds except those given for W and Y	1E+5	4E+5	2E-4	5E-7	1E-3	1E-2
		W, halides and nitrates	-	5E+5	2E-4	7E-7	-	-
		Y, oxides and hydroxides	-	5E+5	2E-4	6E-7	-	-
76	Osmium-181[b]	D, see ^{180}Os	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{180}Os	-	5E+4	2E-5	6E-8	-	-
		Y, see ^{180}Os	-	4E+4	2E-5	6E-8	-	-
76	Osmium-182	D, see ^{180}Os	2E+3	6E+3	2E-6	8E-9	3E-5	3E-4
		W, see ^{180}Os	-	4E+3	2E-6	6E-9	-	-
		Y, see ^{180}Os	-	4E+3	2E-6	6E-9	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
76	Osmium-185	D, see ^{180}Os	2E+3	5E+2	2E-7	7E-10	3E-5	3E-4
		W, see ^{180}Os	-	8E+2	3E-7	1E-9	-	-
		Y, see ^{180}Os	-	8E+2	3E-7	1E-9	-	-
76	Osmium-189m	D, see ^{180}Os	8E+4	2E+5	1E-4	3E-7	1E-3	1E-2
		W, see ^{180}Os	-	2E+5	9E-5	3E-7	-	-
		Y, see ^{180}Os	-	2E+5	7E-5	2E-7	-	-
76	Osmium-191m	D, see ^{180}Os	1E+4	3E+4	1E-5	4E-8	2E-4	2E-3
		W, see ^{180}Os	-	2E+4	8E-6	3E-8	-	-
		Y, see ^{180}Os	-	2E+4	7E-6	2E-8	-	-
76	Osmium-191	D, see ^{180}Os	2E+3	2E+3	9E-7	3E-9	-	-
			LLI wall (3E+3)	-	-	-	3E-5	3E-4
		W, see ^{180}Os	-	2E+3	7E-7	2E-9	-	-
		Y, see ^{180}Os	-	1E+3	6E-7	2E-9	-	-
76	Osmium-193	D, see ^{180}Os	2E+3	5E+3	2E-6	6E-9	-	-
			LLI wall (2E+3)	-	-	-	2E-5	2E-4
		W, see ^{180}Os	-	3E+3	1E-6	4E-9	-	-
		Y, see ^{180}Os	-	3E+3	1E-6	4E-9	-	-
76	Osmium-194	D, see ^{180}Os	4E+2	4E+1	2E-8	6E-11	-	-
			LLI wall (6E+2)	-	-	-	8E-6	8E-5
		W, see ^{180}Os	-	6E+1	2E-8	8E-11	-	-
		Y, see ^{180}Os	-	8E+0	3E-9	1E-11	-	-
77	Iridium-182	D, all compounds except those given for W and Y	4E+4	1E+5	6E-5	2E-7	-	-
			St wall (4E+4)	-	-	-	6E-4	6E-3
		W, halides, nitrates, and metallic iridium	-	2E+5	6E-5	2E-7	-	-
		Y, oxides and hydroxides	-	1E+5	5E-5	2E-7	-	-
77	Iridium-184	D, see ^{182}Ir	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{182}Ir	-	3E+4	1E-5	5E-8	-	-
		Y, see ^{182}Ir	-	3E+4	1E-5	4E-8	-	-
77	Iridium-185	D, see ^{182}Ir	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{182}Ir	-	1E+4	5E-6	2E-8	-	-
		Y, see ^{182}Ir	-	1E+4	4E-6	1E-8	-	-
77	Iridium-186	D, see ^{182}Ir	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		W, see ^{182}Ir	-	6E+3	3E-6	9E-9	-	-
		Y, see ^{182}Ir	-	6E+3	2E-6	8E-9	-	-
77	Iridium-187	D, see ^{182}Ir	1E+4	3E+4	1E-5	5E-8	1E-4	1E-3
		W, see ^{182}Ir	-	3E+4	1E-5	4E-8	-	-
		Y, see ^{182}Ir	-	3E+4	1E-5	4E-8	-	-
77	Iridium-188	D, see ^{182}Ir	2E+3	5E+3	2E-6	6E-9	3E-5	3E-4
		W, see ^{182}Ir	-	4E+3	1E-6	5E-9	-	-
		Y, see ^{182}Ir	-	3E+3	1E-6	5E-9	-	-
77	Iridium-189	D, see ^{182}Ir	5E+3	5E+3	2E-6	7E-9	-	-
			LLI wall (5E+3)	-	-	-	7E-5	7E-4
		W, see ^{182}Ir	-	4E+3	2E-6	5E-9	-	-
		Y, see ^{182}Ir	-	4E+3	1E-6	5E-9	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
77	Iridium-190m[b]	D, see ^{182}Ir	2E+5	2E+5	8E-5	3E-7	2E-3	2E-2
		W, see ^{182}Ir	-	2E+5	9E-5	3E-7	-	-
		Y, see ^{182}Ir	-	2E+5	8E-5	3E-7	-	-
77	Iridium-190	D, see ^{182}Ir	1E+3	9E+2	4E-7	1E-9	1E-5	1E-4
		W, see ^{182}Ir	-	1E+3	4E-7	1E-9	-	-
		Y, see ^{182}Ir	-	9E+2	4E-7	1E-9	-	-
77	Iridium-192m	D, see ^{182}Ir	3E+3	9E+1	4E-8	1E-10	4E-5	4E-4
		W, see ^{182}Ir	-	2E+2	9E-8	3E-10	-	-
		Y, see ^{182}Ir	-	2E+1	6E-9	2E-11	-	-
77	Iridium-192	D, see ^{182}Ir	9E+2	3E+2	1E-7	4E-10	1E-5	1E-4
		W, see ^{182}Ir	-	4E+2	2E-7	6E-10	-	-
		Y, see ^{182}Ir	-	2E+2	9E-8	3E-10	-	-
77	Iridium-194m	D, see ^{182}Ir	6E+2	9E+1	4E-8	1E-10	9E-6	9E-5
		W, see ^{182}Ir	-	2E+2	7E-8	2E-10	-	-
		Y, see ^{182}Ir	-	1E+2	4E-8	1E-10	-	-
77	Iridium-194	D, see ^{182}Ir	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		W, see ^{182}Ir	-	2E+3	9E-7	3E-9	-	-
		Y, see ^{182}Ir	-	2E+3	8E-7	3E-9	-	-
77	Iridium-195m	D, see ^{182}Ir	8E+3	2E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{182}Ir	-	3E+4	1E-5	4E-8	-	-
		Y, see ^{182}Ir	-	2E+4	9E-6	3E-8	-	-
77	Iridium-195	D, see ^{182}Ir	1E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{182}Ir	-	5E+4	2E-5	7E-8	-	-
		Y, see ^{182}Ir	-	4E+4	2E-5	6E-8	-	-
78	Platinum-186	D, all compounds	1E+4	4E+4	2E-5	5E-8	2E-4	2E-3
78	Platinum-188	D, all compounds	2E+3	2E+3	7E-7	2E-9	2E-5	2E-4
78	Platinum-189	D, all compounds	1E+4	3E+4	1E-5	4E-8	1E-4	1E-3
78	Platinum-191	D, all compounds	4E+3	8E+3	4E-6	1E-8	5E-5	5E-4
78	Platinum-193m	D, all compounds	3E+3	6E+3	3E-6	8E-9	-	-
			LLI wall (3E+4)	-	-	-	4E-5	4E-4
78	Platinum-193	D, all compounds	4E+4	2E+4	1E-5	3E-8	-	-
			LLI wall (5E+4)	-	-	-	6E-4	6E-3
78	Platinum-195m	D, all compounds	2E+3	4E+3	2E-6	6E-9	-	-
			LLI wall (2E+3)	-	-	-	3E-5	3E-4
78	Platinum-197m[b]	D, all compounds	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
78	Platinum-197	D, all compounds	3E+3	1E+4	4E-6	1E-8	4E-5	4E-4
78	Platinum-199[b]	D, all compounds	5E+4	1E+5	6E-5	2E-7	7E-4	7E-3
78	Platinum-200	D, all compounds	1E+3	3E+3	1E-6	5E-9	2E-5	2E-4
79	Gold-193	D, all compounds except those given for W and Y	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
		W, halides and nitrates	-	2E+4	9E-6	3E-8	-	-
		Y, oxides and hydroxides	-	2E+4	8E-6	3E-8	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
79	Gold-194	D, see ^{193}Au	3E+3	8E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{193}Au	-	5E+3	2E-6	8E-9	-	-
		Y, see ^{193}Au	-	5E+3	2E-6	7E-9	-	-
79	Gold-195	D, see ^{193}Au	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
		W, see ^{193}Au	-	1E+3	6E-7	2E-9	-	-
		Y, see ^{193}Au	-	4E+2	2E-7	6E-10	-	-
79	Gold-198m	D, see ^{193}Au	1E+3	3E+3	1E-6	4E-9	1E-5	1E-4
		W, see ^{193}Au	-	1E+3	5E-7	2E-9	-	-
		Y, see ^{193}Au	-	1E+3	5E-7	2E-9	-	-
79	Gold-198	D, see ^{193}Au	1E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		W, see ^{193}Au	-	2E+3	8E-7	3E-9	-	-
		Y, see ^{193}Au	-	2E+3	7E-7	2E-9	-	-
79	Gold-199	D, see ^{193}Au	3E+3 LLI wall (3E+3)	9E+3	4E-6	1E-8	-	-
		W, see ^{193}Au	-	4E+3	2E-6	6E-9	4E-5	4E-4
		Y, see ^{193}Au	-	4E+3	2E-6	5E-9	-	-
79	Gold-200m	D, see ^{193}Au	1E+3	4E+3	1E-6	5E-9	2E-5	2E-4
		W, see ^{193}Au	-	3E+3	1E-6	4E-9	-	-
		Y, see ^{193}Au	-	2E+4	1E-6	3E-9	-	-
79	Gold-200[b]	D, see ^{193}Au	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
		W, see ^{193}Au	-	8E+4	3E-5	1E-7	-	-
		Y, see ^{193}Au	-	7E+4	3E-5	1E-7	-	-
79	Gold-201[b]	D, see ^{193}Au	7E+4 St wall (9E+4)	2E+5	9E-5	3E-7	-	-
		W, see ^{193}Au	-	2E+5	1E-4	3E-7	1E-3	1E-2
		Y, see ^{193}Au	-	2E+5	9E-5	3E-7	-	-
80	Mercury-193m	Vapor	-	8E+3	4E-6	1E-8	-	-
		Organic D	4E+3	1E+4	5E-6	2E-8	6E-5	6E-4
		D, sulfates	3E+3	9E+3	4E-6	1E-8	4E-5	4E-4
		W, oxides, hydroxides, halides, nitrates, and sulfides	-	8E+3	3E-6	1E-8	-	-
80	Mercury-193	Vapor	-	3E+4	1E-5	4E-8	-	-
		Organic D	2E+4	6E+4	3E-5	9E-8	3E-4	3E-3
		D, see ^{193m}Hg	2E+4	4E+4	2E-5	6E-8	2E-4	2E-3
		W, see ^{193m}Hg	-	4E+4	2E-5	6E-8	-	-
80	Mercury-194	Vapor	-	3E+1	1E-8	4E-11	-	-
		Organic D	2E+1	3E+1	1E-8	4E-11	2E-7	2E-6
		D, see ^{193m}Hg	8E+2	4E+1	2E-8	6E-11	1E-5	1E-4
		W, see ^{193m}Hg	-	1E+2	5E-8	2E-10	-	-
80	Mercury-195m	Vapor	-	4E+3	2E-6	6E-9	-	-
		Organic D	3E+3	6E+3	3E-6	8E-9	4E-5	4E-4
		D, see ^{193m}Hg	2E+3	5E+3	2E-6	7E-9	3E-5	3E-4
		W, see ^{193m}Hg	-	4E+3	2E-6	5E-9	-	-
80	Mercury-195	Vapor	-	3E+4	1E-5	4E-8	-	-
		Organic D	2E+4	5E+4	2E-5	6E-8	2E-4	2E-3
		D, see ^{193m}Hg	1E+4	4E+4	1E-5	5E-8	2E-4	2E-3
		W, see ^{193m}Hg	-	3E+4	1E-5	5E-8	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values			Table II Effluent Concentrations		Table III Releases to Sewers
			Col. 1 Oral Ingestion	Col 2 Inhalation	Col 3	Col. 1	Col 2	
			ALI (μCi)	ALI (μCi)	DAC (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)	Monthly Average Concentration (μCi/ml)
80	Mercury-197m	Vapor	-	5E+3	2E-6	7E-9	-	-
		Organic D	4E+3	9E+3	4E-6	1E-8	5E-5	5E-4
		D, see ^{193m}Hg	3E+3	7E+3	3E-6	1E-8	4E-5	4E-4
		W, see ^{193m}Hg	-	5E+3	2E-6	7E-9	-	-
80	Mercury-197	Vapor	-	8E+3	4E-6	1E-8	-	-
		Organic D	7E+3	1E+4	6E-6	2E-8	9E-5	9E-4
		D, see ^{193m}Hg	6E+3	1E+4	5E-6	2E-8	8E-5	8E-4
		W, see ^{193m}Hg	-	9E+3	4E-6	1E-8	-	-
80	Mercury-199m[b]	Vapor	-	8E+4	3E-5	1E-7	-	-
		Organic D	6E+4	2E+5	7E-5	2E-7	-	-
			St wall (1E+5)	-	-	-	1E-3	1E-2
		D, see ^{193m}Hg	6E+4	1E+5	6E-5	2E-7	8E-4	8E-3
		W, see ^{193m}Hg	-	2E+5	7E-5	2E-7	-	-
80	Mercury-203	Vapor	-	8E+2	4E-7	1E-9	-	-
		Organic D	5E+2	8E+2	3E-7	1E-9	7E-6	7E-5
		D, see ^{193m}Hg	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
		W, see ^{193m}Hg	-	1E+3	5E-7	2E-9	-	-
81	Thallium-194m[b]	D, all compounds	5E+4	2E+5	6E-5	2E-7	-	-
			St wall (7E+4)	-	-	-	1E-3	1E-2
81	Thallium-194[b]	D, all compounds	3E+5	6E+5	2E-4	8E-7	-	-
			St wall (3E+5)	-	-	-	4E-3	4E-2
81	Thallium-195[b]	D, all compounds	6E+4	1E+5	5E-5	2E-7	9E-4	9E-3
81	Thallium-197	D, all compounds	7E+4	1E+5	5E-5	2E-7	1E-3	1E-2
81	Thallium-198m[b]	D, all compounds	3E+4	5E+4	2E-5	8E-8	4E-4	4E-3
81	Thallium-198	D, all compounds	2E+4	3E+4	1E-5	5E-8	3E-4	3E-3
81	Thallium-199	D, all compounds	6E+4	8E+4	4E-5	1E-7	9E-4	9E-3
81	Thallium-200	D, all compounds	8E+3	1E+4	5E-6	2E-8	1E-4	1E-3
81	Thallium-201	D, all compounds	2E+4	2E+4	9E-6	3E-8	2E-4	2E-3
81	Thallium-202	D, all compounds	4E+3	5E+3	2E-6	7E-9	5E-5	5E-4
81	Thallium-204	D, all compounds	2E+3	2E+3	9E-7	3E-9	2E-5	2E-4
82	Lead-195m[b]	D, all compounds	6E+4	2E+5	8E-5	3E-7	8E-4	8E-3
82	Lead-198	D, all compounds	3E+4	6E+4	3E-5	9E-8	4E-4	4E-3
82	Lead-199[b]	D, all compounds	2E+4	7E+4	3E-5	1E-7	3E-4	3E-3
82	Lead-200	D, all compounds	3E+3	6E+3	3E-6	9E-9	4E-5	4E-4
82	Lead-201	D, all compounds	7E+3	2E+4	8E-6	3E-8	1E-4	1E-3
82	Lead-202m	D, all compounds	9E+3	3E+4	1E-5	4E-8	1E-4	1E-3
82	Lead-202	D, all compounds	1E+2	5E+1	2E-8	7E-11	2E-6	2E-5
82	Lead-203	D, all compounds	5E+3	9E+3	4E-6	1E-8	7E-5	7E-4

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
82	Lead-205	D, all compounds	4E+3	1E+3	6E-7	2E-9	5E-5	5E-4
82	Lead-209	D, all compounds	2E+4	6E+4	2E-5	8E-8	3E-4	3E-3
82	Lead-210	D, all compounds	6E-1 Bone surf (1E+0)	2E-1 Bone surf (4E-1)	1E-10 -	- 6E-13	- 1E-8	- 1E-7
82	Lead-211[b]	D, all compounds	1E+4	6E+2	3E-7	9E-10	2E-4	2E-3
82	Lead-212	D, all compounds	8E+1 Bone surf (1E+2)	3E+1 -	1E-8 -	5E-11 -	- 2E-6	- 2E-5
82	Lead-214[b]	D, all compounds	9E+3	8E+2	3E-7	1E-9	1E-4	1E-3
83	Bismuth-200[b]	D, nitrates W, all other compounds	3E+4 -	8E+4 1E+5	4E-5 4E-5	1E-7 1E-7	4E-4 -	4E-3 -
83	Bismuth-201[b]	D, see ^{200}Bi W, see ^{200}Bi	1E+4 -	3E+4 4E+4	1E-5 2E-5	4E-8 5E-8	2E-4 -	2E-3 -
83	Bismuth-202[b]	D, see ^{200}Bi W, see ^{200}Bi	1E+4 -	4E+4 8E+4	2E-5 3E-5	6E-8 1E-7	2E-4 -	2E-3 -
83	Bismuth-203	D, see ^{200}Bi W, see ^{200}Bi	2E+3 -	7E+3 6E+3	3E-6 3E-6	9E-9 9E-9	3E-5 -	3E-4 -
83	Bismuth-205	D, see ^{200}Bi W, see ^{200}Bi	1E+3 -	3E+3 1E+3	1E-6 5E-7	3E-9 2E-9	2E-5 -	2E-4 -
83	Bismuth-206	D, see ^{200}Bi W, see ^{200}Bi	6E+2 -	1E+3 9E+2	6E-7 4E-7	2E-9 1E-9	9E-6 -	9E-5 -
83	Bismuth-207	D, see ^{200}Bi W, see ^{200}Bi	1E+3 -	2E+3 4E+2	7E-7 1E-7	2E-9 5E-10	1E-5 -	1E-4 -
83	Bismuth-210m	D, see ^{200}Bi W, see ^{200}Bi	4E+1 Kidneys (6E+1) -	5E+0 Kidneys (6E+0) 7E-1	2E-9 - 3E-10	- 9E-12 9E-13	- 8E-7 -	- 8E-6 -
83	Bismuth-210	D, see ^{200}Bi W, see ^{200}Bi	8E+2 - - -	2E+2 Kidneys (4E+2) 3E+1	1E-7 - 1E-8	- 5E-10 4E-11	1E-5 - -	1E-4 - -
83	Bismuth-212[b]	D, see ^{200}Bi W, see ^{200}Bi	5E+3 -	2E+2 3E+2	1E-7 1E-7	3E-10 4E-10	7E-5 -	7E-4 -
83	Bismuth-213[b]	D, see ^{200}Bi W, see ^{200}Bi	7E+3 -	3E+2 4E+2	1E-7 1E-7	4E-10 5E-10	1E-4 -	1E-3 -
83	Bismuth-214[b]	D, see ^{200}Bi W, see ^{200}Bi	2E+4 St wall (2E+4) -	8E+2 - 9E-2	3E-7 - 4E-7	1E-9 - 1E-9	- 3E-4 -	- 3E-3 -
84	Polonium-203[b]	D, all compounds except those given for W W, oxides, hydroxides, and nitrates	3E+4 -	6E+4 9E+4	3E-5 4E-5	9E-8 1E-7	3E-4 -	3E-3 -
84	Polonium-205[b]	D, see ^{203}Po W, see ^{203}Po	2E+4 -	4E+4 7E+4	2E-5 3E-5	5E-8 1E-7	3E-4 -	3E-3 -

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
84	Polonium-207	D, see ^{203}Po	8E+3	3E+4	1E-5	3E-8	1E-4	1E-3
		W, see ^{203}Po	-	3E+4	1E-5	4E-8	-	-
84	Polonium-210	D, see ^{203}Po	3E+0	6E-1	3E-10	9E-13	4E-8	4E-7
		W, see ^{203}Po	-	6E-1	3E-10	9E-13	-	-
85	Astatine-207[b]	D, halides	6E+3	3E+3	1E-6	4E-9	8E-5	8E-4
		W	-	2E+3	9E-7	3E-9	-	-
85	Astatine-211	D, halides	1E+2	8E+1	3E-8	1E-10	2E-6	2E-5
		W	-	5E+1	2E-8	8E-11	-	-
86	Radon-220	With daughters removed	-	2E+4	7E-6	2E-8	-	-
		With daughters present	-	2E+1 (or 12 WLM)	9E-9 (or 1.0 WL)	3E-11	-	-
86	Radon-222	With daughters removed	-	1E+4	4E-6	1E-8	-	-
		With daughters present	-	1E+2 (or 4 WLM)	3E-8 (or 0 33 WL)	1E-10	-	-
87	Francium-222[b]	D, all compounds	2E+3	5E+2	2E-7	6E-10	3E-5	3E-4
87	Francium-223[b]	D, all compounds	6E+2	8E+2	3E-7	1E-9	8E-6	8E-5
88	Radium-223	W, all compounds	5E+0 Bone surf (9E+0)	7E-1	3E-10	9E-13	-	-
				-	-	-	1E-7	1E-6
88	Radium-224	W, all compounds	8E+0 Bone surf (2E+1)	2E+0	7E-10	2E-12	-	-
				-	-	-	2E-7	2E-6
88	Radium-225	W, all compounds	8E+0 Bone surf (2E+1)	7E-1	3E-10	9E-13	-	-
				-	-	-	2E-7	2E-6
88	Radium-226	W, all compounds	2E+0 Bone surf (5E+0)	6E-1	3E-10	9E-13	-	-
				-	-	-	6E-8	6E-7
88	Radium-227[b]	W, all compounds	2E+4 Bone surf (2E+4)	1E+4 Bone surf (2E+4)	6E-6	-	-	-
					-	3E-8	3E-4	3E-3
88	Radium-228	W, all compounds	2E+0 Bone surf (4E+0)	1E+0	5E-10	2E-12	-	-
				-	-	-	6E-8	6E-7
89	Actinium-224	D, all compounds except those given for W and Y	2E+3 LLI wall (2E+3)	3E+1 Bone surf (4E+1)	1E-8	-	-	-
		W, halides and nitrates	-	5E+1	2E-8	5E-11	3E-5	3E-4
		Y, oxides and hydroxides	-	5E+1	2E-8	7E-11	-	-
						6E-11	-	-
89	Actinium-225	D, see ^{224}Ac	5E+1 LLI wall (5E+1)	3E-1 Bone surf (5E-1)	1E-10	-	-	-
		W, see ^{224}Ac	-	6E-1	3E-10	7E-13	7E-7	7E-6
		Y, see ^{224}Ac	-	6E-1	3E-10	9E-13	-	-
						9E-13	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col. 3 DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
89	Actinium-226	D, see ^{224}Ac	1E+2	3E+0	1E-9	-	-	-
			LLI wall (1E+2)	Bone surf (4E+0)	-	5E-12	2E-6	2E-5
		W, see ^{224}Ac	-	5E+0	2E-9	7E-12	-	-
		Y, see ^{224}Ac	-	5E+0	2E-9	6E-12	-	-
89	Actinium-227	D, see ^{224}Ac	2E-1	4E-4	2E-13	-	-	-
			Bone surf (4E-1)	Bone surf (8E-4)	-	1E-15	5E-9	5E-8
		W, see ^{224}Ac	-	2E-3	7E-13	-	-	-
				Bone surf				
			-	(3E-3)	-	4E-15	-	-
		Y, see ^{224}Ac	-	4E-3	2E-12	6E-15	-	-
89	Actinium-228	D, see ^{224}Ac	2E+3	9E+0	4E-9	-	3E-5	3E-4
				Bone surf				
			-	(2E+1)	-	2E-11	-	-
		W, see ^{224}Ac	-	4E+1	2E-8	-	-	-
				Bone surf				
			-	(6E+1)	-	8E-11	-	-
		Y, see ^{224}Ac	-	4E+1	2E-8	6E-11	-	-
90	Thorium-226	W, all compounds except those given for Y	5E+3	2E+2	6E-8	2E-10	-	-
			St wall (5E+3)	-	-	-	7E-5	7E-4
		Y, oxides and hydroxides	-	1E+2	6E-8	2E-10	-	-
90	Thorium-227	W, see ^{226}Th	1E+2	3E-1	1E-10	5E-13	2E-6	2E-5
		Y, see ^{226}Th	-	3E-1	1E-10	5E-13	-	-
90	Thorium-228	W, see ^{226}Th	6E+0	1E-2	4E-12	-	-	-
			Bone surf (1E+1)	Bone surf (2E-2)	-	3E-14	2E-7	2E-6
		Y, see ^{226}Th	-	2E-2	7E-12	2E-14	-	-
90	Thorium-229	W, see ^{226}Th	6E-1	9E-4	4E-13	-	-	-
			Bone surf (1E+0)	Bone surf (2E-3)	-	3E-15	2E-8	2E-7
		Y, see ^{226}Th	-	2E-3	1E-12	-	-	-
				Bone surf				
			-	(3E-3)	-	4E-15	-	-
90	Thorium-230	W, see ^{226}Th	4E+0	6E-3	3E-12	-	-	-
			Bone surf (9E+0)	Bone surf (2E-2)	-	2E-14	1E-7	1E-6
		Y, see ^{226}Th	-	2E-2	6E-12	-	-	-
				Bone surf				
			-	(2E-2)	-	3E-14	-	-
90	Thorium-231	W, see ^{226}Th	4E+3	6E+3	3E-6	9E-9	5E-5	5E-4
		Y, see ^{226}Th	-	6E+3	3E-6	9E-9	-	-
90	Thorium-232	W, see ^{226}Th	7E-1	1E-3	5E-13	-	-	-
			Bone surf (2E+0)	Bone surf (3E-3)	-	4E-15	3E-8	3E-7
		Y, see ^{226}Th	-	3E-3	1E-12	-	-	-
				Bone surf				
			-	(4E-3)	-	6E-15	-	-
90	Thorium-234	W, see ^{226}Th	3E+2	2E+2	8E-8	3E-10	-	-
			LLI wall (4E+2)	-	-	-	5E-6	5E-5
		Y, see ^{226}Th	-	2E+2	6E-8	2E-10	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
91	Protactinium-227[b]	W, all compounds except those given for Y	4E+3	1E+2	5E-8	2E-10	5E-5	5E-4
		Y, oxides and hydroxides	-	1E+2	4E-8	1E-10	-	-
91	Protactinium-228	W, see ^{227}Pa	1E+3	1E+1 Bone surf	5E-9	-	2E-5	2E-4
		Y, see ^{227}Pa	-	(2E+1)	-	3E-11	-	-
			-	1E+1	5E-9	2E-11	-	-
91	Protactinium-230	W, see ^{227}Pa	6E+2 Bone surf	5E+0	2E-9	7E-12	-	-
		Y, see ^{227}Pa	(9E+2) -	- 4E+0	- 1E-9	- 5E-12	1E-5 -	1E-4 -
91	Protactinium-231	W, see ^{227}Pa	2E-1 Bone surf	2E-3 Bone surf	6E-13	-	-	-
		Y, see ^{227}Pa	(5E-1) -	(4E-3) 4E-3 Bone surf	- 2E-12	6E-15 -	6E-9 -	6E-8 -
			-	(6E-3)	-	8E-15	-	-
91	Protactinium-232	W, see ^{227}Pa	1E+3	2E+1 Bone surf	9E-9	-	2E-5	2E-4
		Y, see ^{227}Pa	-	(6E+1)	-	8E-11	-	-
			-	6E+1 Bone surf	2E-8	-	-	-
			-	(7E+1)	-	1E-10	-	-
91	Protactinium-233	W, see ^{227}Pa	1E+3 LLI wall	7E+2	3E-7	1E-9	-	-
		Y, see ^{227}Pa	(2E+3) -	- 6E+2	- 2E-7	- 8E-10	2E-5 -	2E-4 -
91	Protactinium-234	W, see ^{227}Pa	2E+3	8E+3	3E-6	1E-8	3E-5	3E-4
		Y, see ^{227}Pa	-	7E+3	3E-6	9E-9	-	-
92	Uranium-230	D, UF_6, UO_2F_2, $UO_2(NO_3)_2$	4E+0 Bone surf	4E-1 Bone surf	2E-10	-	-	-
		W, UO_3, UF_4, UCl_4	(6E+0) -	(6E-1) 4E-1	- 1E-10	8E-13 5E-13	8E-8 -	8E-7 -
		Y, UO_2, U_3O_8	-	3E-1	1E-10	4E-13	-	-
92	Uranium-231	D, see ^{230}U	5E+3 LLI wall	8E+3	3E-6	1E-8	-	-
		W, see ^{230}U	(4E+3) -	- 6E+3	- 2E-6	- 8E-9	6E-5 -	6E-4 -
		Y, see ^{230}U	-	5E+3	2E-6	6E-9	-	-
92	Uranium-232	D, see ^{230}U	2E+0 Bone surf	2E-1 Bone surf	9E-11	-	-	-
		W, see ^{230}U	(4E+0) -	(4E-1) 4E-1	- 2E-10	6E-13 5E-13	6E-8 -	6E-7 -
		Y, see ^{230}U	-	8E-3	3E-12	1E-14	-	-
92	Uranium-233	D, see ^{230}U	1E+1 Bone surf	1E+0 Bone surf	5E-10	-	-	-
		W, see ^{230}U	(2E+1) -	(2E+0) 7E-1	- 3E-10	3E-12 1E-12	3E-7 -	3E-6 -
		Y, see ^{230}U	-	4E-2	2E-11	5E-14	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
92	Uranium-234[g]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10	-	-	-
		W, see ^{230}U	-	7E-1	3E-10	3E-12	3E-7	3E-6
		Y, see ^{230}U	-	4E-2	2E-11	1E-12	-	-
						5E-14	-	-
92	Uranium-235[g]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	6E-10	-	-	-
		W, see ^{230}U	-	8E-1	3E-10	3E-12	3E-7	3E-6
		Y, see ^{230}U	-	4E-2	2E-11	1E-12	-	-
						6E-14	-	-
92	Uranium-236	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10	-	-	-
		W, see ^{230}U	-	8E-1	3E-10	3E-12	3E-7	3E-6
		Y, see ^{230}U	-	4E-2	2E-11	1E-12	-	-
						6E-14	-	-
92	Uranium-237	D, see ^{230}U	2E+3 LLI wall (2E+3)	3E+3	1E-6	4E-9	-	-
		W, see ^{230}U	-	2E+3	7E-7	-	3E-5	3E-4
		Y, see ^{230}U	-	2E+3	6E-7	2E-9	-	-
						2E-9	-	-
92	Uranium-238[g]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	6E-10	-	-	-
		W, see ^{230}U	-	8E-1	3E-10	3E-12	3E-7	3E-6
		Y, see ^{230}U	-	4E-2	2E-11	1E-12	-	-
						6E-14	-	-
92	Uranium-239[b]	D, see ^{230}U	7E+4	2E+5	8E-5	3E-7	9E-4	9E-3
		W, see ^{230}U	-	2E+5	7E-5	2E-7	-	-
		Y, see ^{230}U	-	2E+5	6E-5	2E-7	-	-
92	Uranium-240	D, see ^{230}U	1E+3	4E+3	2E-6	5E-9	2E-5	2E-4
		W, see ^{230}U	-	3E+3	1E-6	4E-9	-	-
		Y, see ^{230}U	-	2E+3	1E-6	3E-9	-	-
92	Uranium-natural[g]	D, see ^{230}U	1E+1 Bone surf (2E+1)	1E+0 Bone surf (2E+0)	5E-10	-	-	-
		W, see ^{230}U	-	8E-1	3E-10	3E-12	3E-7	3E-6
		Y, see ^{230}U	-	5E-2	2E-11	9E-13	-	-
						9E-14	-	-
93	Neptunium-232[b]	W, all compounds	1E+5	2E+3 Bone surf (5E+2)	7E-7	-	2E-3	2E-2
			-		-	6E-9	-	-
93	Neptunium-233[b]	W, all compounds	8E+5	3E+6	1E-3	4E-6	1E-2	1E-1
93	Neptunium-234	W, all compounds	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
93	Neptunium-235	W, all compounds	2E+4 LLI wall (2E+4)	8E+2 Bone surf (1E+3)	3E-7	-	-	-
					-	2E-9	3E-4	3E-3
93	Neptunium-236 (1 15E+5 y)	W, all compounds	3E+0 Bone surf (6E+0)	2E-2 Bone surf (5E-2)	9E-12	-	-	-
					-	8E-14	9E-8	9E-7
93	Neptunium-236 (22 5 h)	W, all compounds	3E+3 Bone surf (4E+3)	3E+1 Bone surf (7E+1)	1E-8	-	-	-
					-	1E-10	5E-5	5E-4

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
93	Neptunium-237	W, all compounds	5E-1 Bone surf	4E-3 Bone surf	2E-12	-	-	-
			(1E+0)	(1E-2)	-	1E-14	2E-8	2E-7
93	Neptunium-238	W, all compounds	1E+3	6E+1 Bone surf	3E-8	-	2E-5	2E-4
			-	(2E+2)	-	2E-10	-	-
93	Neptunium-239	W, all compounds	2E+3	2E+3	9E-7	3E-9	-	-
			LLI wall (2E+3)	-	-	-	2E-5	2E-4
93	Neptunium-240[b]	W, all compounds	2E+4	8E+4	3E-5	1E-7	3E-4	3E-3
94	Plutonium-234	W, all compounds except PuO_2	8E+3	2E+2	9E-8	3E-10	1E-4	1E-3
		Y, PuO_2	-	2E+2	8E-8	3E-10	-	-
94	Plutonium-235[b]	W, see ^{234}Pu	9E+5	3E+6	1E-3	4E-6	1E-2	1E-1
		Y, see ^{234}Pu	-	3E+6	1E-3	3E-6	-	-
94	Plutonium-236	W, see ^{234}Pu	2E+0 Bone surf	2E-2 Bone surf	8E-12	-	-	-
			(4E+0)	(4E-2)	-	5E-14	6E-8	6E-7
		Y, see ^{234}Pu	-	4E-2	2E-11	6E-14	-	-
94	Plutonium-237	W, see ^{234}Pu	1E+4	3E+3	1E-6	5E-9	2E-4	2E-3
		Y, see ^{234}Pu	-	3E+3	1E-6	4E-9	-	-
94	Plutonium-238	W, see ^{234}Pu	9E-1 Bone surf	7E-3 Bone surf	3E-12	-	-	-
			(2E+0)	(1E-2)	-	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	-	2E-2	8E-12	2E-14	-	-
94	Plutonium-239	W, see ^{234}Pu	8E-1 Bone surf	6E-3 Bone surf	3E-12	-	-	-
			(1E+0)	(1E-2)	-	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	-	2E-2 Bone surf	7E-12	-	-	-
			-	(2E-2)	-	2E-14	-	-
94	Plutonium-240	W, see ^{234}Pu	8E-1 Bone surf	6E-3 Bone surf	3E-12	-	-	-
			(1E+0)	(1E-2)	-	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	-	2E-2 Bone surf	7E-12	-	-	-
			-	(2E-2)	-	2E-14	-	-
94	Plutonium-241	W, see ^{234}Pu	4E+1 Bone surf	3E-1 Bone surf	1E-10	-	-	-
			(7E+1)	(6E-1)	-	8E-13	1E-6	1E-5
		Y, see ^{234}Pu	-	8E-1 Bone surf	3E-10	-	-	-
			-	(1E+0)	-	1E-12	-	-
94	Plutonium-242	W, see ^{234}Pu	8E-1 Bone surf	7E-3 Bone surf	3E-12	-	-	-
			(1E+0)	(1E-2)	-	2E-14	2E-8	2E-7
		Y, see ^{234}Pu	-	2E-2 Bone surf	7E-12	-	-	-
			-	(2E-2)	-	2E-14	-	-
94	Plutonium-243	W, see ^{234}Pu	2E+4	4E+4	2E-5	5E-8	2E-4	2E-3
		Y, see ^{234}Pu	-	4E+4	2E-5	5E-8	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 Inhalation DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
94	Plutonium-244	W, see ^{234}Pu	8E-1 Bone surf (2E+0)	7E-3 Bone surf (1E-2)	3E-12	-	-	-
		Y, see ^{234}Pu	-	2E-2 Bone surf (2E-2)	- 7E-12	2E-14 -	2E-8 -	2E-7 -
			-		-	2E-14	-	-
94	Plutonium-245	W, see ^{234}Pu	2E+3	5E+3	2E-6	6E-9	3E-5	3E-4
		Y, see ^{234}Pu	-	4E+3	2E-6	6E-9	-	-
94	Plutonium-246	W, see ^{234}Pu	4E+2 LLI wall (4E+2)	3E+2	1E-7	4E-10	-	-
		Y, see ^{234}Pu	-	3E+2	- 1E-7	- 4E-10	6E-6 -	6E-5 -
95	Americium-237[b]	W, all compounds	8E+4	3E+5	1E-4	4E-7	1E-3	1E-2
95	Americium-238[b]	W, all compounds	4E+4	3E+3 Bone surf (6E+3)	1E-6	-	5E-4	5E-3
			-		-	9E-9	-	-
95	Americium-239	W, all compounds	5E+3	1E+4	5E-6	2E-8	7E-5	7E-4
95	Americium-240	W, all compounds	2E+3	3E+3	1E-6	4E-9	3E-5	3E-4
95	Americium-241	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
95	Americium-242m	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
95	Americium-242	W, all compounds	4E+3	8E+1 Bone surf (9E+1)	4E-8 -	- 1E-10	5E-5 -	5E-4 -
95	Americium-243	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12 -	- 2E-14	- 2E-8	- 2E-7
95	Americium-244m[b]	W, all compounds	6E+4 St wall (8E+4)	4E+3 Bone surf (7E+3)	2E-6 -	- 1E-8	- 1E-3	- 1E-2
95	Americium-244	W, all compounds	3E+3	2E+2 Bone surf (3E+2)	8E-8 -	- 4E-10	4E-5 -	4E-4 -
95	Americium-245	W, all compounds	3E+4	8E+4	3E-5	1E-7	4E-4	4E-3
95	Americium-246m[b]	W, all compounds	5E+4 St wall (6E+4)	2E+5 -	8E-5 -	3E-7 -	- 8E-4	- 8E-3
95	Americium-246[b]	W, all compounds	3E+4	1E+5	4E-5	1E-7	4E-4	4E-3
96	Curium-238	W, all compounds	2E+4	1E+3	5E-7	2E-9	2E-4	2E-3
96	Curium-240	W, all compounds	6E+1 Bone surf (8E+1)	6E-1 Bone surf (6E-1)	2E-10 -	- 9E-13	- 1E-6	- 1E-5

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 DAC (μCi/ml)	Table II Effluent Concentrations Col. 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
96	Curium-241	W, all compounds	1E+3	3E+1 Bone surf	1E-8	-	2E-5	2E-4
			-	(4E+1)	-	5E-11	-	-
96	Curium-242	W, all compounds	3E+1 Bone surf (5E+1)	3E-1 Bone surf (3E-1)	1E-10	-	-	-
					-	4E-13	7E-7	7E-6
96	Curium-243	W, all compounds	1E+0 Bone surf (2E+0)	9E-3 Bone surf (2E-2)	4E-12	-	-	-
					-	2E-14	3E-8	3E-7
96	Curium-244	W, all compounds	1E+0 Bone surf (3E+0)	1E-2 Bone surf (2E-2)	5E-12	-	-	-
					-	3E-14	3E-8	3E-7
96	Curium-245	W, all compounds	7E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12	-	-	-
					-	2E-14	2E-8	2E-7
96	Curium-246	W, all compounds	7E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12	-	-	-
					-	2E-14	2E-8	2E-7
96	Curium-247	W, all compounds	8E-1 Bone surf (1E+0)	6E-3 Bone surf (1E-2)	3E-12	-	-	-
					-	2E-14	2E-8	2E-7
96	Curium-248	W, all compounds	2E-1 Bone surf (4E-1)	2E-3 Bone surf (3E-3)	7E-13	-	-	-
					-	4E-15	5E-9	5E-8
96	Curium-249[b]	W, all compounds	5E+4	2E+4 Bone surf	7E-6	-	7E-4	7E-3
			-	(3E+4)	-	4E-8	-	-
96	Curium-250	W, all compounds	4E-2 Bone surf (6E-2)	3E-4 Bone surf (5E-4)	1E-13	-	-	-
					-	8E-16	9E-10	9E-9
97	Berkelium-245	W, all compounds	2E+3	1E+3	5E-7	2E-9	3E-5	3E-4
97	Berkelium-246	W, all compounds	3E+3	3E+3	1E-6	4E-9	4E-5	4E-4
97	Berkelium-247	W, all compounds	5E-1 Bone surf (1E+0)	4E-3 Bone surf (9E-3)	2E-12	-	-	-
					-	1E-14	2E-8	2E-7
97	Berkelium-249	W, all compounds	2E+2 Bone surf (5E+2)	2E+0 Bone surf (4E+0)	7E-10	-	-	-
					-	5E-12	6E-6	6E-5
97	Berkelium-250	W, all compounds	9E+3	3E+2 Bone surf	1E-7	-	1E-4	1E-3
			-	(7E+2)	-	1E-9	-	-
98	Californium-244[b]	W, all compounds except those given for Y	3E+4 St wall (3E+4)	6E+2	2E-7	8E-10	-	-
		Y, oxides and hydroxides	-	-	-	-	4E-4	4E-3
				6E+2	2E-7	8E-10	-	-
98	Californium-246	W, see ^{244}Cf	4E+2	9E+0	4E-9	1E-11	5E-6	5E-5
		Y, see ^{244}Cf	-	9E+0	4E-9	1E-11	-	-

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Col 2 Inhalation ALI (μCi)	Col 3 DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Col. 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
98	Californium-248	W, see ^{244}Cf	8E+0 Bone surf (2E+1)	6E-2 Bone surf (1E-1)	3E-11 -	-	-	-
		Y, see ^{244}Cf	-	1E-1	4E-11	2E-13	2E-7	2E-6
98	Californium-249	W, see ^{244}Cf	5E-1 Bone surf (1E+0)	4E-3 Bone surf (9E-3)	2E-12 -	1E-13 -	- -	- -
		Y, see ^{244}Cf	-	1E-2 Bone surf (1E-2)	4E-12 -	1E-14 -	2E-8 -	2E-7 -
98	Californium-250	W, see ^{244}Cf	1E+0 Bone surf (2E+0)	9E-3 Bone surf (2E-2)	4E-12 -	2E-14 -	- -	- -
		Y, see ^{244}Cf	-	3E-2	1E-11	3E-14 4E-14	3E-8 -	3E-7 -
98	Californium-251	W, see ^{244}Cf	5E-1 Bone surf (1E+0)	4E-3 Bone surf (9E-3)	2E-12 -	- 1E-14	- 2E-8	- 2E-7
		Y, see ^{244}Cf	-	1E-2 Bone surf (1E-2)	4E-12 -	- 2E-14	- -	- -
98	Californium-252	W, see ^{244}Cf	2E+0 Bone surf (5E+0)	2E-2 Bone surf (4E-2)	8E-12 -	- 5E-14	- 7E-8	- 7E-7
		Y, see ^{244}Cf	-	3E-2	1E-11	5E-14	-	-
98	Californium-253	W, see ^{244}Cf	2E+2 Bone surf (4E+2)	2E+0 -	8E-10 -	3E-12 -	- 5E-6	- 5E-5
		Y, see ^{244}Cf	-	2E+0	7E-10	2E-12	-	-
98	Californium-254	W, see ^{244}Cf Y, see ^{244}Cf	2E+0 -	2E-2 2E-2	9E-12 7E-12	3E-14 2E-14	3E-8 -	3E-7 -
99	Einsteinium-250	W, all compounds	4E+4	5E+2 Bone surf (1E+3)	2E-7 -	- 2E-9	6E-4 -	6E-3 -
99	Einsteinium-251	W, all compounds	7E+3	9E+2 Bone surf (1E+3)	4E-7 -	- 2E-9	1E-4 -	1E-3 -
99	Einsteinium-253	W, all compounds	2E+2	1E+0	6E-10	2E-12	2E-6	2E-5
99	Einsteinium-254m	W, all compounds	3E+2 LLI wall (3E+2)	1E+1 -	4E-9 -	1E-11 -	- 4E-6	- 4E-5
99	Einsteinium-254	W, all compounds	8E+0 Bone surf (2E+1)	7E-2 Bone surf (1E-1)	3E-11 -	- 2E-13	- 2E-7	- 2E-6
100	Fermium-252	W, all compounds	5E+2	1E+1	5E-9	2E-11	6E-6	6E-5
100	Fermium-253	W, all compounds	1E+3	1E+1	4E-9	1E-11	1E-5	1E-4
100	Fermium-254	W, all compounds	3E+3	9E+1	4E-8	1E-10	4E-5	4E-4
100	Fermium-255	W, all compounds	5E+2	2E+1	9E-9	3E-11	7E-6	7E-5
100	Fermium-257	W, all compounds	2E+1 Bone surf (4E+1)	2E-1 Bone surf (2E-1)	7E-11 -	- 3E-13	- 5E-7	- 5E-6

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No	Radionuclide	Class	Table I Occupational Values Col 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col. 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
101	Mendelevium-257	W, all compounds	7E+3	8E+1 Bone surf	4E-8	-	1E-4	1E-3
			-	(9E+1)	-	1E-10	-	-
101	Mendelevium-258	W, all compounds	3E+1 Bone surf	2E-1 Bone surf	1E-10	-	-	-
			(5E+1)	(3E-1)	-	5E-13	6E-7	6E-6
- Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours		Submersion[a]	-	2E+2	1E-7	1E-9	-	
- Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours		....	-	2E-1	1E-10	1E-12	1E-8	1E-7
- Any single radionuclide not listed above that decays by alpha emission or spontaneous fission, or any mixture for which either the identity or the concentration of any radionuclide in the mixture is not known			-	4E-4	2E-13	1E-15	2E-9	2E-8

Footnotes:

[a] *"Submersion" means that values given are for submersion in a hemispherical semi-infinite cloud of airborne material.*

[b] *These radionuclides have radiological half-lives of less than 2 hours The total effective dose equivalent received during operations with these radionuclides might include a significant contribution from external exposure. The DAC values for all radionuclides, other than those designated Class "Submersion," are based upon the committed effective dose equivalent due to the intake of the radionuclide into the body and do NOT include potentially significant contributions to dose equivalent from external exposures The licensee may substitute 1E-7 μCi/ml for the listed DAC to account for the submersion dose prospectively, but should use individual monitoring devices or other radiation measuring instruments that measure external exposure to demonstrate compliance with the limits (See s HFS 157.22 (3))*

[c] *For soluble mixtures of U-238, U-234, and U-235 in air, chemical toxicity may be the limiting factor (see D 201e) If the percent by weight enrichment of U-235 is not greater than 5, the concentration value for a 40-hour workweek is 0.2 milligrams uranium per cubic meter of air average For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek may not exceed 8E-3 (SA) μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The specific activity for natural uranium is 6 77E-7 curies per gram U The specific activity for other mixtures of U-238, U-235, and U-234, if not known, shall be*

$SA = 3\ 6E\text{-}7$ *curies/gram U U-depleted*

$SA = [0\ 4 + 0\ 38\ enrichment + 0\ 0034\ enrichment^2]\ E\text{-}6,\ enrichment \geq 0.72$

where enrichment is the percentage by weight of U-235, expressed as percent

Note

1. If the identity of each radionuclide in a mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the DAC for the mixture shall be the most restrictive DAC of any radionuclide in the mixture

2 If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in this appendix are not present in the mixture, the inhalation ALI, DAC, and effluent and sewage concentrations for the mixture are the lowest values specified in this appendix for any radionuclide that is not known to be absent from the mixture, or

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) of Radionuclides for Occupational Exposure
Effluent Concentrations
Concentrations for Release to Sanitary Sewerage *(Continued)*

Atomic No.	Radionuclide	Class	Table I Occupational Values Col. 1 Oral Ingestion ALI (μCi)	Table I Occupational Values Col 2 Inhalation ALI (μCi)	Table I Occupational Values Col 3 DAC (μCi/ml)	Table II Effluent Concentrations Col 1 Air (μCi/ml)	Table II Effluent Concentrations Col 2 Water (μCi/ml)	Table III Releases to Sewers Monthly Average Concentration (μCi/ml)
If it is known that Ac-227-D and Cm-250-W are not present			-	7E-4	3E-13	-	-	-
If, in addition, it is known that Ac-227-W,Y, Th-229-W,Y, Th-230-W, Th-232-W,Y, Pa-231-W,Y, Np-237-W, Pu-239-W, Pu-240-W, Pu-242-W, Am-241-W, Am-242m-W, Am-243-W, Cm-245-W, Cm-246-W, Cm-247-W, Cm-248-W, Bk-247-W, Cf-249-W, and Cf-251-W are not present			-	7E-3	3E-12	-	-	-
If, in addition, it is known that Sm-146-W, Sm-147-W, Gd-148-D,W, Gd-152-D,W, Th-228-W,Y, Th-230-Y, U-232-Y, U-233-Y, U-234-Y, U-235-Y, U-236-Y, U-238-Y, Np-236-W, Pu-236-W,Y, Pu-238-W,Y, Pu-239-Y, Pu-240-Y, Pu-242-Y, Pu-244-W,Y, Cm-243-W, Cm-244-W, Cf-248-W, Cf-249-Y, Cf-250-W,Y, Cf-251-Y, Cf-252-W,Y, and Cf-254-W,Y are not present □			7E-2	3E-11	-	-	-	
If, in addition, it is known that Pb-210-D, Bi-210m-W, Po-210-D,W, Ra-223-W, Ra-225-W, Ra-226-W, Ac-225-D,W,Y, Th-227-W,Y, U-230-D,W,Y, U-232-D,W, Pu-241-W, Cm-240-W, Cm-242-W, Cf-248-Y, Es-254-W, Fm-257-W, and Md-258-W are not present			-	7E-1	3E-10	-	-	-
If, in addition, it is known that Si-32-Y, Ti-44-Y, Fe-60-D, Sr-90-Y, Zr-93-D, Cd-113m-D, Cd-113-D, In-115-D,W, La-138-D, Lu-176-W, Hf-178m-D,W, Hf-182-D,W, Bi-210m-D, Ra-224-W, Ra-228-W, Ac-226-D,W,Y, Pa-230-W,Y, U-233-D,W, U-234-D,W, U-235-D,W, U-236-D,W, U-238-D,W, Pu-241-Y, Bk-249-W, Cf-253-W,Y, and Es-253-W are not present			-	7E+0	3E-9	-	-	-
If it is known that Ac-227-D,W,Y, Th-229-W,Y, Th-232-W,Y, Pa-231-W,Y, Cm-248-W, and Cm-250-W are not present			-	-	-	1E-14	-	-
If, in addition, it is known that Sm-146-W, Gd-148-D,W, Gd-152-D, Th-228-W,Y, Th-230-W,Y, U-232-Y, U-233-Y, U-234-Y, U-235-Y, U-236-Y, U-238-Y, U-Nat-Y, Np-236-W, Np-237-W, Pu-236-W,Y, Pu-238-W,Y, Pu-239-W,Y, Pu-240-W,Y, Pu-242-W,Y, Pu-244-W,Y, Am-241-W, Am-242m-W, Am-243-W, Cm-243-W, Cm-244-W, Cm-245-W, Cm-246-W, Cm-247-W, Bk-247-W, Cf-249-W,Y, Cf-250-W,Y, Cf-251-W,Y, Cf-252-W,Y, and Cf-254-W,Y, are not present			-	-	-	1E-13	-	-
If, in addition, it is known that Sm-147-W, Gd-152-W, Pb-210-D, Bi-210m-W, Po-210-D,W, Ra-223-W, Ra-225-W, Ra-226-W, Ac-225-D,W,Y, Th-227-W,Y, U-230-D,W,Y, U-232-D,W, U-Nat-W, Pu-241-W, Cm-240-W, Cm-242-W, Cf-248-W,Y, Es-254-W, Fm-257-W, and Md-258-W are not present			-	-	-	1E-12	-	-
If, in addition it is known that Fe-60, Sr-90, Cd-113m, Cd-113, In-115, I-129, Cs-134, Sm-145, Sm-147, Gd-148, Gd-152, Hg-194 (organic), Bi-210m, Ra-223, Ra-224, Ra-225, Ac-225, Th-228, Th-230, U-233, U-234, U-235, U-236, U-238, U-Nat, Cm-242, Cf-248, Es-254, Fm-257, and Md-258 are not present			-	-	-	-	1E-6	1E-5

3 If a mixture of radionuclides consists of uranium and its daughters in ore dust (10 μm AMAD particle distribution assumed) prior to chemical separation of the uranium from the ore, the following values may be used for the DAC of the mixture: 6E-11 μCi of gross alpha activity from uranium-238, uranium-234, thorium-230, and radium-226 per milliliter of air; 3E-11 μCi of natural uranium per milliliter of air; or 45 micrograms of natural uranium per cubic meter of air

4 If the identity and concentration of each radionuclide in a mixture are known, the limiting values should be derived as follows determine, for each radionuclide in the mixture, the ratio between the concentration present in the mixture and the concentration otherwise established in Appendix E for the specific radionuclide when not in a mixture. The sum of such ratios for all of the radionuclides in the mixture may not exceed "1," which is "unity".

Example: If radionuclides "A," "B," and "C" are present in concentrations C_A, C_B, and C_C, and if the applicable DACs are DAC_A, DAC_B, and DAC_C, respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{DAC_A} + \frac{C_B}{DAC} SUBB + \frac{C_C}{DAC_C} \leq 1$$

APPENDIX F

QUANTITIES OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING
(In Atomic Number Order)

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)
Note: To convert uCi to kBq, multiply the uCi value by 37			
Hydrogen-3	1,000	Scandium-47	100
Beryllium-7	1,000	Scandium-48	100
Beryllium-10	1	Scandium-49	1,000
Carbon-11	1,000	Titanium-44	1
Carbon-14	100	Titanium-45	1,000
Fluorine-18	1,000	Vanadium-47	1,000
Sodium-22	10	Vanadium-48	100
Sodium-24	100	Vanadium-49	1,000
Magnesium-28	100	Chromium-48	1,000
Aluminum-26	10	Chromium-49	1,000
Silicon-31	1,000	Chromium-51	1,000
Silicon-32	1	Manganese-51	1,000
Phosphorus-32	10	Manganese-52m	1,000
Phosphorus-33	100	Manganese-52	100
Sulfur-35	100	Manganese-53	1,000
Chlorine-36	10	Manganese-54	100
Chlorine-38	1,000	Manganese-56	1,000
Chlorine-39	1,000	Iron-52	100
Argon-39	1,000	Iron-55	100
Argon-41	1,000	Iron-59	10
Potassium-40	100	Iron-60	1
Potassium-42	1,000	Cobalt-55	100
Potassium-43	1,000	Cobalt-56	10
Potassium-44	1,000	Cobalt-57	100
Potassium-45	1,000	Cobalt-58m	1,000
Calcium-41	100	Cobalt-58	100
Calcium-45	100	Cobalt-60m	1,000
Calcium-47	100	Cobalt-60	1
Scandium-43	1,000	Cobalt-61	1,000
Scandium-44m	100	Cobalt-62m	1,000
Scandium-44	100	Nickel-56	100
Scandium-46	10	Nickel-57	100

QUANTITIES OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (uCi)[b/]	Radionuclide	Quantity (uCi)
Note: To convert uCi to kBq, multiply the uCi value by 37.			
Nickel-59	100	Arsenic-73	100
Nickel-63	100	Arsenic-74	100
Nickel-65	1,000	Arsenic-76	100
Nickel-66	10	Arsenic-77	100
Copper-60	1,000	Arsenic-78	1,000
Copper-61	1,000	Selenium-70	1,000
Copper-64	1,000	Selenium-73m	1,000
Copper-67	1,000	Selenium-73	100
Zinc-62	100	Selenium-75	100
Zinc-63	1,000	Selenium-79	100
Zinc-65	10	Selenium-81m	1,000
Zinc-69m	100	Selenium-81	1,000
Zinc-69	1,000	Selenium-83	1,000
Zinc-71m	1,000	Bromine-74m	1,000
Zinc-72	100	Bromine-74	1,000
Gallium-65	1,000	Bromine-75	1,000
Gallium-66	100	Bromine-76	100
Gallium-67	1,000	Bromine-77	1,000
Gallium-68	1,000	Bromine-80m	1,000
Gallium-70	1,000	Bromine-80	1,000
Gallium-72	100	Bromine-82	100
Gallium-73	1,000	Bromine-83	1,000
Germanium-66	1,000	Bromine-84	1,000
Germanium-67	1,000	Krypton-74	1,000
Germanium-68	10	Krypton-76	1,000
Germanium-69	1,000	Krypton-77	1,000
Germanium-71	1,000	Krypton-79	1,000
Germanium-75	1,000	Krypton-81	1,000
Germanium-77	1,000	Krypton-83m	1,000
Germanium-78	1,000	Krypton-85m	1,000
Arsenic-69	1,000	Krypton-85	1,000
Arsenic-70	1,000	Krypton-87	1,000
Arsenic-71	100	Krypton-88	1,000
Arsenic-72	100	Rubidium-79	1,000

Rubidium-81m	1,000	Rubidium-81	1,000

QUANTITIES OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (uCi)[b/]	Radionuclide	Quantity (uCi)
Note: To convert uCi to kBq, multiply the uCi value by 37.			
Rubidium-82m	1,000	Niobium-88	1,000
Rubidium-83	100	Niobium-89m (66 min)	1,000
Rubidium-84	100	Niobium-89 (122 min)	1,000
Rubidium-86	100	Niobium-90	100
Rubidium-87	100	Niobium-93m	10
Rubidium-88	1,000	Niobium-94	1
Rubidium-89	1,000	Niobium-95m	100
Strontium-80	100	Niobium-95	100
Strontium-81	1,000	Niobium-96	100
Strontium-83	100	Niobium-97	1,000
Strontium-85m	1,000	Niobium-98	1,000
Strontium-85	100	Molybdenum-90	100
Strontium-87m	1,000	Molybdenum-93m	100
Strontium-89	10	Molybdenum-93	10
Strontium-90	0.1	Molybdenum-99	100
Strontium-91	100	Molybdenum-101	1,000
Strontium-92	100	Technetium-93m	1,000
Yttrium-86m	1,000	Technetium-93	1,000
Yttrium-86	100	Technetium-94m	1,000
Yttrium-87	100	Technetium-94	1,000
Yttrium-88	10	Technetium-96m	1,000
Yttrium-90m	1,000	Technetium-96	100
Yttrium-90	10	Technetium-97m	100
Yttrium-91m	1,000	Technetium-97	1,000
Yttrium-91	10	Technetium-98	10
Yttrium-92	100	Technetium-99m	1,000
Yttrium-93	100	Technetium-99	100
Yttrium-94	1,000	Technetium-101	1,000
Yttrium-95	1,000	Technetium-104	1,000
Zirconium-86	100	Ruthenium-94	1,000
Zirconium-88	10	Ruthenium-97	1,000
Zirconium-89	100	Ruthenium-103	100
Zirconium-93	1	Ruthenium-105	1,000
Zirconium-95	10	Ruthenium-106	1
Zirconium-97	100	Rhodium-99m	1,000

QUANTITIES OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)[b/]
Note: To convert uCi to kBq, multiply the *u*Ci value by 37.			
Rhodium-99	100	Cadmium-117	1,000
Rhodium-100	100	Indium-109	1,000
Rhodium-101m	1,000	Indium-110 (69.1 min)	1,000
Rhodium-101	10	Indium-110 (4.9 h)	1,000
Rhodium-102m	10	Indium-111	100
Rhodium-102	10	Indium-112	1,000
Rhodium-103m	1,000	Indium-113m	1,000
Rhodium-105	100	Indium-114m	10
Rhodium-106m	1,000	Indium-115m	1,000
Rhodium-107	1,000	Indium-115	100
Palladium-100	100	Indium-116m	1,000
Palladium-101	1,000	Indium-117m	1,000
Palladium-103	100	Indium-117	1,000
Palladium-107	10	Indium-119m	1,000
Palladium-109	100	Tin-110	100
Silver-102	1,000	Tin-111	1,000
Silver-103	1,000	Tin-113	100
Silver-104m	1,000	Tin-117m	100
Silver-104	1,000	Tin-119m	100
Silver-105	100	Tin-121m	100
Silver-106m	100	Tin-121	1,000
Silver-106	1,000	Tin-123m	1,000
Silver-108m	1	Tin-123	10
Silver-11Om	10	Tin-125	10
Silver-111	100	Tin-126	10
Silver-112	100	Tin-127	1,000
Silver-115	1,000	Tin-128	1,000
Cadmium-104	1,000	Antimony-115	1,000
Cadmium-107	1,000	Antimony-116m	1,000
Cadmium-109	1	Antimony-116	1,000
Cadmium-113m	0.1	Antimony-117	1,000
Cadmium-113	100	Antimony-118m	1,000
Cadmium-115m	10	Antimony-119	1,000
Cadmium-115	100	Antimony-120 (16 min)	1,000
Cadmium-117m	1,000	Antimony-120 (5.76 d)	100

QUANTITIES OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)[b/]
Note: To convert uCi to kBq, multiply the uCi value by 37.			
Antimony-122	100	Iodine-128	1,000
Antimony-124m	1,000	Iodine-129	1
Antimony-124	10	Iodine-130	10
Antimony-125	100	Iodine-131	1
Antimony-126m	1,000	Iodine-132m	100
Antimony-126	100	Iodine-132	100
Antimony-127	100	Iodine-133	10
Antimony-128 (10.4 min)	1,000	Iodine-134	1,000
Antimony-128 (9.01 h)	100	Iodine-135	100
Antimony-129	100	Xenon-120	1,000
Antimony-130	1,000	Xenon-121	1,000
Antimony-131	1,000	Xenon-122	1,000
Tellurium-116	1,000	Xenon-123	1,000
Tellurium-121m	10	Xenon-125	1,000
Tellurium-121	100	Xenon-127	1,000
Tellurium-123m	10	Xenon-129m	1,000
Tellurium-123	100	Xenon-131m	1,000
Tellurium-125m	10	Xenon-133m	1,000
Tellurium-127m	10	Xenon-133	1,000
Tellurium-127	1,000	Xenon-135m	1,000
Tellurium-129m	10	Xenon-135	1,000
Tellurium-129	1,000	Xenon-138	1,000
Tellurium-131m	10	Cesium-125	1,000
Tellurium-131	100	Cesium-127	1,000
Tellurium-132	10	Cesium-129	1,000
Tellurium-133m	100	Cesium-130	1,000
Tellurium-133	1,000	Cesium-131	1,000
Tellurium-134	1,000	Cesium-132	100
Iodine-120m	1,000	Cesium-134m	1,000
Iodine-120	100	Cesium-134	10
Iodine-121	1,000	Cesium-135m	1,000
Iodine-123	100	Cesium-135	100
Iodine-124	10	Cesium-136	10
Iodine-125	1	Cesium-137	10
Iodine-126	1	Cesium-138	1,000

QUANTITIES OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)
(Continued)

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)[b/]
NOTE: To convert uCi to kBq, multiply the uCi value by 37.			
Barium-126	1,000	Praseodymium-144	1,000
Barium-128	100	Praseodymium-145	100
Barium-131m	1,000	Praseodymium-147	1,000
Barium-131	100	Neodymium-136	1,000
Barium-133m	100	Neodymium-138	100
Barium-133	100	Neodymium-139m	1,000
Barium-135m	100	Neodymium-139	1,000
Barium-139	1,000	Neodymium-141	1,000
Barium-140	100	Neodymium-147	100
Barium-141	1,000	Neodymium-149	1,000
Barium-142	1,000	Neodymium-151	1,000
Lanthanum-131	1,000	Promethium-141	1,000
Lanthanum-132	100	Promethium-143	100
Lanthanum-135	1,000	Promethium-144	10
Lanthanum-137	10	Promethium-145	10
Lanthanum-138	100	Promethium-146	1
Lanthanum-140	100	Promethium-147	10
Lanthanum-141	100	Promethium-148m	10
Lanthanum-142	1,000	Promethium-148	10
Lanthanum-143	1,000	Promethium-149	100
Cerium-134	100	Promethium-150	1,000
Cerium-135	100	Promethium-151	100
Cerium-137m	100	Samarium-141m	1,000
Cerium-137	1,000	Samarium-141	1,000
Cerium-139	100	Samarium-142	1,000
Cerium-141	100	Samarium-145	100
Cerium-143	100	Samarium-146	1
Cerium-144	1	Samarium-147	100
Praseodymium-136	1,000	Samarium-151	10
Praseodymium-137	1,000	Samarium-153	100
Praseodymium-138m	1,000	Samarium-155	1,000
Praseodymium-139	1,000	Samarium-156	1,000
Praseodymium-142m	1,000	Europium-145	100
Praseodymium-142	100	Europium-146	100
Praseodymium-143	100	Europium-147	100

QUANTITIES OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)[b/]
Note: To convert uCi to kBq, multiply the uCi value by 37.			
Europium-148	10	Dysprosium-157	1,000
Europium-149	100	Dysprosium-159	100
Europium-150 (12.62 h)	100	Dysprosium-165	1,000
Europium-150 (34.2 y)	1	Dysprosium-166	100
Europium-152m	100	Holmium-155	1,000
Europium-152	1	Holmium-157	1,000
Europium-154	1	Holmium-159	1,000
Europium-155	10	Holmium-161	1,000
Europium-156	100	Holmium-162m	1,000
Europium-157	100	Holmium-162	1,000
Europium-158	1,000	Holmium-164m	1,000
Gadolinium-145	1,000	Holmium-164	1,000
Gadolinium-146	10	Holmium-166m	1
Gadolinium-147	100	Holmium-166	100
Gadolinium-148	0.001	Holmium-167	1,000
Gadolinium-149	100	Erbium-161	1,000
Gadolinium-151	10	Erbium-165	1,000
Gadolinium-152	100	Erbium-169	100
Gadolinium-153	10	Erbium-171	100
Gadolinium-159	100	Erbium-172	100
Terbium-147	1,000	Thulium-162	1,000
Terbium-149	100	Thulium-166	100
Terbium-150	1,000	Thulium-167	100
Terbium-151	100	Thulium-170	10
Terbium-153	1,000	Thulium-171	10
Terbium-154	100	Thulium-172	100
Terbium-155	1,000	Thulium-173	100
Terbium-156m (5.0 h)	1,000	Thulium-175	1,000
Terbium-156m (24.4 h)	1,000	Ytterbium-162	1,000
Terbium-156	100	Ytterbium-166	100
Terbium-157	10	Ytterbium-167	1,000
Terbium-158	1	Ytterbium-169	100
Terbium-160	10	Ytterbium-175	100
Terbium-161	100	Ytterbium-177	1,000
Dysprosium-155	1,000	Ytterbium-178	1,000

QUANTITIES OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)[b/]
Note: To convert uCi to kBq, multiply the uCi value by 37.			
Lutetium-169	100	Tantalum-180m	1,000
Lutetium-170	100	Tantalum-180	100
Lutetium-171	100	Tantalum-182m	1,000
Lutetium-172	100	Tantalum-182	10
Lutetium-173	10	Tantalum-183	100
Lutetium-174m	10	Tantalum-184	100
Lutetium-174	10	Tantalum-185	1,000
Lutetium-176m	1,000	Tantalum-186	1,000
Lutetium-176	100	Tungsten-176	1,000
Lutetium-177m	10	Tungsten-177	1,000
Lutetium-177	100	Tungsten-178	1,000
Lutetium-178m	1,000	Tungsten-179	1,000
Lutetium-178	1,000	Tungsten-181	1,000
Lutetium-179	1,000	Tungsten-185	100
Hafnium-170	100	Tungsten-187	100
Hafnium-172	1	Tungsten-188	10
Hafnium-173	1,000	Rhenium-177	1,000
Hafnium-175	100	Rhenium-178	1,000
Hafnium-177m	1,000	Rhenium-181	1,000
Hafnium-178m	0.1	Rhenium-182 (12.7 h)	1,000
Hafnium-179m	10	Rhenium-182 (64.O h)	100
Hafnium-180m	1,000	Rhenium-184m	10
Hafnium-181	10	Rhenium-184	100
Hafnium-182m	1,000	Rhenium-186m	10
Hafnium-182	0.1	Rhenium-186	100
Hafnium-183	1,000	Rhenium-187	1,000
Hafnium-184	100	Rhenium-188m	1,000
Tantalum-172	1,000	Rhenium-188	100
Tantalum-173	1,000	Rhenium-189	100
Tantalum-174	1,000	Osmium-180	1,000
Tantalum-175	1,000	Osmium-181	1,000
Tantalum-176	100	Osmium-182	100
Tantalum-177	1,000	Osmium-185	100
Tantalum-178	1,000	Osmium-189m	1,000
Tantalum-179	100	Osmium-191m	1,000

QUANTITIES OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)
Note: To convert uCi to kBq, multiply the uCi value by 37.			
Osmium-191	100	Gold-200m	100
Osmium-193	100	Gold-200	1,000
Osmium-194	1	Gold-201	1,000
Iridium-182	1,000	Mercury-193m	100
Iridium-184	1,000	Mercury-193	1,000
Iridium-185	1,000	Mercury-194	1
Iridium-186	100	Mercury-195m	100
Iridium-187	1,000	Mercury-195	1,000
Iridium-188	100	Mercury-197m	100
Iridium-189	100	Mercury-197	1,000
Iridium-190m	1,000	Mercury-199m	1,000
Iridium-190	100	Mercury-203	100
Iridium-192m (1.4 min)	10	Thallium-194m	1,000
Iridium-192 (73.8 d)	1	Thallium-194	1,000
Iridium-194m	10	Thallium-195	1,000
Iridium-194	100	Thallium-197	1,000
Iridium-195m	1,000	Thallium-198m	1,000
Iridium-195	1,000	Thallium-198	1,000
Platinum-186	1,000	Thallium-199	1,000
Platinum-188	100	Thallium-201	1,000
Platinum-189	1,000	Thallium-200	1,000
Platinum-191	100	Thallium-202	100
Platinum-193m	100	Thallium-204	100
Platinum-193	1,000	Lead-195m	1,000
Platinum-195m	100	Lead-198	1,000
Platinum-197m	1,000	Lead-199	1,000
Platinum-197	100	Lead-200	100
Platinum-199	1,000	Lead-201	1,000
Platinum-200	100	Lead-202m	1,000
Gold-193	1,000	Lead-202	10
Gold-194	100	Lead-203	1,000
Gold-195	10	Lead-205	100
Gold-198m	100	Lead-209	1,000
Gold-198	100	Lead-210	0.01
Gold-199	100	Lead-211	100

QUANTITIES OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)
Note: To convert uCi to kBq, multiply the uCi value by 37.			
Lead-212	1	Thorium-226	10
Lead-214	100	Thorium-227	0.01
Bismuth-200	1,000	Thorium-228	0.001
Bismuth-201	1,000	Thorium-229	0.001
Bismuth-202	1,000	Thorium-230	0.001
Bismuth-203	100	Thorium-231	100
Bismuth-205	100	Thorium-232	100
Bismuth-206	100	Thorium-234	10
Bismuth-207	10	Thorium-natural	100
Bismuth-210m	0.1	Protactinium-227	10
Bismuth-210	1	Protactinium-228	1
Bismuth-212	10	Protactinium-230	0.1
Bismuth-213	10	Protactinium-231	0.001
Bismuth-214	100	Protactinium-232	1
Polonium-203	1,000	Protactinium-233	100
Polonium-205	1,000	Protactinium-234	100
Polonium-207	1,000	Uranium-230	0.01
Polonium-210	0.1	Uranium-231	100
Astatine-207	100	Uranium-232	0.001
Astatine-211	10	Uranium-233	0.001
Radon-220	1	Uranium-234	0.001
Radon-222	1	Uranium-235	0.001
Francium-222	100	Uranium-236	0.001
Francium-223	100	Uranium-237	100
Radium-223	0.1	Uranium-238	100
Radium-224	0.1	Uranium-239	1,000
Radium-225	0.1	Uranium-240	100
Radium-226	0.1	Uranium-natural	100
Radium-227	1,000	Neptunium-232	100
Radium-228	0.1	Neptunium-233	1,000
Actinium-224	1	Neptunium-234	100
Actinium-225	0.01	Neptunium-235	100
Actinium-226	0.1	Neptunium-236 (1.15E+5 y)	0.001
Actinium-227	0.001	Neptunium-236 (22.5 h)	1
Actinium-228	1	Neptunium-237	0.001

QUANTITIES OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)[b/]
Note: To convert uCi to kBq, multiply the uCi value by 37.			
Neptunium-238	10	Berkelium-245	100
Neptunium-239	100	Berkelium-246	100
Neptunium-240	1,000	Berkelium-247	0.001
Plutonium-234	10	Berkelium-249	0.1
Plutonium-235	1,000	Berkelium-250	10
Plutonium-236	0.001	Californium-244	100
Plutonium-237	100	Californium-246	1
Plutonium-238	0.001	Californium-248	0.01
Plutonium-239	0.001	Californium-249	0.001
Plutonium-240	0.001	Californium-250	0.001
Plutonium-241	0.01	Californium-251	0.001
Plutonium-242	0.001	Californium-252	0.001
Plutonium-243	1,000	Californium-253	0.1
Plutonium-244	0.001	Californium-254	0.001
Plutonium-245	100	Einsteinium-250	100
Americium-237	1,000	Einsteinium-251	100
Americium-238	100	Einsteinium-253	0.1
Americium-239	1,000	Einsteinium-254m	1
Americium-240	100	Einsteinium-254	0.01
Americium-241	0.001	Fermium-252	1
Americium-242m	0.001	Fermium-253	1
Americium-242	10	Fermium-254	10
Americium-243	0.001	Fermium-255	1
Americium-244m	100	Fermium-257	0.01
Americium-244	10	Mendelevium-257	10
Americium-245	1,000	Mendelevium-258	0.01
Americium-246m	1,000		
Americium-246	1,000		
Curium-238	100		
Curium-240	0.1		
Curium-241	1		
Curium-242	0.01		
Curium-243	0.001		
Curium-244	0.001		
Curium-245	0.001		
Curium-246	0.001		
Curium-247	0.001		
Curium-248	0.001		
Curium-249	1,000		

QUANTITIES OF LICENSED OR REGISTERED MATERIAL REQUIRING LABELING

(In Atomic Number Order)

(Continued)

Radionuclide	Quantity (uCi)	Radionuclide	Quantity (uCi)[b/]
Note: To convert uCi to kBq, multiply the uCi value by 37.			
Any alpha-emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	0.001	Any radionuclide other than alpha-emitting radionuclides not listed above, or mixtures of beta emitters of unknown composition	0.01

Note: For purposes of s. HFS 157.29 (1) (e), (5) (a) and s. HFS 157.32 (1) (a) where there is involved a combination of radionuclides in known amounts, the limit for the combination shall be derived as follows: determine, for each radionuclide in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific radionuclide when not in combination. The sum of such ratios for all radionuclides in the combination may not exceed "1" -- that is, unity.

Note: The quantities listed above were derived by taking 1/10th of the most restrictive ALI listed in Table I, Columns 1 and 2, of Appendix E, rounding to the nearest factor of 10 and constraining the values listed between 37 Bq and 37 MBq (0.001 and 1,000 μCi). Values of 3.7 MBq (100 μCi) have been assigned for radionuclides having a radioactive half-life in excess of E+9 years, except rhenium, 37 MBq (1,000 μCi), to take into account their low specific activity.

APPENDIX G

REQUIREMENTS FOR TRANSFER OF LOW-LEVEL RADIOACTIVE WASTE FOR DISPOSAL AT LAND DISPOSAL FACILITIES AND MANIFESTS

Section I. - Manifest.

The shipment manifest shall contain the name, address and telephone number of the person generating the waste. The manifest shall also include the name, address and telephone number or the name and the Environmental Protection Department hazardous waste identification number of the person transporting the waste to the land disposal facility. The manifest shall also indicate: a physical description of the waste, the volume, radionuclide identity and quantity, the total radioactivity and the principal chemical form. The solidification agent shall be specified. Waste containing more than 0.1 percent chelating agents by weight shall be identified and the weight percentage of the chelating agent estimated. Wastes classified as Class A, Class B or Class C in Section I of Appendix H shall be clearly identified as such in the manifest. The total quantity of the radionuclides hydrogen-3, carbon-14, technetium-99, and iodine-129 shall be shown. The manifest required by this paragraph may be shipping papers used to meet the Department of Transportation or the Environmental Protection Department regulations or requirements of the receiver, provided all the required information is included. Copies of manifests required by this section may be legible carbon copies or legible photocopies.

Section II. - Certification.

The waste generator shall include in the shipment manifest a certification that the transported materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and the department. An authorized representative of the waste generator shall sign and date the manifest.

Section III. - Control and Tracking.

(a) Any radioactive waste generator who transfers radioactive waste to a land disposal facility or a licensed waste collector shall comply with the requirements in (a)(1) through (8). Any radioactive waste generator who transfers waste to a licensed waste processor who treats or repackages waste shall comply with the requirements of (a)(4) through (8). A licensee shall:

(1) Prepare all wastes so that the waste is classified according to Section I of Appendix H and meets the waste characteristics requirements in Section II of Appendix H;

(2) Label each package of waste to identify whether it is Class A waste, Class B waste or Class C waste under Section I of Appendix H;

(3) Conduct a quality control program to ensure compliance with Section I and II of Appendix H; the program shall include management evaluation of audits;

(4) Prepare shipping manifests to meet the requirements of Section I and II;

(5) Forward a copy of the manifest to the intended recipient, at the time of shipment, or deliver to a collector at the time the waste is collected, obtaining acknowledgment of receipt in the form of a signed copy of the manifest or equivalent documentation from the collector;

(6) Include one copy of the manifest with the shipment;

(7) Retain a copy of the manifest and documentation of acknowledgment of receipt as the record of transfer of licensed material as required by s. HFS 157.13 (15); and

(8) For any shipments or any portion of a shipment for which acknowledgment of receipt has not been received within the times set forth in this section, conduct an investigation under Section III.(e).

(b) Any waste collector licensee who handles only prepackaged waste shall:

(1) Acknowledge receipt of the waste from the generator within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation;

(2) Prepare a new manifest to reflect consolidated shipments; the new manifest shall serve as a listing or index for the detailed generator manifests. Copies of the generator manifests shall be a part of the new manifest. The waste collector may prepare a new manifest without attaching the generator manifests, provided the new manifest contains for each package the information specified in Section I. The collector licensee shall certify that nothing has been done to the waste that would invalidate the generator's certification;

(3) Forward a copy of the new manifest to the land disposal facility operator at the time of shipment;

(4) Include the new manifest with the shipment to the disposal site;

(5) Retain a copy of the manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by s. HFS 157.13 (15) and retain information from generator manifest until the license is terminated and disposition is authorized by the department; and

(6) For any shipments or any portion of a shipment for which acknowledgement of receipt is not received within the times set forth in this section, conduct an investigation under Section III.(e).

(c) Any licensed waste processor who treats or repackages wastes shall:

(1) Acknowledge receipt of the waste from the generator within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation;

(2) Prepare a new manifest that meets the requirements of Section I and II. Preparation of the new manifest reflects that the processor is responsible for the waste;

(3) Prepare all wastes so that the waste is classified according to Section I of Appendix H and meets the waste characteristics requirements in Section II of Appendix H;

(4) Label each package of waste to identify whether it is Class A waste, Class B waste or Class C waste, under Section I and III of Appendix H;

(5) Conduct a quality control program to ensure compliance with Section I and II of Appendix H. The program shall include management evaluation of audits;

(6) Forward a copy of the new manifest to the disposal site operator or waste collector at the time of shipment, or deliver to a collector at the time the waste is collected, obtaining acknowledgement of receipt in the form of a signed copy of the manifest or equivalent documentation by the collector;

(7) Include the new manifest with the shipment;

(8) Retain copies of original manifests and new manifests and documentation of acknowledgement of receipt as the record of transfer of licensed material required by s. HFS 157.13 (15);

(9) For any shipment or portion of a shipment for which acknowledgement is not received within the times set forth in this section, conduct an investigation under Section III.(e).

(d) The land disposal facility operator shall:

(1) Acknowledge receipt of the waste within 1 week of receipt by returning a signed copy of the manifest or equivalent documentation to the shipper. The shipper to be notified is the licensee who last possessed the waste and transferred the waste to the operator. The returned copy of the manifest or equivalent documentation shall indicate any discrepancies between materials listed on the manifest and materials received;

(2) Maintain copies of all completed manifests or equivalent documentation until license termination;

(3) Notify the shipper, that is, the generator, the collector, or processor, and the department when any shipment or portion of a shipment has not arrived within 60 days after the advance manifest was received unless notified by the shipper that the shipment has been cancelled.

(e) Any shipment or portion of a shipment for which acknowledgement is not received within the times set forth in this section shall:

(1) Be investigated by the shipper if the shipper has not received notification or receipt within 20 days after transfer;

(2) Be traced and reported to the generator. The investigation shall include tracing the shipment and filing a report with the department. Each shipper who conducts a trace investigation shall file a written report with the department within 2 weeks of completion of the investigation.

APPENDIX H

CLASSIFICATION AND CHARACTERISTICS OF LOW-LEVEL RADIOACTIVE WASTE

Section I. - Classification of Radioactive Waste for Land Disposal.

(a) Considerations. Determination of the classification of radioactive waste involves 2 considerations. First, consideration must be given to the concentration of long-lived radionuclides, and their shorter-lived precursors, whose potential hazard will persist long after such precautions as institutional controls, improved waste form, and deeper disposal have ceased to be effective. These precautions delay the time when long-lived radionuclides could cause exposures. In addition, the magnitude of the potential dose is limited by the concentration and availability of the radionuclide at the time of exposure. Second, consideration must be given to the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effective.

(b) Classes of waste.

(1) Class A waste is waste that is usually segregated from other waste classes at the disposal site. The physical form and characteristics of Class A waste must meet the minimum requirements set forth in Section II.(a). If Class A waste also meets the stability requirements set forth in Section II.(b), it is not necessary to segregate the waste for disposal.

(2) Class B waste is waste that must meet more rigorous requirements on waste form to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in Section II.

(3) Class C waste is waste that not only must meet more rigorous requirements on waste form to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion. The physical form and characteristics of Class C waste must meet both the minimum and stability requirements set forth in Section II.

(4) Waste that is generally acceptable for near-surface disposal is waste for which form and disposal methods shall be different, and in general more stringent, than those specified for Class C waste. Such waste must be disposed of in a geologic repositor as defined in 10 CFR 60.

(c) Classification determined by long-lived radionuclides. If the radioactive waste contains only radionuclides listed in Table IV, classification shall be determined as follows:

(1) If the concentration does not exceed 0.1 times the value in Table IV, the waste is Class A.

(2) If the concentration exceeds 0.1 times the value in Table IV, but does not exceed the value in Table IV, the waste is Class C.

(3) If the concentration exceeds the value in Table IV, the waste is not generally acceptable for land disposal.

(4) For wastes containing mixtures of radionuclides listed in Table IV, the total concentration shall be determined by the sum of fractions rule described in Section I.(g).

TABLE IV

Radionuclide	Concentration Curie/Cubic Meter[a/]	Concentration Nanocurie/Gram[b/]
C-14	8	
C-14 in activated metal	80	
Ni-59 in activated metal	220	
Nb-94 in activated metal	0.2	
Tc-99	3	
I-129	0.08	
Alpha emitting transuranic radionuclides with half-life greater than 5 years		100
Pu-241		3,500
Cm-242		20,000
Ra-226		100

[a/] *To convert the Ci/m³ values to gigabecquerel (GBq) per cubic meter, multiply the Ci/m³ value by 37.*

[b/] *To convert the nCi/g values to becquerel (Bq) per gram, multiply the nCi/g value by 37.*

d) Classification determined by short-lived radionuclides. If the waste does not contain any of the radionuclides listed in Table IV, classification shall be determined based on the concentrations shown in Table V. However, as specified in Section I.(f), if radioactive waste does not contain any nuclides listed in either Table IV or V, it is Class A.

1) If the concentration does not exceed the value in Column 1, the waste is Class A.

2) If the concentration exceeds the value in Column 1 but does not exceed the value in Column 2, the waste is Class B.

3) If the concentration exceeds the value in Column 2 but does not exceed the value in Column 3, the waste is Class C.

4) If the concentration exceeds the value in Column 3, the waste is not generally acceptable for near-surface disposal.

5) For wastes containing mixtures of the radionuclides listed in Table V, the total concentration shall be determined by the sum of fractions rule described in Section I.(g).

TABLE V

Radionuclide	Concentration Curie/Cubic Meter[a/]		
	Column 1	Column 2	Column 3
Total of all radio-nuclides with less than 5-year half-life	700	*	*
H-3	40	*	*
Co-60	700	*	*
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

[a/] *Note: To convert the Ci/m³ value to gigabecquerel (GBq) per cubic meter, multiply the Ci/m³ value by 37. There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other radionuclides in Table V determine the waste to be Class C independent of these radionuclides.*

(e) Classification determined by both long- and short-lived radionuclides. If the radioactive waste contains a mixture of radionuclides, some of which are listed in Table IV and some of which are listed in Table V, classification shall be determined as follows:

(1) If the concentration of a radionuclide listed in Table IV does not exceed 0.1 times the value listed in Table IV, the class shall be that determined by the concentration of radionuclides listed in Table V.

(2) If the concentration of a radionuclide listed in Table IV exceeds 0.1 times the value listed in Table IV, but does not exceed the value in Table IV, the waste shall be Class C, provided the concentration of radionuclides listed in Table V does not exceed the value shown in Column 3 of Table V.

(f) Classification of wastes with radionuclides other than those listed in Tables IV and V. If the waste does not contain any radionuclides listed in either Table IV or V, it is Class A.

(g) The sum of the fractions rule for mixtures of radionuclides. For determining classification for waste that contains a mixture of radionuclides, it is necessary to determine the sum of fractions by dividing each radionuclide's concentration by the appropriate limit and adding the resulting values. The appropriate limits must all be taken from the same column of the same table. The sum of the fractions for the column must be less than 1.0 if the waste class is to be determined by that column. Example: A waste contains Sr-90 in a concentration of 1.85 TBq/m^3 (50 Ci/m^3) and Cs-137 in a concentration of 814 GBq/m^3 (22 Ci/m^3). Since the concentrations both exceed the values in Column 1, Table V, they must be compared to Column 2 values. For Sr-90 fraction, 50/150 = 0.33., for Cs-137 fraction, 22/44 = 0.5; the sum of the fractions = 0.83. Since the sum is less than 1.0, the waste is Class B.

(h) Determination of concentrations in wastes. The concentration of a radionuclide may be determined by indirect methods such as use of scaling factors which relate the inferred concentration of one radionuclide to another that is measured, or radionuclide material accountability, if there is reasonable assurance that the indirect methods can be correlated with actual measurements. The concentration of a radionuclide may be averaged over the volume of the waste, or weight of the waste if the units are expressed as becquerel (nanocurie) per gram.

Section II. - Radioactive Waste Characteristics.

(a) The following are minimum requirements for all classes of waste and are intended to facilitate handling and provide protection of health and safety of personnel at the disposal site.

(1) Wastes shall be packaged in conformance with the conditions of the license issued to the site operator to which the waste will be shipped. Where the conditions of the site license are more restrictive than the provisions of this section, the site license conditions shall govern.

(2) Wastes may not be packaged for disposal in cardboard or fiberboard boxes.

(3) Liquid waste shall be packaged in sufficient absorbent material to absorb twice the volume of the liquid.

(4) Solid waste containing liquid shall contain as little free-standing and non-corrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1 percent of the volume.

(5) Waste may not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.

(6) Waste may not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged under Section II.(a)(8).

(7) Waste must not be pyrophoric. Pyrophoric materials contained in wastes shall be treated, prepared, and packaged to be nonflammable.

8) Wastes in a gaseous form shall be packaged at an absolute pressure that does not exceed 1.5 atmospheres at 20°C. Total activity may not exceed 3.7 TBq (100 Ci) per container.

9) Wastes containing hazardous, biological, pathogenic, or infectious material shall be treated to reduce to the maximum extent practicable the potential hazard from the non-radiological materials.

(b) The following requirements are intended to provide stability of the waste. Stability is intended to ensure that the waste does not degrade and affect overall stability of the site through slumping, collapse, or other failure of the disposal unit and thereby lead to water infiltration. Stability is also a factor in limiting exposure to an inadvertent intruder, since it provides a recognizable and nondispersible waste.

1) Waste shall have structural stability. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, and microbial activity, and internal factors such as radiation effects and chemical changes. Structural stability may be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal.

2) Notwithstanding the provisions in Section II.(a)(3) and (4), liquid wastes, or wastes containing liquid, shall be converted into a form that contains as little free-standing and non-corrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1 percent of the volume of the waste when the waste is in a disposal container designed to ensure stability, or 0.5 percent of the volume of the waste for waste processed to a stable form.

3) Void spaces within the waste and between the waste and its package shall be reduced to the extent practicable.

Section III. - Labeling.

Each package of waste shall be clearly labeled to identify whether it is Class A, Class B or Class C waste, under Section I.

APPENDIX I

QUANTITIES FOR USE WITH DECOMMISSIONING UNDER SECTION HFS 157.15

NOTE: To convert μCi to kBq, multiply the μCi value by 37.

Material	Microcurie
Americium-241	0.01
Antimony-122	100
Antimony-124	10
Antimony-125	10
Arsenic-73	100
Arsenic-74	10
Arsenic-76	10
Arsenic-77	100
Barium-131	10
Barium-133	10
Barium-140	10
Bismuth-210	1
Bromine-82	10
Cadmium-109	10
Cadmium-115m	10
Cadmium-115	100
Calcium-45	10
Calcium-47	10
Carbon-14	100
Cerium-141	100
Cerium-143	100
Cerium-144	1
Cesium-131	1,000
Cesium-134m	100
Cesium-134	1
Cesium-135	10
Cesium-136	10
Cesium-137	10
Chlorine-36	10
Chlorine-38	10
Chromium-51	1,000
Cobalt-58m	10
Cobalt-58	10
Cobalt-60	1
Copper-64	100
Dysprosium-165	10
Dysprosium-166	100
Erbium-169	100
Erbium-171	100
Europium-152 (9.2 h)	100
Europium-152 (13 yr)	1

QUANTITIES FOR USE WITH DECOMMISSIONING UNDER SECTION HFS 157.15 *(Continued)*

Material	Microcurie
Europium-154	1
Europium-155	10
Fluorine-18	1,000
Gadolinium-153	10
Gadolinium-159	100
Gallium-72	10
Germanium-71	0
Gold-198	100
Gold-199	100
Hafnium-181	10
Holmium-166	100
Hydrogen-3	1,000
Indium-113m	100
Indium-114m	10
Indium-115m	100
Indium-115	10
Iodine-125	1
Iodine-126	1
Iodine-129	0.1
Iodine-131	1
Iodine-132	10
Iodine-133	1
Iodine-134	10
Iodine-135	10
Iridium-192	10
Iridium-194	100
Iron-55	100
Iron-59	10
Krypton-85	100
Krypton-87	10
Lanthanum-140	10
Lutetium-177	100
Manganese-52	10
Manganese-54	10
Manganese-56	10
Mercury-197m	100
Mercury-197	100
Mercury-203	10
Molybdenum-99	100
Neodymium-147	100
Neodymium-149	100
Nickel-59	100
Nickel-63	10
Nickel-65	100
Niobium-93m	10
Niobium-95	10
Niobium-97	10

QUANTITIES FOR USE WITH DECOMMISSIONING UNDER SECTION HFS 157.15 *(Continued)*

Material	Microcurie
Osmium-185	10
Osmium-191m	100
Osmium-191	100
Osmium-193	100
Palladium-103	100
Palladium-109	100
Phosphorus-32	10
Platinum-191	100
Platinum-193m	100
Platinum-193	100
Platinum-197m	100
Platinum-197	100
Plutonium-239	0.01
Polonium-210	0.1
Potassium-42	10
Praseodymium-142	100
Praseodymium-143	100
Promethium-147	10
Promethium-149	10
Radium-226	0.01
Rhenium-186	100
Rhenium-188	100
Rhodium-103m	100
Rhodium-105	100
Rubidium-86	10
Rubidium-87	10
Ruthenium-97	100
Ruthenium-103	10
Ruthenium-105	10
Ruthenium-106	1
Samarium-151	10
Samarium-153	100
Scandium-46	10
Scandium-47	100
Scandium-48	10
Selenium-75	10
Silicon-31	100
Silver-105	10
Silver-110m	1
Silver-111	100
Sodium-22	1
Sodium-24	10
Strontium-85	10
Strontium-89	1
Strontium-90	0.1

QUANTITIES FOR USE WITH DECOMMISSIONING UNDER SECTION HFS 157.15 *(Continued)*

Material	Microcurie
Strontium-91	10
Strontium-92	10
Sulfur -35	100
Tantalum-182	10
Technetium-96	10
Technetium-97m	100
Technetium-97	100
Technetium-99m	100
Technetium-99	10
Tellurium-125m	10
Tellurium-127m	10
Tellurium-127	100
Tellurium-129m	10
Tellurium-129	100
Tellurium-131m	10
Tellurium-132	10
Terbium-160	10
Thallium-200	100
Thallium-201	100
Thallium-202	100
Thallium-204	10
Thorium (natural)[c/]	100
Thulium-170	10
Thulium-171	10
Tin-113	10
Tin-125	10
Tungsten-181	10
Tungsten-185	10
Tungsten-187	100
Uranium (natural)[d/]	100
Uranium-233	0.01
Uranium-234	0.01
Uranium-235	0.01
Vanadium-48	10
Xenon-131m	1,000
Xenon-133	100
Xenon-135	100
Ytterbium-175	100
Yttrium-90	10
Yttrium-91	10
Yttrium-92	100
Yttrium-93	100
Zinc-65	10

[c/] *Based on alpha disintegration rate of Th-232, Th-230 and their daughter products.*

[d/] *Based on alpha disintegration rate of U-238, U-234, and U-235*

QUANTITIES FOR USE WITH DECOMMISSIONING UNDER SECTION HFS 157.15 *(Continued)*

Material	Microcurie
Zinc- 69m	100
Zinc-69	1,000
Zirconium-93	10
Zirconium-95	10
Zirconium-97	10
Any alpha emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	0.01
Any radionuclide other than alpha emitting radionuclides, not listed above or mixtures of beta emitters of unknown composition	0.1

Note: Where there is involved a combination of isotopes in known amounts, the limit for the combination should be derived as follows: Determine, for each isotope in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific isotope when not in combination. The sum of the ratios for all the isotopes in the combination may not exceed "1" – that is, unity.

APPENDIX J

SUBJECTS TO BE INCLUDED IN TRAINING COURSES FOR WELL LOGGING SUPERVISORS

I. Fundamentals of Radiation Safety

- A. Characteristics of radiation
- B. Units of radiation dose and quantity of radioactivity
- C. Significance of radiation dose **and hazards of exposure to radiation**
  1. Radiation protection standards
  2. Biological effects of radiation dose
- D. Levels of radiation from sources of radiation
- E. Methods of minimizing radiation dose
  1. Working time
  2. Working distances
  3. Shielding
- F. Radiation safety practices including prevention of contamination and methods of decontamination

II. Radiation Detection Instrumentation to be Used

- A. Use of radiation survey instruments
  1. Operation
  2. Calibration
  3. Limitations
- B. Survey techniques
- C. Use of personnel monitoring equipment

III. Equipment to be Used

- A. Handling equipment
- B. Sources of radiation
- C. Storage and control of equipment
- D. Operation and control of equipment

IV. The Requirements of Pertinent Federal and State Regulations

V. The Licensee's or Registrant's Written Operating and Emergency Procedures

VI. The Licensee's or Registrant's Record Keeping Procedures

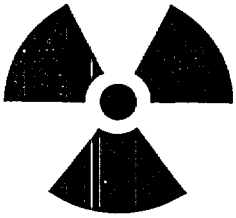
VII. Case histories of well logging accidents

APPENDIX K

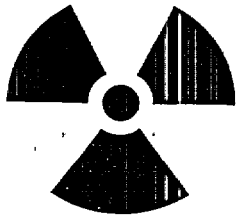
EXAMPLE OF PLAQUE FOR IDENTIFYING WELLS CONTAINING SEALED SOURCES CONTAINING RADIOACTIVE MATERIAL ABANDONED DOWNHOLE

The size of the plaque should be convenient for use on active or inactive wells, e.g., a 17 cm (7-inch) square and at least 3 mm (1/8") thick. Letter size of the word "CAUTION" should be approximately twice the letter size of the rest of the information, e.g., 2-inch and 1-inch letter size, respectively.

{NAME OF COMPANY}
{SECOND HEADING OF NAME OF COMPANY}



CAUTION



{QUANTITY AND TYPE OF RADIOACTIVE MATERIAL}
{DATE LOST AND DEPTH OF RADIOACTIVE MATERIAL}
DO NOT RE-ENTER THIS WELL BEFORE CONTACTING:

RADIATION PROTECTION SECTION
WI DEPARTMENT OF HEALTH AND FAMILY SERVICES

APPENDIX L (RESERVED)

~~DETERMINATION OF COMPETENCE FOR MEDICAL X-RAY OPERATORS~~

~~The following are areas in which the department considers it important that an individual have expertise for the competent operation of x-ray equipment:~~

~~(a) Familiarization with equipment~~
~~(1) Identification of controls~~
~~(2) Function of each control~~
~~(3) How to use a technique chart~~

~~(b) Radiation Protection~~
~~(1) Collimation~~
~~(2) Filtration~~
~~(3) Gonad shielding and other patient protection devices~~
~~(4) Restriction of x-ray tube radiation to the image receptor~~
~~(5) Personnel protection~~
~~(6) Grids~~
~~(7) Protection of children and pregnant women~~
~~(8) Repeat film analysis~~

~~(c) Film Processing~~
~~(1) Film speed as related to patient exposure~~
~~(2) Film processing parameters~~
~~(3) Quality assurance program~~

~~(d) Emergency procedures to terminate the exposure in the event of automatic timing device failure~~

~~(e) Proper use of personnel dpsimetry, if required~~

~~(f) Understanding units of radiation and the physics of radiation production~~

~~(g) Understanding the proper anatomical positioning techniques used for radiography~~

APPENDIX M

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

Persons requesting that the department approve a healing arts screening program shall submit the following information and evaluation. Mammography screening and bone density screening are exempt from this requirement unless persons under age 18 are involved:

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

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

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

d. A description of the population to be examined in the screening program, which is age, sex, physical condition, and other appropriate information. If the study involves women of reproductive age and the exam involves the trunk of the body, what precautions are being taken to ensure the subjects are not pregnant.

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

f. An evaluation by a medical physicist of the x-ray system to be used in the screening program. The evaluation by the medical physicist shall show that the system satisfies all requirements of this chapter. The evaluation shall include a measurement of patient exposures from the x-ray examinations to be performed. This exposure information must be included in the informed consent papers signed by the subject. An explanation of the risk from the radiation exposure shall be included in the informed consent if the head, neck or trunk is involved in the procedure.

g. The name and address of the individual who will interpret the radiograph or images if any are produced. The interpreting physicians must be licensed in Wisconsin.

h. A description of the procedures to be used in advising the individuals screened and their private practitioners of the healing arts of the results of the screening procedure and any further medical needs indicated.

i. A description of the procedures for the retention or disposition of the radiographs, images, graphs and other records pertaining to the x-ray examinations.

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

o. Human-use committee approval of the screening program if one is required by local policy.

p. A copy of the informed consent information being provided to the subjects.

q. If minors are involved, parental consent is required.

APPENDIX N

EXEMPTIONS FROM PATIENT SHIELDING FOR CERTAIN FLUOROSCOPIC PROCEDURES

As specified in s. HFS 157.76 (9) (c), the following fluorscopic procedures are automatically exempt from normal protective barriers.

a. Angiograms

b. Arthrograms

c. Biliary drainage procedures

d. Fluoroscopic biopsy procedures

e. Myelograms

f. Percutaneous cholangiograms

g. Percutaneous nephrostomies

h. Sinograms or fistulograms

i. T-tube cholangiograms

APPENDIX O

DETERMINATION OF A_1 AND A_2

I. Values of A_1 and A_2 for individual radionuclides, which are the bases for many activity limits elsewhere in these regulations, are given in TABLE VI. The curie (Ci) values specified are obtained by converting from the Terabecquerel (TBq) figure. The curie values are expressed to 3 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.

II. For individual radionuclides whose identities are known, but which are not listed in TABLE VI, the determination of the values of A_1 and A_2 requires department approval, except that the values of A_1 and A_2 in TABLE VII may be used without obtaining department approval.

III. In the calculations of A_1 and A_2 for a radionuclide not in TABLE VI, a single radioactive decay chain, in which radionuclides are present in their naturally occurring proportions, and in which no daughter 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 daughter nuclide has a half-life either longer than 10 days, or greater than that of the parent nuclide, the parent and those daughter nuclides shall be considered as mixtures of different nuclides.

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

(a) For special form radioactive material, the maximum quantity transported in a Type A package:

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

(b) For normal form radioactive material, the maximum quantity transported in a Type A package:

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

where B(i) is the activity of radionuclide i and $A_1(i)$ and $A_2(i)$ are the A_1 and A_2 values for radionuclide respectively.
Alternatively, an A_1 value for mixtures of special form material may be determined as follows:

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

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.

An A_2 value for mixtures of normal form material may be determined as follows:

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

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.

V. When the identity of each radionuclide is known, but the individual activities of some of the radionuclides are not known, the radionuclides may be grouped and the lowest A_1 or A_2 value, as appropriate, for the radionuclides in each group may be used in applying the formulas in paragraph IV. 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 VI
A_1 AND A_2 VALUES FOR RADIONUCLIDES

Symbol of RadioNuclide	Element and Atomic No.	A_1 (TBq)	A_1 (Ci)	A_2 (TBq)	A_2 (Ci)	Specific Activity (TBq/g)	(Ci/g)
Ac-225	Actinium (89)	0.6	16.2	$1x10^{-2}$	0.270	$2.1x10^{3}$	$5.8x10^{4}$
Ac-227		40	1080	$2x10^{-5}$	$5.41x10^{-4}$	2.7	$7.2x10^{1}$
Ac-228		0.6	16.2	0.4	10.8	$8.4x10^{4}$	$2.2x10^{6}$
Ag-105	Silver (47)	2	54.1	2	54.1	$1.1x10^{3}$	$3.0x10^{4}$
Ag-108m		0.6	16.2	0.6	16.2	$9.7x10^{-1}$	$2.6x10^{1}$
Ag-110m		0.4	10.8	0.4	10.8	$1.8x10^{2}$	$4.7x10^{3}$
Ag-111		0.6	16.2	0.5	13.5	$5.8x10^{3}$	$1.6x10^{5}$
Al-26	Aluminum (13)	0.4	10.8	0.4	10.8	$7.0x10^{-4}$	$1.9x10^{-2}$
Am-241	Americium (95)	2	54.1	$2x10^{-4}$	$5.41x10^{-3}$	$1.3x10^{-1}$	3.4
Am-242m		2	54.1	$2x10^{-4}$	$5.41x10^{-3}$	$3.6x10^{-1}$	$1.0x10^{1}$
Am-243		2	54.1	$2x10^{-4}$	$5.41x10^{-3}$	$7.4x10^{-3}$	$2.0x10^{-1}$
Ar-37	Argon (18)	40	1080	40	1080	$3.7x10^{3}$	$9.9x10^{4}$
Ar-39		20	541	20	541	1.3	$3.4x10^{1}$
Ar-41		0.6	16.2	0.6	16.2	$1.5x10^{6}$	$4.2x10^{7}$
Ar-42		0.2	5.41	0.2	5.41	9.6	$2.6x10^{2}$
As-72	Arsenic (33)	0.2	5.41	0.2	5.41	$6.2x10^{4}$	$1.7x10^{6}$
As-73		40	1080	40	1080	$8.2x10^{2}$	$2.2x10^{4}$
As-74		1	27.0	0.5	13.5	$3.7x10^{3}$	$9.9x10^{4}$
As-76		0.2	5.41	0.2	5.41	$5.8x10^{4}$	$1.6x10^{6}$
As-77		20	541	0.5	13.5	$3.9x10^{4}$	$1.0x10^{6}$
At-211	Astatine (85)	30	811	2	54.1	$7.6x10^{4}$	$2.1x10^{6}$
Au-193	Gold (79)	6	162	6	162	$3.4x10^{4}$	$9.2x10^{5}$
Au-194		1	27.0	1	27.0	$1.5x10^{4}$	$4.1x10^{5}$
Au-195		10	270	10	270	$1.4x10^{2}$	$3.7x10^{3}$
Au-196		2	54.1	2	54.1	$4.0x10^{3}$	$1.1x10^{5}$
Au-198		3	81.1	0.5	13.5	$9.0x10^{3}$	$2.4x10^{5}$
Au-199		10	270	0.9	24.3	$7.7x10^{3}$	$2.1x10^{5}$
Ba-131	Barium (56)	2	54.1	2	54.1	$3.1x10^{3}$	$8.4x10^{4}$
Ba-133m		10	270	0.9	24.3	$2.2x10^{4}$	$6.1x10^{5}$
Ba-133		3	81.1	3	81.1	9.4	$2.6x10^{2}$
Ba-140		0.4	10.8	0.4	10.8	$2.7x10^{3}$	$7.3x10^{4}$
Be-7	Beryllium (4)	20	541	20	541	$1.3x10^{4}$	$3.5x10^{5}$
Be-10		20	541	0.5	13.5	$8.3x10^{-4}$	$2.2x10^{-2}$

TABLE VI
A_1 AND A_2 VALUES FOR RADIONUCLIDES (cont.)

Symbol of RadioNuclide	Element and Atomic No.	A_1 (TBq)	A_1 (Ci)	A_2 (TBq)	A_2 (Ci)	Specific Activity (TBq/g)	Specific Activity (Ci/g)
Bi-205	Bismuth (83)	0.6	16.2	0.6	16.2	$1.5x10^{-3}$	$4.2x10^{4}$
Bi-206		0.3	8.11	0.3	8.11	$3.8x10^{3}$	$1.0x10^{5}$
Bi-207		0.7	18.9	0.7	18.9	1.9	$5.2x10^{1}$
Bi-210m		0.3	8.11	$3x10^{-2}$	0.811	$2.1x10^{-5}$	$5.7x10^{-4}$
Bi-210		0.6	16.2	0.5	13.5	$4.6x10^{3}$	$1.2x10^{5}$
Bi-212		0.3	8.11	0.3	8.11	$5.4x10^{5}$	$1.5x10^{7}$
Bk-247	Berkelium (97)	2	54.1	$2x10^{-4}$	$5.41x10^{-3}$	$3.8x10^{-2}$	1.0
Bk-249		40	1080	$8x10^{-2}$	2.16	$6.1x10^{1}$	$1.6x10^{3}$
Br-76	Bromine (35)	0.3	8.11	0.3	8.11	$9.4x10^{4}$	$2.5x10^{6}$
Br-77		3	81.1	3	81.1	$2.6x10^{4}$	$7.1x10^{5}$
Br-82		0.4	10.8	0.4	10.8	$4.0x10^{4}$	$1.1x10^{6}$
C-11	Carbon (6)	1	27	0.5	13.5	$3.1x10^{7}$	$8.4x10^{8}$
C-14		40	1080	2	54.1	$1.6x10^{-1}$	4.5
Ca-41	Calcium (20)	40	1080	40	1080	$3.1x10^{-3}$	$8.5x10^{-2}$
Ca-45		40	1080	0.9	24.3	$6.6x10^{2}$	$1.8x10^{4}$
Ca-47		0.9	24.3	0.5	13.5	$2.3x10^{4}$	$6.1x10^{5}$
Cd-109	Cadmium (48)	40	1080	1	27.0	$9.6x10^{1}$	$2.6x10^{3}$
Cd-113m		20	541	$9x10^{-2}$	2.43	8.3	$2.2x10^{2}$
Cd-115m		0.3	8.11	0.3	8.11	$9.4x10^{2}$	$2.5x10^{4}$
Cd-115		4	108	0.5	13.5	$1.9x10^{4}$	$5.1x10^{5}$
Ce-139	Cerium (58)	6	162	6	162	$2.5x10^{2}$	$6.8x10^{3}$
Ce-141		10	270	0.5	13.5	$1.1x10^{3}$	$2.8x10^{4}$
Ce-143		0.6	16.2	0.5	13.5	$2.5x10^{4}$	$6.6x10^{5}$
Ce-144		0.2	5.41	0.2	5.41	$1.2x10^{2}$	$3.2x10^{3}$
Cf-248	Californium (98)	30	811	$3x10^{-3}$	$8.11x10^{-2}$	$5.8x10^{1}$	$1.6x10^{3}$
Cf-249		2	54.1	$2x10^{-4}$	$5.41x10^{-3}$	$1.5x10^{-1}$	4.1
Cf-250		5	135	$5x10^{-4}$	$1.35x10^{-2}$	4.0	$1.1x10^{2}$
Cf-251		2	54.1	$2x10^{-4}$	$5.41x10^{-3}$	$5.9x10^{-2}$	1.6
Cf-252		0.1	2.70	$1x10^{-3}$	$2.70x10^{-2}$	$2.0x10^{1}$	$5.4x10^{2}$
Cf-253		40	1080	$6x10^{-2}$	1.62	$1.1x10^{3}$	$2.9x10^{4}$
Cf-254		$3x10^{-3}$	$8.11x10^{-2}$	$6x10^{-4}$	$1.62x10^{-2}$	$3.1x10^{2}$	$8.5x10^{3}$
Cl-36	Chlorine (17)	20	541	0.5	13.5	$1.2x10^{-3}$	$3.3x10^{-2}$
Cl-38		0.2	5.41	0.2	5.41	$4.9x10^{6}$	$1.3x10^{8}$

TABLE VI
A_1 AND A_2 VALUES FOR RADIONUCLIDES (cont.)

Symbol of RadioNuclide	Element and Atomic No.	A_1 (TBq)	A_1 (Ci)	A_2 (TBq)	A_2 (Ci)	Specific Activity (TBq/g)	Specific Activity (Ci/g)
Cm-240	Curium (96)	40	1080	$2x10^{-2}$	0.541	$7.5x10^{2}$	$2.0x10^{4}$
Cm-241		2	54.1	0.9	24.3	$6.1x10^{2}$	$1.7x10^{4}$
Cm-242		40	1080	$1x10^{-2}$	0.270	$1.2x10^{2}$	$3.3x10^{3}$
Cm-243		3	81.1	$3x10^{-4}$	$8.11x10^{-3}$	1.9	$5.2x10^{1}$
Cm-244		4	108	$4x10^{-4}$	$1.08x10^{-2}$	3.0	$8.1x10^{1}$
Cm-245		2	54.1	$2x10^{-4}$	$5.41x10^{-3}$	$6.4x10^{-3}$	$1.7x10^{-1}$
Cm-246		2	54.1	$2x10^{-4}$	$5.41x10^{-3}$	$1.1x10^{-2}$	$3.1x10^{-1}$
Cm-247		2	54.1	$2x10^{-4}$	$5.41x10^{-3}$	$3.4x10^{-6}$	$9.3x10^{-5}$
Cm-248		$4x10^{-2}$	1.08	$5x10^{-5}$	$1.35x10^{-3}$	$1.6x10^{-4}$	$4.2x10^{-3}$
Co-55	Cobalt (27)	0.5	13.5	0.5	13.5	$1.1x10^{5}$	$3.1x10^{6}$
Co-56		0.3	8.11	0.3	8.11	$1.1x10^{3}$	$3.0x10^{4}$
Co-57		8	216	8	216	$3.1x10^{2}$	$8.4x10^{3}$
Co-58m		40	1080	40	1080	$2.2x10^{5}$	$5.9x10^{6}$
Co-58		1	27.0	1	27.0	$1.2x10^{3}$	$3.2x10^{4}$
Co-60		0.4	10.8	0.4	10.8	$4.2x10^{1}$	$1.1x10^{3}$
Cr-51	Chromium (24)	30	811	30	811	$3.4x10^{3}$	$9.2x10^{4}$
Cs-129	Cesium (55)	4	108	4	108	$2.8x10^{4}$	$7.6x10^{5}$
Cs-131		40	1080	40	1080	$3.8x10^{3}$	$1.0x10^{5}$
Cs-132		1	27.0	1	27.0	$5.7x10^{3}$	$1.5x10^{5}$
Cs-134m		40	1080	9	243	$3.0x10^{5}$	$8.0x10^{6}$
Cs-134		0.6	16.2	0.5	13.5	$4.8x10^{1}$	$1.3x10^{3}$
Cs-135		40	1080	0.9	24.3	$4.3x10^{-5}$	$1.2x10^{-3}$
Cs-136		0.5	13.5	0.5	13.5	$2.7x10^{3}$	$7.3x10^{4}$
Cs-137		2	54.1	0.5	13.5	3.2	$8.7x10^{1}$
Cu-64	Copper (29)	5	135	0.9	24.3	$1.4x10^{5}$	$3.9x10^{6}$
Cu-67		9	243	0.9	24.3	$2.8x10^{4}$	$7.6x10^{5}$
Dy-159	Dysprosium (66)	20	541	20	541	$2.1x10^{2}$	$5.7x10^{3}$
Dy-165		0.6	16.2	0.5	13.5	$3.0x10^{5}$	$8.2x10^{6}$
Dy-166		0.3	8.11	0.3	8.11	$8.6x10^{3}$	$2.3x10^{5}$
Er-169	Erbium (68)	40	1080	0.9	24.3	$3.1x10^{3}$	$8.3x10^{4}$
Er-171		0.6	16.2	0.5	13.5	$9.0x10^{4}$	$2.4x10^{6}$
Es-253	Einsteinium (99)[a/]	200	5400	$2.1x10^{-2}$	$5.4x10^{-1}$	--	--
Es-254		30	811	$3x10^{-3}$	$8.11x10^{-2}$	--	--
Es-254m		0.6	16.2	0.4	10.8	--	--
Es-255		--	--	--	--	--	--

[a/] *International shipments of Einsteinium require multilateral approval of A_1 and A_2 values*

TABLE VI
A_1 AND A_2 VALUES FOR RADIONUCLIDES (cont.)

Symbol of RadioNuclide	Element and Atomic No.	A_1 (TBq)	A_1 (Ci)	A_2 (TBq)	A_2 (Ci)	Specific Activity (TBq/g)	(Ci/g)
Eu-147	Europium (63)	2	54.1	2	54.1	$1.4x10^3$	$3.7x10^4$
Eu-148		0.5	13.5	0.5	13.5	$6.0x10^2$	$1.6x10^4$
Eu-149		20	541	20	541	$3.5x10^2$	$9.4x10^3$
Eu-150		0.7	18.9	0.7	18.9	$6.1x10^4$	$1.6x10^6$
Eu-152m		0.6	16.2	0.5	13.5	$8.2x10^4$	$2.2x10^6$
Eu-152		0.9	24.3	0.9	24.3	6.5	$1 8x10^2$
Eu-154		0.8	21.6	0.5	13.5	9.8	$2.6x10^2$
Eu-155		20	541	2	54.1	$1.8x10^1$	$4.9x10^2$
Eu-156		0.6	16.2	0.5	13.5	$2.0x10^3$	$5.5x10^4$
F-18	Fluorine (9)	1	27.0	0.5	13.5	$3.5x10^6$	$9.5x10^7$
Fe-52	Iron (26)	0.2	5.41	0.2	5.41	$2.7x10^5$	$7.3x10^6$
Fe-55		40	1080	40	1080	$8.8x10^1$	$2.4x10^3$
Fe-59		0.8	21.6	0.8	21.6	$1.8x10^3$	$5.0x10^4$
Fe-60		40	1080	0.2	5.41	$7.4x10^{-4}$	$2.0x10^{-2}$
Fm-255	Fermium (100)[b/]	40	1080	0.8	21.6	-- --	
Fm-257		10	270	$8x10^{-3}$	$21.6x10^{-1}$	-- --	
Ga-67	Gallium (31)	6	162	6	162	$2.2x10^4$	$6.0x10^5$
Ga-68		0.3	8.11	0.3	8.11	$1.5x10^6$	$4.1x10^7$
Ga-72		0.4	10.8	0.4	10.8	$1.1x10^5$	$3.1x10^6$
Gd-146	Gadolinium (64)	0.4	10.8	0.4	10.8	$6.9x10^2$	$1.9x10^4$
Gd-148		3	81.1	$3x10^{-4}$	$8.11x10^{-3}$	1.2	$3.2x10^1$
Gd-153		10	270	5	135	$1.3x10^2$	$3.5x10^3$
Gd-159		4	108	0.5	13.5	$3.9x10^4$	$1.1x10^6$
Ge-68	Germanium (32)	0.3	8.11	0.3	8.11	$2.6x10^2$	$7.1x10^3$
Ge-71		40	1080	40	1080	$5.8x10^3$	$1.6x10^5$
Ge-77		0.3	8.11	0.3	8.11	$1.3x10^5$	$3.6x10^6$
H-3	Hydrogen (1)	See T-Tritium					
Hf-172	Hafnium (72)	0.5	13.5	0.3	8.11	$4.1x10^1$	$1.1x10^3$
Hf-175		3	81.1	3	81.1	$3.9x10^2$	$1.1x10^4$
Hf-181		2	54.1	0.9	24.3	$6.3x10^2$	$1.7x10^4$
Hf-182		4	108	$3x10^{-2}$	0.811	$8.1x10^{-6}$	$2.2x10^{-4}$

[b/] *International shipments of Fermium require multilateral approval of A_1 and A_2 values.*

TABLE VI
A_1 AND A_2 VALUES FOR RADIONUCLIDES (cont.)

Symbol of RadioNuclide	Element and Atomic No.	A_1 (TBq)	A_1 (Ci)	A_2 (TBq)	A_2 (Ci)	Specific Activity (TBq/g)	Specific Activity (Ci/g)
Hg-194	Mercury (80)	1	27.0	1	27.0	1.3×10^{-1}	3.5
Hg-195m		5	135	5	135	1.5×10^{4}	4.0×10^{5}
Hg-197m		10	270	0.9	24.3	2.5×10^{4}	6.7×10^{5}
Hg-197		10	270	10	270	9.2×10^{3}	2.5×10^{5}
Hg-203		4	108	0.9	24.3	5.1×10^{2}	1.4×10^{4}
Ho-163	Holmium (67)	40	1080	40	1080	2.7	7.6×10^{1}
Ho-166m		0.6	16.2	0.3	8.11	6.6×10^{-2}	1.8
Ho-166		0.3	8.11	0.3	8.11	2.6×10^{4}	7.0×10^{5}
I-123	Iodine (53)	6	162	6	162	7.1×10^{4}	1.9×10^{6}
I-124		0.9	24.3	0.9	24.3	9.3×10^{3}	2.5×10^{5}
I-125		20	541	2	54.1	6.4×10^{2}	1.7×10^{4}
I-126		2	54.1	0.9	24.3	2.9×10^{3}	8.0×10^{4}
I-129		Unlimited	Unlimited	Unlimited	Unlimited	6.5×10^{-6}	1.8×10^{-4}
I-131		3	81.1	0.5	13.5	4.6×10^{3}	1.2×10^{5}
I-132		0.4	10.8	0.4	10.8	3.8×10^{5}	1.0×10^{7}
I-133		0.6	16.2	0.5	13.5	4.2×10^{4}	1.1×10^{6}
I-134		0.3	8.11	0.3	8.11	9.9×10^{5}	2.7×10^{7}
I-135		0.6	16.2	0.5	13.5	1.3×10^{5}	3.5×10^{6}
In-111	Indium (49)	2	54.1	2	54.1	1.5×10^{4}	4.2×10^{5}
In-113m		4	108	4	108	6.2×10^{5}	1.7×10^{7}
In-114m		0.3	8.11	0.3	8.11	8.6×10^{2}	2.3×10^{4}
In-115m		6	162	0.9	24.3	2.2×10^{5}	6.1×10^{6}
Ir-189	Iridium (77)	10	270	10	270	1.9×10^{3}	5.2×10^{4}
Ir-190		0.7	18.9	0.7	18.9	2.3×10^{3}	6.2×10^{4}
Ir-192		1	27.0	0.5	13.5	3.4×10^{2}	9.2×10^{3}
Ir-193m		10	270	10	270	2.4×10^{3}	6.4×10^{4}
Ir-194		0.2	5.41	0.2	5.41	3.1×10^{4}	8.4×10^{5}
K-40	Potassium (19)	0.6	16.2	0.6	16.2	2.4×10^{-7}	6.4×10^{-6}
K-42		0.2	5.41	0.2	5.41	2.2×10^{5}	6.0×10^{6}
K-43		1.0	27.0	0.5	13.5	1.2×10^{5}	3.3×10^{6}
Kr-81	Krypton (36)	40	1080	40	1080	7.8×10^{-4}	2.1×10^{-2}
Kr-85m		6	162	6	162	3.0×10^{5}	8.2×10^{6}
Kr-85		20	541	10	270	1.5×10^{1}	3.9×10^{2}
Kr-87		0.2	5.41	0.2	5.41	1.0×10^{6}	2.8×10^{7}
La-137	Lanthanum (57)	40	1080	2	54.1	1.6×10^{-3}	4.4×10^{-2}
La-140		0.4	10.8	0.4	10.8	2.1×10^{4}	5.6×10^{5}

TABLE VI
A_1 AND A_2 VALUES FOR RADIONUCLIDES (cont.)

Symbol of RadioNuclide	Element and Atomic No.	A_1 (TBq)	A_1 (Ci)	A_2 (TBq)	A_2 (Ci)	Specific Activity (TBq/g)	Specific Activity (Ci/g)
Lu-172	Lutetium (71)	0.5	13.5	0.5	13.5	$4.2x10^3$	$1.1x10^5$
Lu-173		8	216	8	216	$5.6x10^1$	$1.5x10^3$
Lu-174m		20	541	8	216	$2.0x10^2$	$5.3x10^3$
Lu-174		8	216	4	108	$2.3x10^1$	$6.2x10^2$
Lu-177		30	811	0.9	24.3	$4.1x10^3$	$1.1x10^5$
MFP	For mixed fission products, use formula for mixtures or TABLE VII.						
Mg-28	Magnesium (12)	0.2	5.41	0.2	5.41	$2.0x10^5$	$5.4x10^6$
Mn-52	Manganese (25)	0.3	8.11	0.3	8.11	$1.6x10^4$	$4.4x10^5$
Mn-53		Unlimited	Unlimited	Unlimited	Unlimited	$6.8x10^{-5}$	$1.8x10^{-3}$
Mn-54		1	27.0	1	27.0	$2.9x10^2$	$7.7x10^3$
Mn-56		0.2	5.41	0.2	5.41	$8.0x10^5$	$2.2x10^7$
Mo-93	Molybdenum (42)	40	1080	7	189	$4.1x10^{-2}$	1.1
Mo-99		0.6	16.2	0.5	13.5[g]	$1.8x10^4$	$4.8x10^5$
N-13	Nitrogen (7)	0.6	16.2	0.5	13.5	$5.4x10^7$	$1.5x10^9$
Na-22	Sodium (11)	0.5	13.5	0.5	13.5	$2.3x10^2$	$6.3x10^3$
Na-24		0.2	5.41	0.2	5.41	$3.2x10^5$	$8.7x10^6$
Nb-92m	Niobium (41)	0.7	18.9	0.7	18.9	$5.2x10^3$	$1.4x10^5$
Nb-93m		40	1080	6	162	8.8	$2.4x10^2$
Nb-94		0.6	16.2	0.6	16.2	$6.9x10^{-3}$	$1.9x10^{-1}$
Nb-95		1	27.0	1	27.0	$1.5x10^3$	$3.9x10^4$
Nb-97		0.6	16.2	0.5	13.5	$9.9x10^5$	$2.7x10^7$
Nd-147	Neodymium (60)	4	108	0.5	13.5	$3.0x10^3$	$8.1x10^4$
Nd-149		0.6	16.2	0.5	13.5	$4.5x10^5$	$1.2x10^7$
Ni-59	Nickel (28)	40	1080	40	1080	$3.0x10^{-3}$	$8.0x10^{-2}$
Ni-63		40	1080	30	811	2.1	$5.7x10^1$
Ni-65		0.3	8.11	0.3	8.11	$7.1x10^5$	$1.9x10^7$
Np-235	Neptunium (93)	40	1080	40	1080	$5.2x10^1$	$1.4x10^3$
Np-236		7	189	$1x10^{-3}$	$2.70x10^{-2}$	$4.7x10^{-4}$	$1.3x10^{-2}$
Np-237		2	54.1	$2x10^{-4}$	$5.41x10^{-3}$	$2.6x10^{-5}$	$7.1x10^{-4}$
Np-239		6	162	0.5	13.5	$8.6x10^3$	$2.3x10^5$

[g] *20 Ci for Mo^{99} for domestic use*

TABLE VI
A_1 AND A_2 VALUES FOR RADIONUCLIDES (cont.)

Symbol of RadioNuclide	Element and Atomic No.	A_1 (TBq)	A_1 (Ci)	A_2 (TBq)	A_2 (Ci)	Specific Activity (TBq/g)	Specific Activity (Ci/g)
Os-185	Osmium (76)	1	27.0	1	27.0	2.8×10^{2}	7.5×10^{3}
Os-191m		40	1080	40	1080	4.6×10^{4}	1.3×10^{6}
Os-191		10	270	0.9	24.3	1.6×10^{3}	4.4×10^{4}
Os-193		0.6	16.2	0.5	13.5	2.0×10^{4}	5.3×10^{5}
Os-194		0.2	5.41	0.2	5.41	1.1×10^{1}	3.1×10^{2}
P-32	Phosphorus (15)	0.3	8.11	0.3	8.11	1.1×10^{4}	2.9×10^{5}
P-33		40	1080	0.9	24.3	5.8×10^{3}	1.6×10^{5}
Pa-230	Protactinium (91)	2	54.1	0.1	2.70	1.2×10^{3}	3.3×10^{4}
Pa-231		0.6	16.2	6×10^{-5}	1.62×10^{-3}	1.7×10^{-3}	4.7×10^{-2}
Pa-233		5	135	0.9	24.3	7.7×10^{2}	2.1×10^{4}
Pb-201	Lead (82)	1	27.0	1	27.0	6.2×10^{4}	1.7×10^{6}
Pb-202		40	1080	2	54.1	1.2×10^{-4}	3.4×10^{-3}
Pb-203		3	81.1	3	81.1	1.1×10^{4}	3.0×10^{5}
Pb-205		Unlimited	Unlimited	Unlimited	Unlimited	4.5×10^{-6}	1.2×10^{-4}
Pb-210		0.6	16.2	9×10^{-3}	0.243	2.8	7.6×10^{1}
Pb-212		0.3	8.11	0.3	8.11	5.1×10^{4}	1.4×10^{6}
Pd-103	Palladium (46)	40	1080	40	1080	2.8×10^{3}	7.5×10^{4}
Pd-107		Unlimited	Unlimited	Unlimited	Unlimited	1.9×10^{-5}	5.1×10^{-4}
Pd-109		0.6	16.2	0.5	13.5	7.9×10^{4}	2.1×10^{6}
Pm-143	Promethium (61)	3	81.1	3	81.1	1.3×10^{2}	3.4×10^{3}
Pm-144		0.6	16.2	0.6	16.2	9.2×10^{1}	2.5×10^{3}
Pm-145		30	811	7	189	5.2	1.4×10^{2}
Pm-147		40	1080	0.9	24.3	3.4×10^{1}	9.3×10^{2}
Pm-148m		0.5	13.5	0.5	13.5	7.9×10^{2}	2.1×10^{4}
Pm-149		0.6	16.2	0.5	13.5	1.5×10^{4}	4.0×10^{5}
Pm-151		3	81.1	0.5	13.5	2.7×10^{4}	7.3×10^{5}
Po-208	Polonium (84)	40	1080	2×10^{-2}	0.541	2.2×10^{1}	5.9×10^{2}
Po-209		40	1080	2×10^{-2}	0.541	6.2×10^{-1}	1.7×10^{1}
Po-210		40	1080	2×10^{-2}	0.541	1.7×10^{2}	4.5×10^{3}
Pr-142	Praseodymium (59)	0.2	5.41	0.2	5.41	4.3×10^{4}	1.2×10^{6}
Pr-143		4	108	0.5	13.5	2.5×10^{3}	6.7×10^{4}

TABLE VI
A_1 AND A_2 VALUES FOR RADIONUCLIDES (cont.)

Symbol of RadioNuclide	Element and Atomic No.	A_1 (TBq)	A_1 (Ci)	A_2 (TBq)	A_2 (Ci)	Specific Activity (TBq/g)	Specific Activity (Ci/g)
Pt-188	Platinum (78)	0.6	16.2	0.6	16.2	2.5×10^{3}	6.8×10^{4}
Pt-191		3	81.1	3	81.1	8.7×10^{3}	2.4×10^{5}
Pt-193m		40	1080	9	243	5.8×10^{3}	1.6×10^{5}
Pt-193		40	1080	40	1080	1.4	3.7×10^{1}
Pt-195m		10	270	2	54.1	6.2×10^{3}	1.7×10^{5}
Pt-197m		10	270	0.9	24.3	3.7×10^{5}	1.0×10^{7}
Pt-197		20	541	0.5	13.5	3.2×10^{4}	8.7×10^{5}
Pu-236	Plutonium (94)	7	189	7×10^{-4}	1.89×10^{-2}	2.0×10^{1}	5.3×10^{2}
Pu-237		20	541	20	541	4.5×10^{2}	1.2×10^{4}
Pu-238		2	54.1	2×10^{-4}	5.41×10^{-3}	6.3×10^{-1}	1.7×10^{1}
Pu-239		2	54.1	2×10^{-4}	5.41×10^{-3}	2.3×10^{-3}	6.2×10^{-2}
Pu-240		2	54.1	2×10^{-4}	5.41×10^{-3}	8.4×10^{-3}	2.3×10^{-1}
Pu-241		40	1080	1×10^{-2}	0.270	3.8	1.0×10^{2}
Pu-242		2	54.1	2×10^{-4}	5.41×10^{-3}	1.5×10^{-4}	3.9×10^{-3}
Pu-244		0.3	8.11	2×10^{-4}	5.41×10^{-3}	6.7×10^{-7}	1.8×10^{-5}
Ra-223	Radium (88)	0.6	16.2	3×10^{-2}	0.811	1.9×10^{3}	5.1×10^{4}
Ra-224		0.3	8.11	6×10^{-2}	1.62	5.9×10^{3}	1.6×10^{5}
Ra-225		0.6	16.2	2×10^{-2}	0.541	1.5×10^{3}	3.9×10^{4}
Ra-226		0.3	8.11	2×10^{-2}	0.541	3.7×10^{-2}	1.0
Ra-228		0.6	16.2	4×10^{-2}	1.08	1.0×10^{1}	2.7×10^{2}
Rb-81	Rubidium (37)	2	54.1	0.9	24.3	3.1×10^{5}	8.4×10^{6}
Rb-83		2	54.1	2	54.1	6.8×10^{2}	1.8×10^{4}
Rb-84		1	27.0	0.9	24.3	1.8×10^{3}	4.7×10^{4}
Rb-86		0.3	8.11	0.3	8.11	3.0×10^{3}	8.1×10^{4}
Rb-87		Unlimited	Unlimited	Unlimited	Unlimited	3.2×10^{-9}	8.6×10^{-8}
Rb (natural)		Unlimited	Unlimited	Unlimited	Unlimited	6.7×10^{6}	1.8×10^{8}
Re-183	Rhenium (75)	5	135	5	135	3.8×10^{2}	1.0×10^{4}
Re-184m		3	81.1	3	81.1	1.6×10^{2}	4.3×10^{3}
Re-184		1	27.0	1	27.0	6.9×10^{2}	1.9×10^{4}
Re-186		4	108	0.5	13.5	6.9×10^{3}	1.9×10^{5}
Re-187		Unlimited	Unlimited	Unlimited	Unlimited	1.4×10^{-9}	3.8×10^{-8}
Re-188		0.2	5.41	0.2	5.41	3.6×10^{4}	9.8×10^{5}
Re-189		4	108	0.5	13.5	2.5×10^{4}	6.8×10^{5}
Re (natural)		Unlimited	Unlimited	Unlimited	Unlimited	-- 2.4×10^{-8}	
Rh-99	Rhodium (45)	2	54.1	2	54.1	3.0×10^{3}	8.2×10^{4}
Rh-101		4	108	4	108	4.1×10^{1}	1.1×10^{3}
Rh-102m		2	54.1	0.9	24.3	2.3×10^{2}	6.2×10^{3}
Rh-102		0.5	13.5	0.5	13.5	4.5×10^{1}	1.2×10^{3}
Rh-103m		40	1080	40	1080	1.2×10^{6}	3.3×10^{7}
Rh-105		10	270	0.9	24.3	3.1×10^{4}	8.4×10^{5}

TABLE VI
A_1 AND A_2 VALUES FOR RADIONUCLIDES (cont.)

Symbol of RadioNuclide	Element and Atomic No.	A_1 (TBq)	A_1 (Ci)	A_2 (TBq)	A_2 (Ci)	Specific Activity (TBq/g)	Specific Activity (Ci/g)
Rn-222	Radon (86)	0.2	5.41	$4x10^{-3}$	0.108	$5.7x10^{3}$	$1.5x10^{5}$
Ru-97	Ruthenium (44)	4	108	4	108	$1.7x10^{4}$	$4.6x10^{5}$
Ru-103		2	54.1	0.9	24.3	$1.2x10^{3}$	$3.2x10^{4}$
Ru-105		0.6	16.2	0.5	13.5	$2.5x10^{5}$	$6.7x10^{6}$
Ru-106		0.2	5.41	0.2	5.41	$1.2x10^{2}$	$3.3x10^{3}$
S-35	Sulfur (16)	40	1080	2	54.1	$1.6x10^{3}$	$4.3x10^{4}$
Sb-122	Antimony (51)	0.3	8.11	0.3	8.11	$1.5x10^{4}$	$4.0x10^{5}$
Sb-124		0.6	16.2	0.5	13.5	$6.5x10^{2}$	$1.7x10^{4}$
Sb-125		2	54.1	0.9	24.3	$3.9x10^{1}$	$1.0x10^{3}$
Sb-126		0.4	10.8	0.4	10.8	$3.1x10^{3}$	$8.4x10^{4}$
Sc-44	Scandium (21)	0.5	13.5	0.5	13.5	$6.7x10^{5}$	$1.8x10^{7}$
Sc-46		0.5	13.5	0.5	13.5	$1.3x10^{3}$	$3.4x10^{4}$
Sc-47		9	243	0.9	24.3	$3.1x10^{4}$	$8.3x10^{5}$
Sc-48		0.3	8.11	0.3	8.11	$5.5x10^{4}$	$1.5x10^{6}$
Se-75	Selenium (34)	3	81.1	3	81.1	$5.4x10^{2}$	$1.5x10^{4}$
Se-79		40	1080	2	54.1	$2.6x10^{-3}$	$7.0x10^{-2}$
Si-31	Silicon (14)	0.6	16.2	0.5	13.5	$1.4x10^{6}$	$3.9x10^{7}$
Si-32		40	1080	0.2	5.41	3.9	$1.1x10^{2}$
Sm-145	Samarium (62)	20	541	20	541	$9.8x10^{1}$	$2.6x10^{3}$
Sm-147		Unlimited	Unlimited	Unlimited	Unlimited	$8.5x10^{-1}$	$2.3x10^{-8}$
Sm-151		40	1080	4	108	$9.7x10^{-1}$	$2.6x10^{1}$
Sm-153		4	108	0.5	13.5	$1.6x10^{4}$	$4.4x10^{5}$
Sn-113	Tin (50)	4	108	4	108	$3.7x10^{2}$	$1.0x10^{4}$
Sn-117m		6	162	2	54.1	$3.0x10^{3}$	$8.2x10^{4}$
Sn-119m		40	1080	40	1080	$1.4x10^{2}$	$3.7x10^{3}$
Sn-121m		40	1080	0.9	24.3	2.0	$5.4x10^{1}$
Sn-123		0.6	16.2	0.5	13.5	$3.0x10^{2}$	$8.2x10^{3}$
Sn-125		0.2	5.41	0.2	5.41	$4.0x10^{3}$	$1.1x10^{5}$
Sn-126		0.3	8.11	0.3	8.11	$1.0x10^{-3}$	$2.8x10^{-2}$

TABLE VI
A_1 AND A_2 VALUES FOR RADIONUCLIDES (cont.)

Symbol of RadioNuclide	Element and Atomic No.	A_1 (TBq)	A_1 (Ci)	A_2 (TBq)	A_2 (Ci)	Specific Activity (TBq/g)	Specific Activity (Ci/g)
Sr-82	Strontium (38)	0.2	5.41	0.2	5.41	2.3×10^{3}	6.2×10^{4}
Sr-85m		5	135	5	135	1.2×10^{6}	3.3×10^{7}
Sr-85		2	54.1	2	54.1	8.8×10^{2}	2.4×10^{4}
Sr-87m		3	81.1	3	81.1	4.8×10^{5}	1.3×10^{7}
Sr-89		0.6	16.2	0.5	13.5	1.1×10^{3}	2.9×10^{4}
Sr-90		0.2	5.41	0.1	2.70	5.1	1.4×10^{2}
Sr-91		0.3	8.11	0.3	8.11	1.3×10^{5}	3.6×10^{6}
Sr-92		0.8	21.6	0.5	13.5	4.7×10^{5}	1.3×10^{7}
T	Tritium (1)	40	1080	40	1080	3.6×10^{2}	9.7×10^{3}
Ta-178	Tantalum (73)	1	27.0	1	27.0	4.2×10^{6}	1.1×10^{8}
Ta-179		30	811	30	811	4.1×10^{1}	1.1×10^{3}
Ta-182		0.8	21.6	0.5	13.5	2.3×10^{2}	6.2×10^{3}
Tb-157	Terbium (65)	40	1080	10	270	5.6×10^{-1}	1.5×10^{1}
Tb-158		1	27.0	0.7	18.9	$5\ 6\times10^{-1}$	1.5×10^{1}
Tb-160		0.9	24.3	0.5	13.5	4.2×10^{2}	1.1×10^{4}
Tc-95m	Technetium (43)	2	54.1	2	54.1	8.3×10^{2}	2.2×10^{4}
Tc-96m		0.4	10.8	0.4	10.8	1.4×10^{6}	3.8×10^{7}
Tc-96		0.4	10.8	0.4	10.8	1.2×10^{4}	3.2×10^{5}
Tc-97m		40	1080	40	1080	5.6×10^{2}	1.5×10^{4}
Tc-97		Unlimited	Unlimited	Unlimited	Unlimited	5.2×10^{-5}	1.4×10^{-3}
Tc-98		0.7	18.9	0.7	18.9	3.2×10^{-5}	8.7×10^{-4}
Tc-99m		8	216	8	216	1.9×10^{5}	5.3×10^{6}
Tc-99		40	1080	0.9	24.3	6.3×10^{-4}	1.7×10^{-2}
Te-118	Tellurium (52)	0.2	5.41	0.2	5.41	6.8×10^{3}	1.8×10^{5}
Te-121m		5	135	5	135	2.6×10^{2}	7.0×10^{3}
Te-121		2	54.1	2	54.1	2.4×10^{3}	6.4×10^{4}
Te-123m		7	189	7	189	3.3×10^{2}	8.9×10^{3}
Te-125m		30	811	9	243	6.7×10^{2}	1.8×10^{4}
Te-127m		20	541	0.5	13.5	3.5×10^{2}	9.4×10^{3}
Te-127		20	541	0.5	13.5	9.8×10^{4}	2.6×10^{6}
Te-129m		0.6	16.2	0.5	13.5	1.1×10^{3}	3.0×10^{4}
Te-129		0.6	16.2	0.5	13.5	7.7×10^{5}	2.1×10^{7}
Te-131m		0.7	18.9	0.5	13.5	3.0×10^{4}	8.0×10^{5}
Te-132		0.4	10.8	0.4	10.8	1.1×10^{4}	3.0×10^{5}

TABLE VI
A_1 AND A_2 VALUES FOR RADIONUCLIDES (cont.)

Symbol of RadioNuclide	Element and Atomic No.	A_1 (TBq)	A_1 (Ci)	A_2 (TBq)	A_2 (Ci)	Specific Activity (TBq/g)	(Ci/g)
Th-227	Thorium (90)	9	243	$1x10^{-2}$	0.270	$1.1x10^{3}$	$3.1x10^{4}$
Th-228		0.3	8.11	$4x10^{-4}$	$1.08x10^{-2}$	$3.0x10^{1}$	$8.2x10^{2}$
Th-229		0.3	8.11	$3x10^{-5}$	$8.11x10^{-4}$	$7.9x10^{-3}$	$2.1x10^{-1}$
Th-230		2	54.1	$2x10^{-4}$	$5.41x10^{-3}$	$7.6x10^{-4}$	$2.1x10^{-2}$
Th-231		40	1080	0.9	24.3	$2.0x10^{4}$	$5.3x10^{5}$
Th-232		Unlimited	Unlimited	Unlimited	Unlimited	$4.0x10^{-9}$	$1.1x10^{-7}$
Th-234		0.2	5.41	0.2	5.41	$8.6x10^{2}$	$2.3x10^{4}$
Th (natural)		Unlimited	Unlimited	Unlimited	Unlimited	$8.1x10^{-9}$	$2.2x10^{-7}$
Ti-44	Titanium (22)	0.5	13.5	0.2	5.41	6.4	$1.7x10^{2}$
Tl-200	Thallium (81.1)	0.8	21.6	0.8	21.6	$2.2x10^{4}$	$6.0x10^{5}$
Tl-201		10	270	10	270	$7.9x10^{3}$	$2.1x10^{5}$
Tl-202		2	54.1	2	54.1	$2.0x10^{3}$	$5.3x10^{4}$
Tl-204		4	108	0.5	13.5	$1.7x10^{1}$	$4.6x10^{2}$
Tm-167	Thulium (69)	7	189	7	189	$3.1x10^{3}$	$8.5x10^{4}$
Tm-168		0.8	21.6	0.8	21.6	$3.1x10^{2}$	$8.3x10^{3}$
Tm-170		4	108	0.5	13.5	$2.2x10^{2}$	$6.0x10^{3}$
Tm-171		40	1080	10	270	$4.0x10^{1}$	$1.1x10^{3}$
U-230	Uranium (92)	40	1080	$1x10^{-2}$	0.270	$1.0x10^{3}$	$2.7x10^{4}$
U-232		3	81.1	$3x10^{-4}$	$8.11x10^{-3}$	$8.3x10^{-1}$	$2.2x10^{1}$
U-233		10	270	$1x10^{-3}$	$2.70x10^{-2}$	$3.6x10^{-4}$	$9.7x10^{-3}$
U-234		10	270	$1x10^{-3}$	$2.70x10^{-2}$	$2.3x10^{-4}$	$6.2x10^{-3}$
U-235		Unlimited	Unlimited	Unlimited	Unlimited	$8.0x10^{-8}$	$2.2x10^{-6}$
U-236		10	270	$1x10^{-3}$	$2.70x10^{-2}$	$2.4x10^{-6}$	$6.5x10^{-5}$
U-238		Unlimited	Unlimited	Unlimited	Unlimited	$1.2x10^{-8}$	$3.4x10^{-7}$
U (natural)		Unlimited	Unlimited	Unlimited	Unlimited	$2.6x10^{-8}$	$7.1x10^{-7}$
U (enriched 5 percent or less)		Unlimited	Unlimited	Unlimited	Unlimited	-- (TABLE VIII)	
U (enriched > 5 percent)		10	270	$1x10^{-3}$	$2.70x10^{-2}$	-- (TABLE VIII)	
U (depleted)		Unlimited	Unlimited	Unlimited	Unlimited	-- (TABLE VIII)	
V-48	Vanadium (23)	0.3	8.11	0.3	8.11	$6.3x10^{3}$	$1.7x10^{5}$
V-49		40	1080	40	1080	$3.0x10^{2}$	$8.1x10^{3}$
W-178	Tungsten (74)	1	27.0	1	27.0	$1.3x10^{3}$	$3.4x10^{4}$
W-181		30	811	30	811	$2.2x10^{2}$	$6.0x10^{3}$
W-185		40	1080	0.9	24.3	$3.5x10^{2}$	$9.4x10^{3}$
W-187		2	54.1	0.5	13.5	$2.6x10^{4}$	$7.0x10^{5}$
W-188		0.2	5.41	0.2	5.41	$3.7x10^{2}$	$1.0x10^{4}$

TABLE VI
A_1 AND A_2 VALUES FOR RADIONUCLIDES (cont.)

Symbol of RadioNuclide	Element and Atomic No.	A_1 (TBq)	A_1 (Ci)	A_2 (TBq)	A_2 (Ci)	Specific Activity (TBq/g)	(Ci/g)
Xe-122	Xenon (54)	0.2	5.41	0.2	5.41	$4.8x10^4$	$1.3x10^6$
Xe-123		0.2	5.41	0.2	5.41	$4.4x10^5$	$1.2x10^7$
Xe-127		4	108	4	108	$1.0x10^3$	$2.8x10^4$
Xe-131m		40	1080	40	1080	$3.1x10^3$	$8.4x10^4$
Xe-133		20	541	20	541	$6.9x10^3$	$1.9x10^5$
Xe-135		4	108	4	108	$9.5x10^4$	$2.6x10^6$
Y-87	Yttrium (39)	2	54.1	2	54.1	$1.7x10^4$	$4.5x10^5$
Y-88		0.4	10.8	0.4	10.8	$5.2x10^2$	$1.4x10^4$
Y-90		0.2	5.41	0.2	5.41	$2.0x10^4$	$5.4x10^5$
Y-91m		2	54.1	2	54.1	$1.5x10^6$	$4.2x10^7$
Y-91		0.3	8.11	0.3	8.11	$9.1x10^2$	$2.5x10^4$
Y-92		0.2	5.41	0.2	5.41	$3.6x10^5$	$9.6x10^6$
Y-93		0.2	5.41	0.2	5.41	$1.2x10^5$	$3.3x10^6$
Yb-169	Ytterbium (70)	3	81.1	3	81.1	$8.9x10^2$	$2.4x10^4$
Yb-175		30	811	0.9	24.3	$6.6x10^3$	$1.8x10^5$
Zn-65	Zinc (30)	2	54.1	2	54.1	$3.0x10^2$	$8.2x10^3$
Zn-69m		2	54.1	0.5	13.5	$1.2x10^5$	$3.3x10^6$
Zn-69		4	108	0.5	13.5	$1.8x10^6$	$4.9x10^7$
Zr-88	Zirconium (40)	3	81.1	3	81.1	$6.6x10^2$	$1.8x10^4$
Zr-93		40	1080	0.2	5.41	$9.3x10^{-5}$	$2.5x10^{-3}$
Zr-95		1	27.0	0.9	24.3	$7.9x10^2$	$2.1x10^4$
Zr-97		0.3	8.11	0.3	8.11	$7.1x10^4$	$1.9x10^6$

TABLE VII
GENERAL VALUES FOR A_1 AND A_2

Contents	A_1		A_2	
	TBq	Ci	TBq	Ci
Only beta- or gamma-emitting nuclides are known to be present.	0.2	5	0.02	0.5
Alpha-emitting nuclides are known to be present, or no relevant data are available.	0.10	2.70	$2x10^{-5}$	$5.4x10^{-4}$

TABLE VIII
ACTIVITY-MASS RELATIONSHIPS FOR URANIUM

Uranium Enrichment*/ weight percent U-235 present	Specific Activity	
	Ci/g	TBq/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}

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

APPENDIX P

QUANTITIES OF RADIOACTIVE MATERIALS REQUIRING CONSIDERATION OF THE NEED FOR A CONTINGENCY PLAN FOR RESPONDING TO A RELEASE

Radioactive Material[1/]	Release Fraction	Quantity (GBq)	Quantity (Ci)
Actinium-228	0.001	148,000	4,000
Americium-241	0.001	74	2
Americium-242	0.001	74	2
Americium-243	0.001	74	2
Antimony-124	0.01	148,000	4,000
Antimony-126	0.01	222,000	6,000
Barium-133	0.01	370,000	10,000
Barium-140	0.01	1,110,000	30,000
Bismuth-207	0.01	185,000	5,000
Bismuth-210	0.01	22,200	600
Cadmium-109	0.01	37,000	1,000
Cadmium-113	0.01	2,960	80
Calcium-45	0.01	740,000	20,000
Californium-252	0.001	333	9 (20 mg)
Carbon-14 (Non-CO_2)	0.01	1,850,000	50,000
Cerium-141	0.01	370,000	10,000
Cerium-144	0.01	11,100	300
Cesium-134	0.01	74,000	2,000
Cesium-137	0.01	111,000	3,000
Chlorine-36	0.5	3,700	100
Chromium-51	0.01	11,100,000	300,000
Cobalt-60	0.001	185,000	5,000
Copper-64	0.01	7,400,000	200,000
Curium-242	0.001	2,220	60
Curium-243	0.001	110	3
Curium-244	0.001	148	4
Curium-245	0.001	74	2
Europium-152	0.01	18,500	500
Europium-154	0.01	14,800	400
Europium-155	0.01	111,000	3,000
Gadolinium-153	0.01	185,000	5,000
Germanium	0.01	74,000	2,000
Gold-198	0.01	1,110,000	30,000

QUANTITIES OF RADIOACTIVE MATERIALS REQUIRING CONSIDERATION OF THE NEED FOR A CONTINGENCY PLAN FOR RESPONDING TO A RELEASE (cont.)

Radioactive Material[1/]	Release Fraction	Quantity (GBq)	Quantity (Ci)
Hafnium-172	0.01	14,800	400
Hafnium-181	0.01	259,000	7,000
Holmium-166m	0.01	3,700	100
Hydrogen-3	0.5	740,000	20,000
Indium-114m	0.01	37,000	1,000
Iodine-125	0.5	370	10
Iodine-131	0.5	370	10
Iridium-192	0.001	1,480,000	40,000
Iron-55 0.01	1,480,000	40,000	
Iron-59 0.01	259,000	7,000	
Krypton-85	1.0	222,000,000	6,000,000
Lead-210	0.01	296	8
Manganese-56	0.01	2,220,000	60,000
Mercury-203	0.01	370,000	10,000
Molybdenum-99	0.01	1,110,000	30,000
Neptunium-237	0.001	74	2
Nickel-63	0.01	740,000	20,000
Niobium-94	0.01	11,100	300
Phosphorus-32	0.5	3,700	100
Phosphorus-33	0.5	37,000	1,000
Polonium-210	0.01	370	10
Potassium-42	0.01	333,000	9,000
Promethium-145	0.01	148,000	4,000
Promethium-147	0.01	148,000	4,000
Ruthenium-106	0.01	7,400	200
Samarium-151	0.01	148,000	4,000
Scandium-46	0.01	111,000	3,000
Selenium-75	0.01	370,000	10,000
Silver-110m	0.01	37,000	1,000
Sodium-22	0.01	333,000	9,000
Sodium-24	0.01	370,000	10,000
Strontium-89	0.01	111,000	3,000
Strontium-90	0.01	3,330	90
Sulfur-35	0.5	33,30	900
Technetium-99	0.01	370,000	10,000
Technetium-99m	0.01	14,800,000	400,000
Tellurium-127m	0.01	185,000	5,000
Tellurium-129m	0.01	185,000	5,000
Terbium-160	0.01	148,000	4,000
Thulium-170	0.01	148,000	4,000

QUANTITIES OF RADIOACTIVE MATERIALS REQUIRING CONSIDERATION OF THE NEED FOR A CONTINGENCY PLAN FOR RESPONDING TO A RELEASE (cont.)

Radioactive Material[1/]	Release Fraction	Quantity (GBq)	Quantity (Ci)
Tin-1130.01	370,000	10,000	
Tin-1230.01	111,000	3,000	
Tin-1260.01	37,000	1,000	
Titanium-44	0.01	3,700	100
Vanadium-48	0.01	259,000	7,000
Xenon-133	1.0	33,300,000	900,000
Yttrium-91	0.01	74,000	2,000
Zinc-65 0.01	185,000	5,000	
Zirconium-93	0.01	14,800	400
Zirconium-95	0.01	185,000	5,000
Any other beta-gamma emitter	0.01	370,000	10,000
Mixed fission products	0.01	37,000	1,000
Mixed corrosion products	0.01	370,000	10,000
Contaminated equipment, beta-gamma	0.001	370,000	10,000
Irradiated material, any form other than solid noncombustible	0.01	37,000	1,000
Irradiated material, solid Noncombustible	0.001	370,000	10,000
Mixed radioactive waste, beta-gamma	0.01	37,000	1,000
Packaged mixed waste,[2/] beta-gamma	0.001	370,000	10,000
Any other alpha emitter	0.001	74	2
Contaminated equipment, alpha 0.0001	740	20	
Packaged waste, alpha[2/]	0.0001	740	20

[1/] *For combinations of radioactive materials, the licensee is required to consider whether an emergency plan is needed if the sum of the ratios of the quantity of each radioactive material authorized to the quantity listed for that material above exceeds one.*

[2/] *Waste packaged in Type B containers does not require an emergency plan.*

APPENDIX Q

CONTENTS OF AN EMERGENCY PLAN

Contents of a emergency Plan. An emergency plan for responding to an event in which radioactive material could be released from the site shall include the following information:

a. Facility description. A brief description of the licensee or applicant's facility and surroundings.

b. Types of accidents. An identification of each type of radioactive materials accident for which actions by licensee staff or offsite response organizations will be needed to protect members of the public.

c. Classification of accidents. A method for classifying and declaring an accident as alert or site area emergency.

d. Detection of accidents. Identification of the means for detecting each type of alert or site area emergency in a timely manner.

e. Mitigation of consequences. A brief description of the means and equipment that are available for mitigating the consequences of each type of accident, including those provided to protect workers onsite, and a description of the program for maintaining the equipment.

f. Assessment of releases. A brief description of the methods and equipment available to assess releases of radioactive material.

g. Responsibilities. A brief description of the responsibilities of the **licensee or** applicant's personnel who will respond if an accident occurs, including identification of personnel responsible for promptly notifying offsite response organizations, including the department.

h. Plan maintenance. A brief description of the positions assigned and methods to develop, maintain and update the plan.

i. A list of offsite response organizations, description of their responsibilities and anticipated actions, and copy of formal commitments, if any.

j. Notification and coordination. A brief description of the means to promptly notify the offsite response organizations and request offsite assistance including medical assistance for the treatment of contaminated injured onsite workers. The notification and coordination must include alternate provisions in case key personnel, parts of the facility, or some equipment are unavailable. The licensee shall also commit to notify the department immediately after notification of the appropriate offsite response organizations and not later than one hour after the licensee declares an emergency.

k. Information to be communicated. A brief description of the types of information on facility status, radioactive releases and recommended protective actions, if necessary, to be given to offsite response organizations and the department. **A licensee shall allow the offsite response organizations expected to respond in case of an accident 60 days to comment on the licensees emergency plan before submitting it to the department. A licensee shall provide any comments received within the 60 days to the department with the emergency plan.**

l. Training. A brief description of the frequency, performance objectives and plan for training that the licensee or applicant will provide workers on how to respond to an emergency, including any special instructions and orientation tours that the **licensee or** applicant will offer to fire, police, medical and other emergency personnel. The training shall familiarize personnel with site-specific hazards and emergency procedures. The training shall also prepare site personnel for their responsibilities in the event of accident scenarios postulated as most probable for the specific site, including the use of drills, exercises and team training for such scenarios.

m. Drills and exercises. Provisions for conducting quarterly communications checks with offsite response organizations and biennial onsite exercises to test response to simulated emergencies. The **licensee or** applicant shall invite offsite response organizations to participate in biennial exercises. The exercises shall use accident scenarios postulated as the most probable for the specific site and the scenarios may not be known to most exercise participants. Critiques of exercises must evaluate the appropriateness of the plan, emergency procedures, facilities, equipment, training of personnel and overall effectiveness of the response. Deficiencies found by the critiques must be corrected.

n. Safe condition. A brief description of the means of restoring the facility and surroundings to a safe condition after an accident.

o. Hazardous chemicals. A certification that the applicant has met its responsibilities under the Emergency Planning and Community Right-To-Know Act of 1986, Title III, Pub.L.99-499, if applicable to the applicant's activities at the proposed place of use of the radioactive material.

APPENDIX R

EXAMPLES OF SEVERITY LEVELS

The following examples of severity levels apply to licensees or registrants and are neither exhaustive nor controlling. They reflect only the seriousness of the violation and not the intent of the violator, the history of the violator, the amount necessary to deter future violations, or efforts to correct the violation.

A. Severity Level 1 - Most Significant Violations.

1. Exposure of a worker in excess of 250 mSv (25 rems) of radiation to the whole body, or 1.50 Sv (150 rems) to the skin of the whole body, or 3.75 Sv (375 rems) to the feet, ankles, hands, or forearms.

2. Annual whole body exposure in excess of 25 mSv (2.5 rems) of radiation to a non-radiation worker or a radiation worker who is a minor.

3. Release of radioactive material to an unrestricted area in excess of 10 times the limits specified in this chapter.

4. Radiation levels, contamination levels, or releases that exceed 10 times the limits specified in this chapter or the license.

5. Disposal of licensed material into a sanitary sewerage system in quantities or concentrations which exceed 10 times the limits of s. HFS 157.30 (3).

6. Exposure of a worker in a restricted area to 10 times the limits of s. HFS 157.22 (1).

7. A required system or equipment designed to prevent or mitigate a serious safety event not being operable when actually required to perform its designed function.

8. A material false statement in which the statement made is deliberately false.

9. Action by management to discriminate against an employee for attempting to communicate or for actually communicating with the department to report a real or suspected violation of this chapter or license condition.

10. Deliberate exposure of an individual except by or under the supervision of an individual licensed to engage in the healing arts.

11. Refusing authorized department personnel access to facilities, equipment or records necessary to conduct inspections or investigations.

12. Possession of licensable quantities of radioactive material without a license or loss of control of a source of radiation.

13. Falsification of records required by this chapter in which the records were deliberately falsified by or with the knowledge of the licensee or registrant.

14. Licensee or registrant failure to promptly respond to an emergency that has actual or potential offsite consequences.

15. Operating a mammography facility without proper certification.

~~16. Operating a mammography facility with repeat level 1 violations under 21 CFR Part 900.~~

B. Severity Level 2 - Very Significant Violations.

1. Single exposure of a worker in excess of 50 mSv of radiation to the whole body, 300 mSv to the skin of the whole body, or 750 mSv to the feet, ankles, hands or forearms.

2. Annual whole body exposure in excess of 50 mSv of radiation to a non-radiation worker or radiation worker who is a minor.

3. Release of radioactive material to an unrestricted area in excess of 5 times the limits of s. HFS 157.23 (2).

4. Radiation levels, contamination levels, or releases that exceed 5 times the limits specified in this chapter.

5. Failure to immediately notify the department as required by s. HFS 157.32 (1) and s. HFS 157.32 (2) (a) and (b).

6. Unauthorized disposal of licensed material in quantities or concentrations in excess of 5 times the limits of s. HFS 157.30 (3).

7. Exposure of a worker in a restricted area in excess of 5 times the limits specified in s. HFS 157.22.

8. A required system designed to prevent or mitigate a serious safety event or unnecessary exposure is absent or inoperable.

9. Failure to obtain appropriate department approval before moving to a new use or storage location.

10. A material false statement or a reporting failure involving information which, had it been available to the department and accurate at the time the information should have been submitted, would have resulted in regulatory action or would likely have resulted in the department seeking further information.

11. Radiation output on fluoroscopic devices which exceed 200 mGy per minute in high rate mode.

12. Failure to register sources of radiation as required by this chapter.

13. Operating a mammography facility without qualified personnel, under 21 CFR Part 900.

~~14. Operating a mammography facility without qualified personnel, under 21 CFR Part 900.~~

C. Severity Level 3 - Significant Violations.

1. Single exposure of a worker in excess of 30 mSv (3 rem) of radiation to the whole body, or 75 mSv (7.5 rem) to the skin of the whole body, or 187.5 mSv (18.75 rem) to the feet, ankles, hands or forearms.

2. A radiation level in an unrestricted area such that an individual could receive greater than 1.0 mSv (100 millirem) in a one-hour period or 5.0 mSv (500 millirem) in any 7 consecutive days.

3. Failure to notify the department immediately as required by s. HFS 157.32 (2) (a) or failure to notify the department within 24 hours as required by s. HFS 157.32 (2) (b).

4. Substantial potential for an exposure or release in excess of the limits of this chapter, such as entry into high radiation areas without performing an adequate survey or operation of a radiation device with a nonfunctioning interlock system, if one is required.

5. Release of radioactive material to an unrestricted area in excess of the limits of s. HFS 157.23 (2).

6. Unauthorized disposal of licensed material not covered in severity levels I or II.

7. Exposure of a worker in restricted areas in excess of the limits of s. HFS 157.22 (1).

8. Release for unrestricted use of radioactive material or contaminated equipment which poses a potential for significant exposure to members of the public, or which reflects a programmatic rather than isolated weakness in the radiation safety program.

9. Cumulative worker exposure regulatory limits in this chapter when such exposure reflects a programmatic rather than an isolated weakness in radiation protection.

~~10. Conduct of licensee or registrant activities by an unauthorized or an unqualified individual, including the use of x-ray machine operators without proper training as required in s. HFS 157.74(2).~~

~~11~~10. Any noncompliance with posting, labeling, placarding, shipping papers, packaging, loading, or other transportation requirements that could result in the following:

a. Improper identification of the type, quantity, or form of material.
b. Failure of the carrier or recipient to exercise adequate controls.
c. Substantial potential for personnel exposure or contamination.
d. Improper transfer of material.

~~12~~11. Failure to control access to licensed materials as specified by this chapter.

~~13~~12. Possession or use by a licensee or registrant of a unauthorized radiation machine or radioactive material in conducting registrant or licensee activities.

~~14~~13. Radiation levels, contamination levels or releases that exceed the limits specified in the license.

~~15~~14. Failure to use exposure reduction devices properly, such as collimators, filtration or patient shielding.

~~16~~15. Failure to hospitalize patients who have sealed source implants or therapeutic quantities of radioactive material in accordance with the license or license conditions.

D. Severity Level 4 - Violations.

1. Exposure in excess of the limits of s. HFS 157.22 (1) not constituting severity I, II, or III violations.

2. A radiation level in an unrestricted area such that an individual could receive greater than 0.02 mSv (2 millirems) in any one hour period or 1.0 mSv (100 millirems) in any 7 consecutive days.

3. Failure to notify the department within 30 days as required by s. HFS 157.32 (3).

4. Failure to make a follow-up written report to the department as required by s. HFS 157.32 (1) (b) or s. HFS 157.32 (6).

5. Failure to conduct required leakage or contamination tests or to use properly calibrated equipment.

6. Unless specified in a more severe category, changes in procedures or other conditions of a license or certificate of registration of which the department was not informed, such as change of address, change of person in control or changes in the use of registered or licensed devices.

7. Failure to maintain complete records and forms required by this chapter.

8. Failure to report medical events as required in s. HFS 157.72.

9. Failure to report a dose to a embryo, fetus or nursing child as required by s. HFS 157.72 (2).

10. Fluoroscopic systems where the maximum table top skin entrance exposure rate is 100 mGy (11.5 R) per minute having test values greater than 140 mGy (16.1 R) per minute but less than 200 mGy (23 R) per minute.

11. Radiographic systems in which it is possible to produce x-rays with the timer in the zero or off position.

12. Radiation therapy systems in which the registrant fails to maintain proper surveys, calibrations, spot checks or operating procedures.

E. Severity Level 5 - Minor Violations.

1. Failure to maintain a current copy of this chapter and current copies of active licenses or certificates of registration.

2. Failure to post notices required by this chapter.

3. Failure to report leaking sources as required by s. HFS 157.72 (3).

4. Other violations that have minor safety or environmental significance.

APPENDIX S

COURSE OUTLINE FOR PORTABLE GAUGE AND XRF DEVICE RADIATION SAFETY TRAINING PROGRAM

The following are areas in which the department considers it important that an individual have expertise for the competent operation of portable gauges and XRF devices using sealed sources of radioactive material. The course shall be at least 8 hours in length.

I. PRINCIPLES AND FUNDAMENTALS OF RADIATION SAFETY

A. Types and Characteristics of Radiation
1. Alpha, Beta, Gamma, X-ray and Neutron Radiation
2. Exposure: Natural versus Man-made Radiation
3. Irradiation versus Contamination/Internal vs. External
4. Radioactive Material Used in Portable Gauges and XRF Devices

B. Units of Radiation Dose and Quantities of Radioactivity
1. Curie, Rad, Rem and Roentgen
2. Prefixes
3. SI Units

C. Basic Math and Calculations Related to Radioactivity
1. Radioactive Decay
2. Dose Rates from the sources commonly used
3. Inverse Square Law

D. Biological Effects of Radiation
1. Acute, Chronic and Genetic Effects of Exposure
2. Radiation Protection Standards
3. The ALARA Philosophy

E. Radiation Levels From Radioactive Sealed Sources
1. Survey Meter Use for Portable Gauge Users, not including XRF devices

F. Methods of Controlling Radiation Dose
1. Time
2. Distance
3. Shielding

II. STATE AND FEDERAL REGULATIONS
A. Chapter HFS 157, Wisconsin Administrative Code
B. Title 10, Code of Federal Regulations, US Nuclear Regulatory Commission
C. Title 49, Code of Federal Regulations, Transportation

III. LICENSING AND INSPECTION
A. License Items and Conditions
B. Notices, Instructions and Reports to Workers
C. Inspections by the Department

IV. OPERATING AND EMERGENCY PROCEDURES

A. Operating Procedures
1. Training and Supervision
2. Personnel Monitoring
3. Availability of Procedures
4. Security of the Gauges or Devices When Stored and At The Work Location.
5. ALARA Philosophy
6. Transportation of the Gauges or Devices and Security
7. General Rules of Use
8. Posting Requirements
9. Routine Maintenance
10. Radiation Surveys Using Survey Meters at the Work Site for Portable Gauges

B. Emergency Procedures
1. Preventive Measures
2. Emergency Response
3. Notification Requirements
4. Case Histories

V. TRANSFER/DISPOSAL REQUIREMENTS

A. State and NRC Regulations
B. Transportation Requirements

VI. PRACTICAL TRAINING

A. Transport/Storage Containers
B. Hands-on Training Specific to the Gauge or Device
1. Proper Use
2. Safe Handling
3. Calibration of XRF Device Including Substrate Corrections
4. Demonstration of Measurements of Various Materials
5. Use of Survey Meters by Portable Gauge Users.

VII. Q&A SESSION