



Public Law 90-602  
90th Congress, H. R. 10790  
October 18, 1968

**An Act**

To amend the Public Health Service Act to provide for the protection of the public health from radiation emissions from electronic products.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,*

Radiation  
Control for  
Health and  
Safety Act of  
1968.

SHORT TITLE

SECTION 1. This Act may be cited as the "Radiation Control for Health and Safety Act of 1968".

AMENDMENTS TO PUBLIC HEALTH SERVICE ACT

SEC. 2. Part F of title III of the Public Health Service Act is amended—  
(1) by striking out the heading for such part and inserting in lieu thereof the following:

58 Stat. 703;  
81 Stat. 536.  
42 USC 262-  
263a.

"PART F—LICENSING OF BIOLOGICAL PRODUCTS AND CLINICAL LABORATORIES AND CONTROL OF RADIATION

"SUBPART 1—BIOLOGICAL PRODUCTS";

(2) by inserting immediately above the section heading of section 353 the following:

"SUBPART 2—CLINICAL LABORATORIES": and

(3) by adding at the end of such part F the following new subpart:

"SUBPART 3—ELECTRONIC PRODUCT RADIATION CONTROL

"DECLARATION OF PURPOSE

"SEC. 354. The Congress hereby declares that the public health and safety must be protected from the dangers of electronic product radiation. Thus, it is the purpose of this subpart to provide for the establishment by the Secretary of an electronic product radiation control program which shall include the development and administration of performance standards to control the emission of electronic product radiation from electronic products and the undertaking by public and private organizations of research and investigation into the effects and control of such radiation emissions.

82 STAT. 1173  
82 STAT. 1174

"DEFINITIONS

"SEC. 355. As used in this subpart—

"(1) the term 'electronic product radiation' means—

"(A) any ionizing or non-ionizing electromagnetic or particulate radiation, or

"(B) any sonic, infrasonic, or ultrasonic wave, which is emitted from an electronic product as the result of the operation of an electronic circuit in such product;

"(2) the term 'electronic product' means (A) any manufactured or assembled product which, when in operation, (i) contains or acts as part of an electronic circuit and (ii) emits (or in the absence of effective shielding or other controls would emit) elec-

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TITLE 180 CONTROL OF RADIATION

CHAPTER 7 MEDICAL USE OF RADIOACTIVE MATERIAL

### GENERAL INFORMATION

7-001 SCOPE AND AUTHORITY: 180 NAC 7 establishes requirements and provisions for the use of radionuclides in the healing arts and for issuance of licenses authorizing the medical use of this material. These requirements and provisions provide for the protection of the public health and safety. The requirements and provisions of 180 NAC 7 are in addition to, and not in substitution for, others in Title 180. The requirements and provisions of 180 NAC 1, 3, 4, 10, 13, 15, 17, and 18 apply to applicants and licensees subject to 180 NAC 7 unless specifically exempted. The regulations are authorized by and implement the Nebraska Radiation Control Act, Neb. Stat. Rev. sections 71-3501 to 3519.

7-002 DEFINITIONS: As used in 180 NAC 7, the following definitions apply:

Address of use means the building or buildings that are identified on the license and where radioactive material may be received, used, or stored.

Area of use means a portion of an address of use that has been set aside for the purpose of receiving, using, or storing radioactive material.

Authorized nuclear pharmacist means a pharmacist who is:

1. Board certified as a nuclear pharmacist by the Board of Pharmaceutical Specialties;
2. Identified as an authorized nuclear pharmacist on an Agency, U.S. Nuclear Regulatory Commission, or Agreement State license that authorizes the use of byproduct material in the practice of nuclear pharmacy; or
3. Identified as an authorized nuclear pharmacist on a permit issued by an Agency, U.S. Nuclear Regulatory Commission, or Agreement State specific licensee of broad scope that is authorized to permit the use of byproduct material in the practice of nuclear pharmacy.

Authorized user means a physician who meets the training and experience requirements in 180 NAC 7-055.02, 7-066.03, 7-066.04, 7-066.06, 7-066.08, or 7-066.09 and who is identified as an authorized user on an Agency, Agreement State, or U.S. Nuclear Regulatory Commission license that authorizes the medical use of radioactive material.

Brachytherapy means a method of radiation therapy in which sealed sources are utilized to deliver a radiation dose at a distance of up to a few centimeters, by surface, intracavitary, or interstitial application. "Dedicated check source" means a radioactive source that is used to assure the constant operation of a radiation detection or measurement device over several months or years. This source may also be used for other purposes.

Dedicated check source means a radioactive source that is used to assure the constant operation of a radiation detection or measurement device over several months or years. This source may also be used for other purposes

Diagnostic clinical procedures manual means a collection of written procedures that describes each method (and other instructions and precautions) by which the licensee performs diagnostic clinical procedures; where each diagnostic clinical procedure has been approved by the authorized user and includes the radiopharmaceutical, dosage, and route of administration.

Management means the chief executive officer or that individual's designee.

Medical institution means an organization in which several medical disciplines are practiced.

Medical use means the intentional internal or external administration of radioactive material, or the radiation therefrom, to patients or human research subjects under the supervision of an authorized user.

Misadministration means the administration of:

1. A radiopharmaceutical dosage greater than 1.11 MBq (30 microcuries) of either sodium iodide I-125 or I-131:
  - a. Involving the wrong individual or wrong radiopharmaceutical, or
  - b. When both the administered dosage differs from the prescribed dosage by more than 20 percent of the prescribed dosage and the difference between the administered dosage and prescribed dosage exceeds 1.11 MBq (30 microcuries).
2. A therapeutic radiopharmaceutical dosage, other than sodium iodide I-125 or I-131:
  - a. Involving the wrong individual, wrong radiopharmaceutical, or wrong route of administration; or
  - b. When the administered dosage differs from the prescribed dosage by more than 20 percent of the prescribed dosage.
3. A gamma stereotactic radiosurgery radiation dose:
  - a. Involving the wrong individual or wrong treatment site; or
  - b. When the calculated total administered dose differs from the total prescribed dose by more than 10 percent of the total prescribed dose.

4. A teletherapy radiation dose:
  - a. Involving the wrong individual, wrong mode of treatment, or wrong treatment site;
  - b. When the treatment consists of three or fewer fractions and the calculated total administered dose differs from the total prescribed dose by more than 10 percent of the total prescribed dose;
  - c. When the calculated weekly administered dose is 30 percent greater than the weekly prescribed dose; or (d) when the calculated total administered dose differs from the total prescribed dose by more than 20 percent of the total prescribed dose.
  
5. A brachytherapy radiation dose:
  - a. Involving the wrong individual, wrong radioisotope, or wrong treatment site (excluding, for permanent implants, seeds that were implanted in the correct site but migrated outside the treatment site);
  - b. Involving a sealed source that is leaking;
  - c. When, for a temporary implant, one or more sealed sources are not removed upon completion of the procedure; or
  - d. When the calculated administered dose differs from the prescribed dose by more than 20 percent of the prescribed dose.
  
6. A diagnostic radiopharmaceutical dosage, other than quantities greater than 1.11 MBq (30 microcuries) of either sodium iodide I-125 or I-131, both:
  - a. Involving the wrong individual, wrong radiopharmaceutical, wrong route of administration, or when the administered dosage differs from the prescribed dosage; and
  - b. When the dose to the individual exceeds 50 mSv (5 rem) effective dose equivalent or 500 mSv (50 rem) dose equivalent to any individual organ.

Mobile nuclear medicine service means the transportation and medical use of radioactive material.

Output means the exposure rate, dose rate, or a quantity related in a known manner to these rates from a teletherapy unit for a specified set of exposure conditions.

Physician means someone licensed or otherwise authorized to perform medicine and surgery pursuant to Neb. Rev. Stat. sections 71-1, 102. to 71-1, 107.14 Neb. Rev. Stat. and sections 71-1, 137 through 71-1, 141 of the Act.

Prescribed dosage means the quantity of radiopharmaceutical activity as documented:

1. In a written directive; or
2. Either in the diagnostic clinical procedures manual or in any appropriate record in accordance with the directions of the authorized user for diagnostic procedures.

Prescribed dose means:

1. For gamma stereotactic radiosurgery, the total dose;

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2. For teletherapy, the total dose and dose per fraction;
3. For brachytherapy, either the total source strength and exposure time or the total dose.

Teletherapy means therapeutic irradiation in which the source of radiation is at a distance from the body.

Teletherapy physicist means the individual identified as the teletherapy physicist on an Agency license.

Written directive means an order in writing for a specific patient or human research subject, dated and signed by an authorized user prior to the administration of a radiopharmaceutical or radiation, except as specified in paragraph (6) of this definition, containing the following information:

1. For any administration of a quantities greater than 30 microcuries of either sodium iodide I-125 or I-131: the dosage;
2. For a therapeutic administration of a radiopharmaceutical other than sodium iodide I-125 or I-131: the radiopharmaceutical, dosage, and route of administration;
3. For gamma stereotactic radiosurgery: target coordinates, collimator size, plug pattern, and total dose;
4. For teletherapy: the total dose, dose per fraction, treatment site, and overall treatment period;
5. For high-dose-rate remote afterloading brachytherapy: the radioisotope, treatment site, and total dose; or
6. For all other brachytherapy:
  - a. Prior to implantation: the radioisotope, number of sources, and source strengths; and
  - b. After implantation but prior to completion of the procedure: the radioisotope, treatment site, and total source strength and exposure time (or, equivalently, the total dose).

7-003 PROVISIONS FOR RESEARCH INVOLVING HUMAN SUBJECTS: A licensee may conduct research involving human subjects using radioactive material provided that the research is conducted, funded, supported, or regulated by a Federal Agency which has implemented the Federal Policy for the Protection of Human Subjects. Otherwise, a licensee shall apply for and receive approval of a specific amendment to its Agency license before conducting such research. Both types of licensees shall, at a minimum, obtain informed consent from the human subjects and obtain prior review and approval of the research activities by an "Institutional Review Board" in accordance with the meaning of these terms as defined and described in the Federal Policy for the Protection of Human Subjects.

7-004 FDA, FEDERAL AND STATE REQUIREMENTS: Nothing in this part relieves the licensee from complying with applicable FDA, Federal, and State requirements governing radioactive drugs or devices.

GENERAL REGULATORY REQUIREMENTS

7-005 LICENSE REQUIRED

7-005.01 No person shall manufacture, produce, acquire, receive, possess, own, use, transport, or transfer radioactive material for medical use except in accordance with a specific license issued pursuant to Title 180.

7-005.02 Unless prohibited by license condition, an individual may manufacture, produce, acquire, receive, possess, own, use, transport, or transfer radioactive material in accordance with the regulations in 180 NAC 7 under the supervision of an authorized user as provided in 180 NAC 7-013.

7-005.03 Unless prohibited by license condition, an individual may prepare unsealed radioactive material for medical use in accordance with Title 180 under the supervision of an authorized nuclear pharmacist or authorized user as provided in 180 NAC 7-013.

7-006 APPLICATION FOR LICENSE, AMENDMENT, OR RENEWAL

7-006.01 If the application is for medical use sited in a medical institution, only the institution's management may apply. If the application is for medical use not sited in a medical institution, any person may apply.

7-006.02 An application for a license for medical use of radioactive material as described in 180 NAC 7-034, 7-036, 7-040, 7-044, and 7-046 must be made by filing an original and one copy of Form NRH-5A (Medical/Teletherapy), "Application for Radioactive Material License - Medical or Teletherapy". For guidance in completing the form, refer to the instructions in the most current versions of the appropriate Regulatory Guides. A request for a license amendment or renewal may be submitted as an original and one copy in letter format.

7-006.03 An application for a license for medical use of radioactive material as described in 180 NAC 7-052 must be made by filing an original and one copy of Form NRH-5A (Medical/Teletherapy), "Application for Radioactive Material License - Medical or Teletherapy" and Form NRH-5A Supplement C, "Application for Radioactive Material License - Medical or Teletherapy Requirements Specific to Teletherapy". For guidance in completing the form, refer to the instructions in the most current version of the appropriate Regulatory Guide. A request for a license amendment or renewal may be submitted as an original and one copy in letter format.

7-006.04 For copies of regulatory guides, application forms, or to submit an application or an amendment request, refer to 180 NAC 1-012.

7-006.05 An applicant that satisfies the requirements specified in 180 NAC 3-013.02 may apply for a Type A specific license of broad scope.

7-007 LICENSE AMENDMENTS: A licensee shall apply for and receive a license amendment:

7-007.01 Before using radioactive material for a method or type of medical use not permitted by the license issued under 180 NAC 7-007;

7-007.02 Before permitting anyone, to work as an authorized user or authorized nuclear pharmacist under the license, except an individual who is:

1. An authorized user certified by the organizations specified in 180 NAC 7-066.02, item 1., 7-066.03, item 1., 7-066.04, item 1., 7-066.06, item 1., 7-066.08, item 1., or 7-066.09, item 2.;
2. An authorized nuclear pharmacist certified by the organization specified in 180 NAC 7-001;
3. Identified as an authorized user or an authorized nuclear pharmacist on an Agency, U.S. Nuclear Regulatory Commission or Agreement State license that authorizes the use of radioactive material in medical use or in the practice of nuclear pharmacy, respectively; or
4. Identified as an authorized user or an authorized nuclear pharmacist on a permit issued by an Agency, U.S. Nuclear Regulatory Commission, or Agreement State specific licensee of broad scope that is authorized to permit the use of radioactive material in medical use or in the practice of nuclear pharmacy, respectively.

7-007.03 Before changing a Radiation Safety Officer or Teletherapy Physicist;

7-007.04 Before receiving radioactive material in excess of the amount authorized, or radionuclide or form different than authorized on the license;

7-007.05 Before adding to or changing the areas of use or address or addresses of use identified in the application or on the license; and

7-006.06 Before changing statements, representations, and procedures which are incorporated into the license.

#### 7-008 NOTIFICATIONS

7-008.01 A licensee shall provide to the Agency a copy of the board certification, the Agency, U.S. Nuclear Regulatory Commission, or Agreement State license, or the permit issued by a licensee of broad scope for each individual no later than 30 days after the date that the licensee permits the individual to work as an authorized user or an authorized nuclear pharmacist pursuant to 180 NAC 7-007.02, items 1. through 4.

7-008.02 A licensee shall notify the Agency by letter no later than 30 days after:

1. An authorized user, an authorized nuclear pharmacist, Radiation Safety Officer, or teletherapy physicist permanently discontinues performance of duties under the license or has a name change; or
2. The licensee's mailing address changes.

7-008.03 The licensee shall mail documents required in this 180 NAC 7-008 to the appropriate address identified in 180 NAC 1-002.

ADDITIONAL REQUIREMENTS

7-009 ALARA PROGRAM

7-009.01 Each licensee shall develop and implement a written program to maintain radiation doses and releases of radioactive material in effluents to unrestricted areas as low as reasonably achievable (ALARA) as defined in 180 NAC 1-002.

7-009.02 To satisfy the requirement of 180 NAC 7-009.01:

1. At a medical institution, the management, Radiation Safety Officer, and all authorized users shall participate in the establishment, implementation, and operation of the program as required by Title 180 or the Radiation Safety Committee; or
2. For licensees that are not medical institutions, management and all authorized users shall participate in the program as required by the Radiation Safety Officer.

7-009.03 The program must include notice to workers of the program's existence and workers responsibility to help keep dose equivalents ALARA, a review of the summaries of the types and amounts of radioactive material used, occupational doses, changes in radiation safety measures, and continuing education and training for all personnel who work with or in the vicinity of radioactive material. The purpose of the review is to ensure that licensees make every reasonable effort to maintain individual and collective occupational doses ALARA.

7-009.04 The licensee shall retain a current written description of the ALARA program for the duration of the license. The written description shall include:

1. A commitment by management to keep occupational doses as low as reasonably achievable;
2. A requirement that the Radiation Safety Officer brief management once each year on the radiation safety program;
3. Personnel exposure investigational levels as established in accordance with 180 NAC 7-011.02, item 8. that, when exceeded, will initiate an investigation by the Radiation Safety Officer of the cause of the exposure; and
4. Personnel exposure investigational levels that, when exceeded, will initiate a prompt investigation by the Radiation Safety Officer of the cause of the exposure and a consideration of actions that might be taken to reduce the probability of recurrence.

7-010 RADIATION SAFETY OFFICER

7-010.01 A licensee shall appoint a Radiation Safety Officer responsible for implementing the radiation safety program. The licensee, through the Radiation Safety Officer, shall ensure that radiation safety activities are being performed in accordance with approved procedures and regulatory requirements in the daily operation of the licensee's radioactive material program.

7-010.02 The Radiation Safety Officer shall:

1. Investigate overexposures, accidents, spills, losses, thefts, unauthorized receipts, uses, transfers, disposals, misadministrations and other deviations from approved radiation safety practice and implement corrective actions as necessary;
2. Establish, collect in one binder or file and implement written policy and procedures for:
  - a. Authorizing the purchase of radioactive material;
  - b. Receiving and opening packages of radioactive material;
  - c. Storing radioactive material;
  - d. Keeping an inventory record of radioactive material;
  - e. Using radioactive material safely;
  - f. Taking emergency action if control of radioactive material is lost;
  - g. Performing periodic radiation surveys;
  - h. Performing checks and calibrations of survey instruments and other safety equipment;
  - i. Disposing of radioactive material;
  - j. Training personnel who work in or frequent areas where radioactive material is used or stored; and
  - k. Keeping a copy of all records and reports required by the Agency regulations, a copy of Title 180, a copy of each licensing request and license and amendments, and the written policy and procedures required by the regulations.
3. Brief management once each year on the radioactive material program;
4. Establish a table of investigational levels for occupational dose that, when exceeded, will initiate investigations and considerations of action by the Radiation Safety Officer.
5. For medical use not sited at a medical institution, approve or disapprove radiation safety program changes with the advice and consent of management prior to submittal to the Agency for licensing action; and
6. For medical use sited at a medical institution, assist the Radiation Safety Committee in the performance of its duties.

7-011 RADIATION SAFETY COMMITTEE: Each medical institution licensee shall establish a Radiation Safety Committee to oversee the use of radioactive material:

7-011.01 The Committee shall meet the following administrative requirements:

1. Membership must consist of at least three individuals and shall include an authorized user of each type of use permitted by the license, the Radiation Safety Officer, a representative of the nursing service, and a representative of management who is neither an authorized user nor a Radiation Safety Officer. Other members may be included as the licensee deems appropriate.
2. The committee shall meet at least once each calendar quarter.

3. To establish a quorum and to conduct business, one-half of the Committee's membership shall be present, including the Radiation Safety Officer and the management's representative.
4. The minutes of each Radiation Safety Committee meeting shall include:
  - a. The date of the meeting;
  - b. Members present;
  - c. Members absent;
  - d. Summary of deliberations and discussions;
  - e. Recommended actions and the numerical results of all ballots; and
  - f. Documentation of any reviews required in 180 NAC 7-009.03 and 180 NAC 7-011.02.
5. The Committee shall provide each member with a copy of the meeting minutes, and retain one copy for the duration of the license.

7-011.02 To oversee the use of licensed material, the Committee shall:

1. Be responsible for monitoring the institutional program to maintain occupational doses as low as reasonably achievable;
2. Review:
  - a. Review, on the basis of safety and with regard to the training and experience standards of this 180 NAC 7-011, and approve or disapprove any individual who is to be listed as an authorized user, the Radiation Safety Officer, or Teletherapy Physicist before submitting a license application or request for amendment or renewal;
  - b. Review, pursuant to 180 NAC 7-007.02, items 1. through 4., on the basis of the board certification, the license, or the permit identifying an individual, and approve or disapprove any individual prior to allowing that individual to work as an authorized user or authorized nuclear pharmacist;
3. Review on the basis of safety and approve or disapprove each proposed method of use of radioactive material;
4. Review on the basis of safety, and approve with the advice and consent of the Radiation Safety Officer and the management representative, or disapprove procedures and radiation safety program changes prior to submittal to the Agency for licensing action;
5. Review quarterly with the assistance of the Radiation Safety Officer, occupational radiation exposure records of all personnel working with radioactive material;
6. Review quarterly, with the assistance of the Radiation Safety Officer, all incidents involving radioactive material with respect to cause and subsequent actions taken; and
7. Review annually, with the assistance of the Radiation Safety Officer, the radiation safety program.

7-012 STATEMENT OF AUTHORITIES AND RESPONSIBILITIES

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7-012.01 A licensee shall provide sufficient authority and organizational freedom and management prerogative to the Radiation Safety Officer and at a medical institution the Radiation Safety Committee to:

1. Identify radiation safety problems;
2. Initiate, recommend, or provide corrective actions; and
3. Verify implementation of corrective actions.

7-012.02 A licensee shall establish in writing the authorities, duties, responsibilities, and radiation safety activities of the Radiation Safety Officer and the Radiation Safety Committee.

7-013 SUPERVISION

7-013.01 A licensee who permits the receipt, possession, use, or transfer of radioactive material by an individual under the supervision of an authorized user as allowed by 180 NAC 7-005.02 shall:

1. Instruct the supervised individual in the principles of radiation safety appropriate to that individual's use of radioactive material;
2. Review the supervised individual's use of radioactive material, provide re-instruction as needed and review records kept to reflect this use;
3. Require the authorized user to be immediately available to communicate with the supervised individual; and
4. Require that only those individuals specifically trained, and designated by the authorized user, shall be permitted to administer radionuclides or radiation to patients or human research subjects.

7-013.02 A licensee shall require the supervised individual receiving, possessing, using or transferring radioactive material under 180 NAC 7-005 to:

1. Follow the instructions of the supervising authorized user;
2. Follow the written radiation safety procedures established by the licensee;
3. Follow the procedures established by the Radiation Safety Officer; and
4. Comply with Title 180 and the license conditions with respect to the use of radioactive material.

7-013.03 A licensee that supervises an individual is responsible for the acts and omissions of the supervised individual.

7-014 RESERVED

7-015 MOBILE NUCLEAR MEDICINE SERVICE ADMINISTRATIVE REQUIREMENTS

7-015.01 The Agency will license mobile nuclear medicine services only in accordance with 180 NAC 7-015 and other applicable requirements of Title 180. An authorized user or an on-site-physician who has met the training and experience requirements of 180 NAC 7-066, needs to be present during administration of radioactive material.

7-015.02 Mobile nuclear medicine service licensees shall obtain a letter signed by the management of each client for which services are rendered that authorizes use of radioactive material at the client's address of use. The mobile nuclear medicine service licensee shall retain the letter for three years after the last provision of service.

7-015.03 If a mobile nuclear medicine service licensee provides services that the client is also authorized to provide, the client is responsible for assuring that services are conducted in accordance with the regulations in 180 NAC 7-015 while the mobile nuclear medicine service is under the client's direction.

7-015.04 A mobile nuclear medicine service licensee may not order radioactive material to be delivered directly from the manufacturer or the distributor to the client's address of use.

7-016 RESERVED

7-017 NOTIFICATIONS, RECORDS AND REPORTS OF MISADMINISTRATIONS

7-017.01 For any misadministration of radioactive material or radiation:

1. The licensee shall notify the Agency by telephone no later than the next day after discovery of the misadministration.
2. The licensee shall submit a written report to the Agency within 15 days after discovery of the misadministration. The written report must include the licensee's name; the prescribing physician's name; a brief description of the event; why the event occurred; the effect on the individual who received the misadministration; what improvements are needed to prevent recurrence; actions taken to prevent recurrence; whether the licensee notified the individual or the individual's responsible relative or guardian, and if not, why not, and if there was notification, what information was provided. The report must not contain the individual's name or other information that could lead to identification of the individual. To meet the requirements of this 180 NAC 7-017.01, the notification of the individual receiving the misadministration may be made instead to that individual's responsible relative or guardian, when appropriate.
3. The licensee shall notify the referring physician and also notify the individual receiving the misadministration of the misadministration no later than 24 hours after its discovery, unless the referring physician personally informs the licensee either that he will inform the individual or that, based on medical judgment, telling the individual would be harmful. The licensee is not required to notify the individual without first consulting the referring physician. If the referring physician or the individual receiving the misadministration cannot be reached within 24 hours, the licensee shall notify the individual as soon as possible thereafter. The licensee shall not delay appropriate medical care for the individual, including any necessary remedial care as a result of the misadministration, because of any delay in notification.

4. If the individual was notified, the licensee shall also furnish, within 15 days after discovery of the misadministration, a written report to the individual by sending either a copy of the report that was submitted to the Agency, or a brief description of both the event and the consequences as they may affect the individual, provided a statement is included that the report submitted to the Agency can be obtained from the licensee.

7-017.02 Each licensee shall retain a record of each misadministration for five years. The record shall contain the names of all individuals involved in the event, including the prescribing physician, allied health personnel, the individual subject who received the misadministration, and the individual's referring physician, if applicable, the individual's social security number or other identification number if one has been assigned, a brief description of the misadministration, why it occurred, the effect on the individual, improvements needed to prevent recurrence, and the actions taken, to prevent recurrence.

7-017.03 Aside from the notification requirement, nothing in this 180 NAC 17-017.03 affects any rights or duties of licensees, and physicians in relation to each other, individuals receiving misadministrations, or the individual's responsible relatives or guardians.

7-018 SUPPLIERS: A licensee shall use for medical use only:

7-018.01 Radioactive material manufactured, labeled, packaged, and distributed in accordance with a license issued pursuant to 180 NAC 3 and 180 NAC 3-014.10 through 3-014.12 of Title 180 or the equivalent regulations of the U.S. Nuclear Regulatory Commission or another Agreement State;

7-018.02 Reagent kits that have been manufactured, labeled, packaged, and distributed in accordance with an approval issued by the U.S. Food and Drug Administration, the Agency, the U.S. Nuclear Regulatory Commission or an Agreement State under equivalent regulations for the preparation of radiopharmaceuticals for medical use; or

7-18.03 Teletherapy sources manufactured and distributed in accordance with a license issued pursuant to 180 NAC 3, or the equivalent regulations of the U.S. Nuclear Regulatory Commission or another Agreement State.

#### SPECIFIC REQUIREMENTS

#### 7-019 POSSESSION, USE, CALIBRATION, AND CHECK OF DOSE CALIBRATORS

7-019.01 A medical use licensee authorized to administer radiopharmaceuticals shall possess a dose calibrator and use it to measure the amount of activity administered to each patient and human research subject.

7-019.02 A licensee shall:

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1. Check each dose calibrator for constancy with a dedicated check source at the beginning of each day of use. To satisfy the requirement of 180 NAC 7-019.02, the check shall be done on a frequently used setting with a sealed source of not less than 370 kBq (10 microcuries) of radium-226 or 1.85 MBq (50 microcuries) of any other photon-emitting radionuclide with a half-life greater than 90 days;
2. Test each dose calibrator for accuracy upon installation and at intervals not to exceed 12 months thereafter by assaying at least two sealed sources containing different radionuclides, the activity of which the manufacturer has determined within 5 percent of the stated activity, with minimum activity of 370 kBq (10 microcuries) for radium-226 and 1.85 MBq (50 microcuries) for any other photon-emitting radionuclide, and at least one of which has a principal photon energy between 100 keV and 500 keV;
3. Test each dose calibrator for linearity upon installation and at intervals not to exceed three months thereafter over the range of use between 1.1 MBq (30 microcuries) and the highest dosage that will be administered to a patient or human research subject; and
4. Test each dose calibrator for geometry dependence upon installation over the range of volumes and volume configurations for which it will be used. The licensee shall keep a record of this test for the duration of the use of the dose calibrator.

7-019.03 A licensee shall mathematically correct dosage readings for any geometry or linearity error that exceeds 10 percent if the dosage is greater than 370 kBq (10 microcuries) and shall repair or replace the dose calibrator if the accuracy or constancy error exceeds 10 percent.

7-019.04 A licensee shall also perform checks and tests required by 180 NAC 7-019.02 following adjustment or repair of the dose calibrator.

7-019.05 A licensee shall retain a record of each check and test required by 180 NAC 7-019 for 3 years. The records required by 180 NAC 7-019.02 shall include:

1. For 180 NAC 7-019.02, item 1., the model and serial number of the dose calibrator, the identity and calibrated activity of the radionuclide contained in the check source, the date of the check, the activity measured, the instrument settings, and the initials of the individual who performed the check;
2. For 180 NAC 7-019.02, item 2., the model and serial number of the dose calibrator, the model and serial number of each source used and the identity of the radionuclide contained in the source and its activity, the date of the test, the results of the test, the instrument settings, and the signature of the Radiation Safety Officer;

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3. For 180 NAC 7-019.02, item 3., the model and serial number of the dose calibrator, and the calculated activities, the measured activities, the date of the test, and the signature of the Radiation Safety Officer; and
4. For 180 NAC 7-019.02, item 4., the model and serial number of the dose calibrator, the configuration and calibrated activity of the source measured, the activity of the source, the activity measured and the instrument setting for each volume measured, the date of the test, and the signature of the Radiation Safety Officer.

7-020 CALIBRATION AND CHECK OF SURVEY INSTRUMENTS

7-020.01 A licensee shall ensure that the survey instruments used to show compliance with 180 NAC 7-020 have been calibrated before first use, annually, and following repair.

7-020.02 To satisfy the requirements of 180 NAC 7-020.01, the licensee shall:

1. Calibrate all required scale readings up to 10 mSv (1000 millirems) per hour with a radiation source;
2. Each scale shall be calibrated at 1/3 and 2/3 of the full-scale reading; and
3. Conspicuously note on the instrument the apparent dose rate from a dedicated check source as determined at the time of calibration, and the date of calibration.

7-020.03 To satisfy the requirements of 180 NAC 7-020.02, the licensee shall consider a point as calibrated if the indicated exposure rate differs from the calculated exposure rate by not more than 10 percent, and shall conspicuously attach a correction chart or graph to the instrument if the calibration is greater than  $\pm 10$  percent but less than  $\pm 20$  percent. Instruments greater than  $\pm 20$  percent shall be repaired or replaced.

7-020.04 A licensee shall check each survey instrument for proper operation with the dedicated check source before each day of use. The licensee is not required to keep records of these checks.

7-020.05 The licensee shall retain a record of each calibration required in 180 NAC 7-020.01 for three years. The record shall include:

1. A description of the calibration procedure; and
2. A description of the source used and the certified dose rates from the source, and the rates indicated by the instrument being calibrated, the correction factors deduced from the calibration data, the signature of the individual who performed the calibration, and the date of calibration.

7-020.06 To meet the requirements of 180 NAC 7-020.01 through 7-020.03, the licensee may obtain the services of individuals licensed by the Agency, the U.S. Nuclear Regulatory Commission, or an Agreement State to perform calibrations of survey instruments. Records of calibrations which contain information required by 180 NAC 7-020.05 shall be maintained by the licensee.

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7-021 POSSESSION, USE, CALIBRATION, AND CHECK OF INSTRUMENTS TO MEASURE  
DOSAGE OF ALPHA- OR BETA-EMITTING RADIONUCLIDES

7-021.01 180 NAC 7-007.21 does not apply to unit dosages of alpha- or beta-emitting radionuclides that are obtained from a manufacturer or preparer licensed pursuant to 180 NAC 3-014.10 or equivalent U.S. Nuclear Regulatory Commission or Agreement State requirements.

7-021.02 For other than unit dosages obtained pursuant to 180 NAC 7-201.01, a licensee shall possess and use instrumentation to measure the radioactivity of alpha- or beta-emitting radionuclides. The licensee shall have procedures for use of the instrumentation. The licensee shall measure, by direct measurement or by a combination of measurements and calculations, the amount of radioactivity in dosages of alpha- or beta-emitting radionuclides prior to administration to each individual. In addition, the licensee shall:

1. Perform tests before initial use, periodically, and following repair, on each instrument for accuracy, linearity, and geometry dependence, as appropriate for the use of the instrument; and make adjustments when necessary; and
2. Check each instrument for constancy and proper operation at the beginning of each day of use.

7-022 MEASUREMENT OF UNSEALED RADIOACTIVE MATERIAL FOR MEDICAL USE

7-022.01 Measure the activity of each dosage of a photon-emitting radionuclide prior to medical use;

7-022.02 Measure, by direct measurement or by combination of measurement and calculations, the activity of each dosage of a alpha- or a beta-emitting radionuclide prior to medical use, except for unit dosages obtained from a manufacturer or preparer licensed pursuant to 180 NAC 3-014.10 or equivalent U.S. Nuclear Regulatory Commission or Agreement State Requirements;

7-022.03 Retain a record of the measurements required by 180 NAC 7-022.01 and 7-022.02 for three years. To satisfy this requirement, the record shall contain the:

1. Generic name, trade name, or abbreviation of the radiopharmaceutical, its lot number, and expiration dates and the radionuclide;
2. Patient's or human research subject's name, and identification number if one has been assigned;
3. Prescribed dosage and activity of the dosage at the time of measurement, or notation that the total activity is less than 1.1 MBq (30 microcuries);
4. Date and time of the administration measurement; and
5. Initials of the individual who made the record.

7-023 AUTHORIZATION FOR CALIBRATION AND REFERENCE SOURCES Any person authorized by 180 NAC 7-005 for medical use of radioactive material may receive, possess, and use the following radioactive material for check, calibration and reference use:

7-023.01 Sealed sources manufactured and distributed by persons specifically licensed pursuant to 180 NAC 3-014.12 or equivalent provisions of the U.S. Nuclear Regulatory Commission or Agreement State regulations and that do not exceed 555 MBq (15 millicuries) each;

7-023.02 Any radioactive material authorized by 180 NAC 7-034 or 7-036 with a half-life of 100 days or less in individual amounts not to exceed 555 MBq (15 millicuries);

7-023.03 Any radioactive material authorized by 180 NAC 7-034 or 7-036 with a half-life greater than 100 days in individual amounts not to exceed 7.4 MBq (200 microcuries) each; and

7-023.04 Technetium-99m in individual amounts not to exceed 1.85 GBq (50 millicuries).

#### 7-024 REQUIREMENTS FOR POSSESSION OF SEALED SOURCES AND BRACHYTHERAPY SOURCES

7-024.01 A licensee in possession of any sealed source or brachytherapy source shall follow the radiation safety and handling instructions supplied by the manufacturer or equivalent instructions approved by the Agency and shall maintain the instructions for the duration of source use in a legible form convenient to users.

7-024.02 A licensee in possession of a sealed source shall assure that:

1. The source is tested for leakage before its first use unless the licensee has a certificate from the supplier indicating that the source was tested within six months before transfer to the licensee; and
2. The source is tested for leakage at intervals not to exceed six months or at intervals approved by the Agency, another Agreement State, or the U.S. Nuclear Regulatory Commission.

7-024.03 To satisfy the leak test requirements of 180 NAC 7-024.02, the licensee shall assure that:

1. Leak tests are capable of detecting the presence of 185 Bq (0.005 microcuries) of radioactive material on the test sample, or in the case of radium, the escape of radon at the rate of 37 Bq (0.001 microcuries) per 24 hours;
2. Test samples are taken from the source or from the surfaces of the device in which the source is mounted or stored on which radioactive contamination might be expected to accumulate; and
3. Test samples are taken when the source is in the "off" position.

7-024.04 A licensee shall retain leak test records for five years. The records shall contain the model number, and serial number, if assigned, of each source tested, the identity of each source radionuclide and its estimated activity, the measured activity of each test sample expressed in becquerels (microcuries), a description of the method used to measure each test sample, the date of the test, and the signature of the Radiation Safety Officer

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7-024.05 If the leak test reveals the presence of 185 Bq (0.005 microcuries) or more of removable contamination, the licensee shall:

1. Immediately withdraw the sealed source from use and store it in accordance with the requirements of 180 NAC 4; and
2. File a report with the Agency within five days of receiving the leak test results describing the equipment involved, the test results, and the action taken.

7-024.06 A licensee need not perform a leak test on the following sources:

1. Sources containing only radioactive material with a half-life of less than 30 days;
2. Sources containing only radioactive material as a gas;
3. Sources containing 3.7 MBq (100 microcuries) or less of beta or gamma-emitting material or 370 kBq (10 microcuries) or less of alpha-emitting material;
4. Seeds of iridium-192 encased in nylon ribbon; or
5. Sources stored and not being used. The licensee shall, however, test each such source for leakage before any use or transfer unless it has been tested for leakage within six months before the date of use or transfer.

7-024.07 A licensee in possession of a sealed source or brachytherapy source shall conduct a physical inventory of all such sources at intervals not to exceed three months. The licensee shall retain each inventory record for five years. The inventory records shall contain the model number of each source, and serial number if one has been assigned, the identity of each source radionuclide and its estimated activity, the location of each source, date of the inventory, and the signature of the Radiation Safety Officer.

7-024.08 A licensee in possession of a sealed source or brachytherapy source shall survey with a radiation survey instrument at intervals not to exceed three months all areas where such sources are stored. This does not apply to teletherapy sources in teletherapy units or sealed sources in diagnostic devices.

7-024.09 A licensee shall retain a record of each survey required in 180 NAC 7-024.08 for three years. The record shall include the date of the survey, a sketch of each area that was surveyed, the measured dose rate at several points in each area expressed in microsieverts (millirems) per hour, the model number and serial number of the survey instrument used to make the survey, and the signature of the Radiation Safety Officer.

7-025 SYRINGE SHIELDS

7-025.01 A licensee shall keep syringes that contain radioactive material to be administered in a radiation shield.

7-025.02 A licensee shall require each individual who prepares or administers radiopharmaceuticals to use a syringe radiation shield unless the use of the shield is contraindicated for that patient or human research subject.

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7-026 SYRINGE LABELS: Unless utilized immediately, a licensee shall conspicuously label each syringe, or syringe radiation shield that contains a syringe with a radiopharmaceutical, with the radiopharmaceutical name or its abbreviation, the type of diagnostic study or therapy procedure to be performed, and the patient's or human research subject's name.

7-027 VIAL SHIELDS: A licensee shall require each individual preparing or handling a vial that contains a radiopharmaceutical to keep the vial in a vial radiation shield.

7-028 VIAL SHIELD LABELS: A licensee shall conspicuously label each vial radiation shield that contains a vial of a radiopharmaceutical with the radiopharmaceutical name or its abbreviation.

7-029 SURVEYS FOR CONTAMINATION AND AMBIENT RADIATION DOSE RATE

7-029.01 A licensee shall survey with a radiation detection survey instrument at the end of each day of use all areas where radiopharmaceuticals are routinely prepared for use or administered.

7-029.02 A licensee shall survey with a radiation detection survey instrument at least once each week all areas where radiopharmaceuticals or radioactive wastes are stored.

7-029.03 A licensee shall conduct the surveys required by 180 NAC 7-029.01 and 7-029.02 so as to be able to measure dose rates as low as 1  $\mu$ Sv (0.1 millirem) per hour.

7-029.04 A licensee shall establish dose rate action levels for the surveys required by 180 NAC 7-029.01 and 7-029.02 and shall require that the individual performing the survey immediately notify the Radiation Safety Officer if a dose rate exceeds an action level.

7-029.05 A licensee shall survey for removable contamination once each week all areas where radiopharmaceuticals are routinely prepared for use or administered and where radioactive materials are stored.

7-029.06 A licensee shall conduct the surveys required by 180 NAC 7-029.05 so as to be able to detect contamination on each wipe sample of 33.3 Bq (2000 dpm).

7-029.07 A licensee shall establish removable contamination action levels for the surveys required by 180 NAC 7-029.05 and shall require that the individual performing the survey immediately notify the Radiation Safety Officer if contamination exceeds action levels.

7-029.08 A licensee shall retain a record of each survey required by 180 NAC 7-029.01, 7-029.02 and 7-029.05 for three years. The record must include the date of the survey, a sketch of each area surveyed, action levels established for each area, the measured dose rate at several points in each area expressed in microsieverts (millirems) per hour or the removable contamination in each area expressed in becquerels (dpm) per 100 square centimeters, the serial number and the model number of the instrument used to make the survey or analyze the samples, and the initials of the individual who performed the survey.

7-030 RELEASE OF INDIVIDUALS CONTAINING RADIOPHARMACEUTICALS OR PERMANENT IMPLANTS

7-030.01 The licensee may authorize the release from its control of any individual who has been administered radiopharmaceuticals or permanent implants containing radioactive material if the total effective dose equivalent to any other individual from exposure to the released individual is not likely to exceed 5 mSv (0.5 rem).<sup>1</sup>

7-030.02 The licensee shall provide the released individual with instructions, including written instructions, on actions recommended to maintain doses to other individuals as low as is reasonably achievable if the total effective dose equivalent to any other individual is likely to exceed 1 mSv (0.1 rem). If the dose to a breast-feeding infant or child could exceed 1 mSv (0.1 rem) assuming there were no interruption of breast-feeding, the instructions shall also include:

1. Guidance on the interruption or discontinuation of breast-feeding and
2. Information on the consequences of failure to follow the guidance.

7-030.03 The licensee shall maintain a record of the basis for authorizing the release of an individual, for 3 years after the date of release, if the total effective dose equivalent is calculated by:

1. Using the retained activity rather than the activity administered,
2. Using an occupancy factor less than 0.25 at 1 meter,
3. Using the biological or effective half-life, or
4. Considering the shielding by tissue.

7-030.04 The licensee shall maintain a record, for 3 years after the date of release, that instructions were provided to a breast-feeding woman if the radiation dose to the infant or child from continued breast-feeding could result in a total effective dose equivalent exceeding 5 mSv (0.5 rem).

7-031 MOBILE NUCLEAR MEDICINE SERVICE TECHNICAL REQUIREMENTS: A licensee providing mobile nuclear medicine service shall:

7-031.01 Transport to each address of use only syringes or vials containing prepared radiopharmaceuticals or radiopharmaceuticals that are intended for reconstitution of radiopharmaceutical kits;

7-031.02 Bring into each location of use all radioactive material to be used and, before leaving, remove all unused radioactive material and associated radioactive waste;

7-031.03 Secure or keep under constant surveillance and immediate control all radioactive material when in transit or at an address of use;

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<sup>1</sup>Regulatory Guide 7.1, "Release of Patients Administered Radioactive Materials," describes methods for calculating doses to other individuals and contains tables of activities not likely to cause doses exceeding 5 mSv (0.5 rem).

7-031.04 Check survey instruments and dose calibrators as required in 180 NAC 7-019 and 7-020, and check all other transported equipment for proper function before medical use at each address of use;

7-031.05 Carry a calibrated survey meter in each vehicle that is being used to transport radioactive material, and, before leaving a client address of use, survey all areas of radiopharmaceutical use with a radiation detection survey instrument to ensure that all radiopharmaceuticals and all associated radioactive waste have been removed; and

7-031.06 Retain a record of each survey required by 180 NAC 7-031.05 for three years. The record must include the date of the survey, a plan of each area that was surveyed, the measured dose rate at several points in each area of use expressed in microsieverts (millirems) per hour, the model and serial number of the instrument used to make the survey, and the initials of the individual who performed the survey.

#### 7-032 STORAGE OF VOLATILES AND GASES

7-032.01 A licensee shall store volatile radiopharmaceuticals and radioactive gases in the shippers' radiation shield and container.

7-032.02 A licensee shall store and use a multidose container in a properly functioning fume hood.

#### 7-033 DECAY-IN-STORAGE

7-033.01 A licensee shall hold radioactive material for decay-in-storage before disposal in ordinary trash and is exempt from the waste disposal requirements of 180 NAC 4 if the licensee:

1. Holds radioactive material for decay a minimum of ten half-lives;
2. Monitors radioactive material at the container surface before disposal as ordinary trash and determines that its radioactivity cannot be distinguished from the background radiation level with a radiation detection survey instrument set on its most sensitive scale and with no interposed shielding;
3. Removes or obliterates all radiation labels; and
4. Separates and monitors each generator column individually with all radiation shielding removed to ensure that its contents have decayed to background radiation level before disposal.

7-033.02 For radioactive material disposed in accordance with 180 NAC 7-033.01, the licensee shall retain a record of each disposal for three years. The record must include the date of the disposal, the date on which the radioactive material was placed in storage, the radionuclides disposed, the model and serial number of the survey instrument used, the background radiation level, the radiation level measured at the surface of each waste container, and the name of the individual who performed the disposal.

#### SPECIFIC REQUIREMENTS FOR THE USE OF UNSEALED RADIOACTIVE MATERIALS

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FOR UPTAKE, DILUTION, OR EXCRETION STUDIES

7-034 USE OF UNSEALED RADIOACTIVE MATERIAL FOR UPTAKE, DILUTION, AND EXCRETION STUDIES: A licensee may use for uptake, dilution, or excretion studies any unsealed radioactive material prepared for medical use that is either:

7-034.01 Obtained from a manufacturer or preparer licensed pursuant to 180 NAC 3-014.10 or equivalent U.S. Nuclear Regulatory Commission or Agreement State requirements; or

7-034.02 Prepared by an authorized nuclear pharmacist, a physician who is an authorized user and who meets the requirements specified in 180 NAC 7-066.02, or an individual under the supervision of either as specified in 180 NAC 7-013.

7-035 POSSESSION OF SURVEY INSTRUMENT: A licensee authorized to use radioactive material for uptake, dilution, and excretion studies shall possess a portable radiation detection survey instrument capable of detecting dose rates over the range 1.0  $\mu$ Sv (0.1 millirem) per hour to 1000  $\mu$ Sv (100 millirems) per hour. The instrument shall be operable and calibrated in accordance with 180 NAC 7-020.

SPECIFIC REQUIREMENTS FOR THE USE OF UNSEALED RADIOACTIVE MATERIAL,  
GENERATORS,  
AND REAGENT KITS FOR IMAGING AND LOCALIZATION STUDIES

7-036 USE OF UNSEALED RADIOACTIVE MATERIAL FOR IMAGING AND LOCALIZATION STUDIES: A licensee may use for imaging and localization studies any unsealed radioactive material prepared for medical use that is either:

7-036.01 Obtained from a manufacturer or preparer licensed pursuant to 180 NAC 3-014.10 or equivalent Agreement State requirements; or

7-036.02 Prepared by an authorized nuclear pharmacist, a physician who is an authorized user and who meets the requirements specified in 180 NAC 7-066.03, or an individual under the supervision of either as specified in 180 NAC 7-013.

7-037 PERMISSIBLE MOLYBDENUM-99 CONCENTRATION

7-037.01 A licensee shall not administer to humans a radiopharmaceutical containing more than 0.15 kBq of molybdenum-99 per MBq of technetium-99m (0.15  $\mu$ Ci of molybdenum-99 per mCi of technetium-99m).

7-037.02 A licensee preparing technetium-99m radiopharmaceuticals from molybdenum-99/technetium-99m generators shall measure the molybdenum-99 concentration in each eluate or extract.

7-037.03 A licensee who must measure molybdenum concentration shall retain a record of each measurement for three years. The record shall include, for each elution or extraction of technetium-99m, the measured activity of the technetium expressed in MBq (mCi), the measured activity of molybdenum expressed in kBq ( $\mu$ Ci), the ratio of the measures expressed as kBq ( $\mu$ Ci) of molybdenum per MBq (mCi) of technetium, the time and date of the test, and the initials of the individual who performed the test.

7-037.04 A licensee shall report immediately to the Agency each occurrence of molybdenum-99 concentration exceeding the limits specified in 180 NAC 7-037.01.

#### 7-038 CONTROL OF AEROSOLS AND GASES

7-038.01 A licensee who administers radioactive aerosols or gases shall do so with a system that will keep airborne concentrations within the limits prescribed in 180 NAC 4.

7-038.02 The system shall either be directly vented to the atmosphere through an air exhaust or provide for collection and decay or disposal of the aerosol or gas in a shielded container.

7-038.03 A licensee shall only administer radioactive gases in rooms that are at negative pressure compared to surrounding rooms.

7-038.04 Before receiving, using, or storing a radioactive gas, the licensee shall calculate the amount of time needed after a release to reduce the concentration in the area of use to the occupational limit listed in Appendix 004-B of 180 NAC 4. The calculation shall be based on the highest activity of gas handled in a single container, the air volume of the room, and the measured available air exhaust rate.

7-038.05 A licensee shall post the time calculated in 180 NAC 7-038.04 at the area of use and requires that, in case of a gas spill, individuals evacuate the room until the posted time has elapsed.

7-038.06 A licensee shall check the operation of collection systems monthly and measure the ventilation rates in areas of use at intervals not to exceed six months. Records of these checks and measurements shall be maintained for three years.

7-038.07 A copy of the calculations required in 180 NAC 7-038.04 shall be recorded and retained for the duration of the license.

7-039 POSSESSION OF SURVEY INSTRUMENTS: A licensee authorized to use radioactive material for imaging and localization studies shall possess a portable radiation detection survey instrument capable of detecting dose rates over the range of 1  $\mu$ Sv (0.1 millirem) per hour to 500  $\mu$ Sv (50 millirems) per hour. If generators (Mo 99m/Tc 99m) are utilized, a portable radiation measurement survey instrument capable of measuring dose rates over the range 10  $\mu$ Sv (1 millirem) per hour to 10 mSv (1000 millirems) per hour. The instruments shall be operable and calibrated in accordance with 180 NAC 7-020.

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SPECIFIC REQUIREMENTS FOR THE USE OF UNSEALED RADIOACTIVE MATERIAL FOR  
THERAPY

7-040 USE OF UNSEALED RADIOACTIVE MATERIAL FOR THERAPEUTIC

ADMINISTRATION: A licensee may use for therapeutic administration any unsealed radioactive material prepared for medical use that is either:

1. Iodine-131 as iodide for treatment of hyperthyroidism, cardiac dysfunction; or
2. Iodine-131 as iodide for treatment of thyroid carcinoma; or
3. Phosphorus-32 as soluble phosphate for treatment of polycythemia vera, leukemia, and bone metastases; or
4. Phosphorus-32 as colloidal chromic phosphate for intracavitary treatment of malignant effusions;
5. Gold-198 as colloid for intracavitary treatment of malignant effusions;
6. Strontium-89 as chloride for bone pain;
7. Any radioactive material in a radiopharmaceutical and for a therapeutic use for which the Food and Drug Administration has accepted a "Notice of Claimed Investigational Exemption for a New Drug" (IND), or approved a "New Drug Application" (NDA). The licensee shall comply with the package insert instructions regarding indications and method of administration.

7-041 SAFETY INSTRUCTION

7-041.01 A licensee shall provide oral and written radiation safety instruction for all personnel caring for patients or human research subjects undergoing radiopharmaceutical therapy and hospitalized for compliance with 180 NAC 7-030. Refresher training shall be provided at intervals not to exceed one year.

7-041.02 To satisfy 180 NAC 7-014.01, the instruction shall describe the licensee's procedures for:

1. Patient or human research subject control;
2. Visitor control;
3. Contamination control;
4. Waste control;
5. Notification of the Radiation Safety Officer or authorized user in case of the patient's or human research subject's death or medical emergency; and
6. 180 NAC 10 training requirements.

7-041.03 A licensee shall keep a record of individuals receiving instruction required by 180 NAC 7-041.01, a description of the instruction, the date of instruction, and the name of the

individual who gave the instruction. Such record shall be maintained for inspection by the Agency for three years.

7-042 SAFETY PRECAUTIONS

7-042.01 For each patient or human research subject receiving radiopharmaceutical therapy and hospitalized for compliance with 180 NAC 7-030, a licensee shall:

1. Provide a private room with a private sanitary facility;
2. Post the patient's or the human research subject's door with a "Caution: Radioactive Materials" sign and note on the door or on the patient's or human research subject's chart where and how long visitors may stay in the patient's or the human research subject's room;
3. Authorize visits by individuals under 18 years of age only on a case-by-case basis with the approval of the authorized user after consultation with the Radiation Safety Officer;
4. Promptly after administration of the dosage, measure the dose rates in contiguous restricted and unrestricted areas with a radiation measurement survey instrument to demonstrate compliance with the requirements of 180 NAC 4 and retain for three years a record of each survey that includes the time and date of the survey, a plan of the area or list of points surveyed, the measured dose rate at several points expressed in  $\mu\text{Sv}$  (millirems) per hour, the instrument used to make the survey, and the initials of the individual who made the survey;
5. Monitor material and items removed from the patient's or the human research subject's room to determine that any contamination cannot be distinguished from the natural background radiation level with a radiation detection survey instrument set on its most sensitive scale and with no interposed shielding. Items found to be above background may be cleaned to background levels, decayed to background by storage or disposed of as radioactive waste;
6. Reserved;
7. Survey the patient's or the human research subject's room and private sanitary facility for removable contamination with a radiation detection survey instrument before assigning another patient or human research subject to the room. The room must not be reassigned until removable contamination is less than 3.33 Bq (200 dpm) per 100 square centimeters; and
8. Measure the thyroid burden of each individual who helped prepare or administer a dosage of iodine-131 within three days after administering the dosage, and retain for the period required by 180 NAC 4-050.01 a record of each thyroid burden measurement, date of measurement, the name of the individual whose thyroid burden was measured, and the initials of the individual who made the measurements.

7-042.02 A licensee shall notify the Radiation Safety Officer or the authorized user immediately if the patient or the human research subject dies or has a medical emergency.

7-043 POSSESSION OF SURVEY INSTRUMENTS: A licensee authorized to use radioactive material for radiopharmaceutical therapy shall possess a portable radiation detection survey instrument capable of detecting dose rates over the range 1  $\mu\text{Sv}$  (0.1 millirem) per hour to 500  $\mu\text{Sv}$

(50 millirems) per hour, and a portable radiation measurement survey instrument capable of measuring dose rates over the range 10  $\mu$ Sv (1 millirem) per hour to 10 mSv (1000 millirems) per hour. The instruments shall be operable and calibrated in accordance with 180 NAC 7-020.

#### SPECIFIC REQUIREMENTS FOR THE USE OF SEALED SOURCES FOR DIAGNOSIS

7-044 USE OF SEALED SOURCES FOR DIAGNOSIS: A licensee shall use the following sealed sources in accordance with the manufacturer's radiation safety and handling instructions:

1. Iodine-125, Americium-241, Gadolinium-153 as a sealed source in a device for bone mineral analysis; and
2. Iodine-125 as a sealed source in a portable device for imaging.

7-045 AVAILABILITY OF SURVEY INSTRUMENT: A licensee authorized to use radioactive material as a sealed source for diagnostic purposes shall have available for use a portable radiation detection survey instrument capable of detecting dose rates over the range 1  $\mu$ Sv (0.1 millirem) per hour to 500  $\mu$ Sv (50 millirems) per hour or a portable radiation measurement survey instrument capable of measuring dose rates over the range 10  $\mu$ Sv (1 millirem) per hour to 10 mSv (1000 millirems) per hour. The instrument shall be operable and calibrated in accordance with 180 NAC 7-020.

#### SPECIFIC REQUIREMENTS FOR THE USE OF SOURCES FOR BRACHYTHERAPY

7-046 USE OF SOURCES FOR BRACHYTHERAPY: A licensee shall use the following sources in accordance with the manufacturer's radiation safety and handling instructions:

1. Cesium-137 as a sealed source in needles and applicator cells for topical, interstitial, and intracavitary treatment of cancer;
2. Cobalt-60 as a sealed source in needles and applicator cells for topical, interstitial, and intracavitary treatment of cancer;
3. Gold-198 as a sealed source in seeds for interstitial treatment of cancer;
4. Iodine-125 as a sealed source in seeds for interstitial treatment of cancer;
5. Iridium-192 as seeds encased in nylon ribbon for interstitial treatment of cancer;
6. Radium-226 as a sealed source in needles or applicator cells for topical, interstitial, and intracavitary treatment of cancer;
7. Radon-222 as seeds for interstitial treatment of cancer;
8. Strontium-90 as a sealed source in an applicator for treatment of superficial eye conditions; and

9. Palladium-103 as a sealed source in seeds for the interstitial treatment of cancer.

#### 7-047 SAFETY INSTRUCTION

7-047.01 The licensee shall provide oral and written radiation safety instruction to all personnel caring for a patient or the human research subject receiving implant therapy. Refresher training shall be provided at intervals not to exceed one year.

7-047.02 To satisfy 180 NAC 7-047.01, the instruction shall describe:

1. Size and appearance of the brachytherapy sources;
2. Safe handling and shielding instructions in case of a dislodged source;
3. Procedures for patient or human research subject control;
4. Procedures for visitor control;
5. Procedures for notification of the Radiation Safety Officer or authorized user if the patient or the human research subject dies or has a medical emergency; and
6. 180 NAC 10 training requirements.

7-047.03 A licensee shall maintain for three years a record of individuals receiving instruction required by 180 NAC 7-047.01 and 7-047.02, a description of the instruction, the date of instruction, and the name of the individual who gave the instruction.

#### 7-048 SAFETY PRECAUTIONS

7-048.01 For each patient or human research subject receiving implant therapy and not released from licensee control pursuant to 180 NAC 7-030, a licensee shall:

1. Not quarter the patient or the human research subject in the same room as an individual who is not receiving radiation therapy;
2. Post the patient's or human research subject's door with a "Caution: Radioactive Materials" sign and note on the door or the patient's or human research subject's chart where and how long visitors may stay in the patient's or human research subject's room. In addition, the posted sign shall indicate that pregnant women, or women who suspect that they are pregnant, shall contact the attendant staff for additional safety instructions or precautions. The bed, cubicle, or room of the hospital brachytherapy patient or human research subject shall be marked with a sign indicating the presence of brachytherapy sources. This sign shall incorporate the radiation symbol and specify the radionuclide, the activity, date, and the individual(s) to contact for radiation safety instructions.
3. Authorize visits by individuals under 18 years of age only on a case-by-case basis with approval of the authorized user after consultation with the Radiation Safety Officer;
4. Promptly after implanting the sources, survey the dose rates in contiguous restricted and unrestricted areas with a radiation measurement survey instrument to demonstrate compliance with 180 NAC 4 and retain for three years a record of each survey that includes the time and date of the survey, a sketch of the area or list of points surveyed, the measured dose rate at several points expressed in

$\mu$ Sv (millirems) per hour, the instrument used to make the survey, and the initials of the individual who made the survey.

7-048.02 A licensee shall notify the Radiation Safety Officer or authorized user immediately if the patient or the human research subject dies or has a medical emergency.

7-048.03 The following information shall be included in the patient's or human research subject's chart:

1. The radionuclide administered, number of sources, activity in GBq or mCi and time and date of administration;
2. The exposure rate at 1 meter, the time the determination was made, and name of the individual who made the determination;
3. The precautionary instructions necessary to assure that the exposure of individuals does not exceed that permitted under 180 NAC 4-006, and;
4. The radiation symbol.

#### 7-049 BRACHYTHERAPY SOURCES INVENTORY

7-049.01 Promptly after removing them from a patient or a human research subject, a licensee shall return brachytherapy sources to the storage area, and count the number returned to ensure that all sources taken from the storage area have been returned.

7-049.02 A licensee shall make a record of brachytherapy source utilization which includes:

1. The names of the individuals permitted to handle the sources;
2. The number and activity of sources removed from storage, the room number of use and the patient's or the human research subject's name, the time and date they were removed from storage, the number and activity of sources in storage after the removal, and the initials of the individual who removed the sources from storage; and
3. The number and activity of sources returned to storage, the room number of use and patient's or the human research subject's name, the time and date they were returned to storage, the number and activity of sources in storage after the return, and the initials of the individual who returned the sources to storage.

7-049.03 Immediately after implanting sources in a patient or a human research subject, the licensee shall make a radiation survey of the patient or the human research subject and the area of use to confirm that no sources have been misplaced. The licensee shall make a record of each survey.

7-049.04 A licensee shall maintain the records required in 180 NAC 7-049.02 and 7-049.03C for three years.

#### 7-050 RELEASE OF PATIENTS OR HUMAN RESEARCH SUBJECTS TREATED WITH TEMPORARY IMPLANTS

7-050.01 Immediately after removing the last temporary implant source from a patient or a human research subject, the licensee shall perform a radiation survey of the patient or the human research subject with a radiation detection survey instrument to confirm that all sources have been removed. The licensee shall not release from confinement for medical care a patient or a human research subject treated by temporary implant until all sources have been removed.

7-050.02 A licensee shall maintain for three years a record of patient or human research subject surveys which demonstrate compliance with 180 NAC 7-050.01. Each record shall include the date of the survey, the name of the patient or the human research subject, the dose rate from the patient or the human research subject expressed as  $\mu\text{Sv}$  (millirems) per hour and measured within one meter from the patient or the human research subject, the survey instrument used, and the initials of the individual who made the survey.

7-051 POSSESSION OF SURVEY INSTRUMENTS: A licensee authorized to use radioactive material for implant therapy shall possess a portable radiation detection survey instrument capable of detecting dose rates over the range 1  $\mu\text{Sv}$  (0.1 millirem) per hour to 500  $\mu\text{Sv}$  (50 millirems) per hour, and a portable radiation measurement survey instrument capable of measuring dose rates over the range 10  $\mu\text{Sv}$  (1 millirem) per hour to 10 mSv (1000 millirems) per hour. The instruments shall be operable and calibrated in accordance with 007.20.

#### SPECIFIC REQUIREMENTS FOR THE USE OF A SEALED SOURCE IN TELETHERAPY

7-052 USE OF A SEALED SOURCE IN A TELETHERAPY UNIT: A licensee shall use cobalt-60 or cesium-137 as a sealed source in a teletherapy unit for medical use in accordance with the manufacturer's radiation safety and operating instructions.

7-053 MAINTENANCE AND REPAIR RESTRICTIONS: Only a person specifically licensed by the Agency, the U.S. Nuclear Regulatory Commission, or an Agreement State to perform teletherapy unit maintenance and repair shall install, relocate, or remove a teletherapy sealed source or a teletherapy unit that contains a sealed source or maintain, adjust, or repair the source drawer, the shutter or other mechanism of a teletherapy unit that could expose the source, reduce the shielding around the source, or result in increased radiation levels.

7-054 AMENDMENTS: In addition to the requirements specified in 180 NAC 7-007, a licensee shall apply for and receive a license amendment before:

1. Making any change in the treatment room shielding;
2. Making any change in the location of the teletherapy unit within the treatment room;
3. Using the teletherapy unit in a manner that could result in increased radiation levels in areas outside the teletherapy treatment room;
4. Relocating the teletherapy unit; or

5. Allowing an individual not listed on the licensee's license to perform the duties of the teletherapy physicist.

#### 7-055 SAFETY INSTRUCTION

7-055.01 A licensee shall conspicuously post instructions at the teletherapy unit console. To satisfy this requirement, these instructions shall inform the operator of:

1. The procedure to be followed to ensure that only the patient or the human research subject is in the treatment room before turning the primary beam of radiation on to begin a treatment or after a door interlock interruption;
2. The procedure to be followed if the operator is unable to turn the primary beam of radiation off with controls outside the treatment room or any other abnormal operation occurs; and
3. The names and telephone numbers of the authorized users and Radiation Safety Officer to be immediately contacted if the teletherapy unit or console operates abnormally.

7-055.02 A licensee shall provide instruction in the topics identified in 180 NAC 7-055.01 to all individuals who operate a teletherapy unit and shall provide appropriate refresher training to individuals at intervals not to exceed one year.

7-055.03 A licensee shall maintain for three years a record of individuals receiving instruction required by 180 NAC 7-055.02, a description of the instruction, the date of instruction, and the name of the individual who gave the instruction.

#### 7-056 SAFETY PRECAUTIONS

7-056.01 A licensee shall control access to the teletherapy room by a door at each entrance.

7-056.02 A licensee shall equip each entrance to the teletherapy room with an electrical interlock system that shall:

1. Prevent the operator from turning the primary beam of radiation on unless each treatment room entrance door is closed;
2. Turn the primary beam of radiation off immediately when an entrance door is opened; and
3. Prevent the primary beam of radiation from being turned on following an interlock interruption until all treatment room entrance doors are closed and the beam on-off control is reset at the console.

7-056.03 A licensee shall equip each entrance to the teletherapy room with a conspicuously visible beam condition indicator light.

7-056.04 A licensee shall have in each teletherapy room a permanent radiation monitor capable of continuously monitoring beam status.

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1. Each radiation monitor must provide visible notice of a teletherapy unit malfunction that results in an exposed or partially exposed source. The visible indicator of high radiation levels shall be observable by an individual entering the teletherapy room.
2. Each radiation monitor shall be equipped with a backup power supply separate from the power supply to the teletherapy unit. This backup power supply may be a battery system.
3. A radiation monitor shall be checked with a dedicated check source for proper operation each day before the teletherapy unit is used for treatment of patients or human research subjects.
4. A licensee shall maintain a record of the check required by 180 NAC 7-056.04, item 3. for three years. The record shall include the date of the check, notation that the monitor indicates when its detector is and is not exposed, and the initials of the individual who performed the check.
5. If a radiation monitor is inoperable, the licensee shall require any individual entering the teletherapy room to use a survey instrument or audible alarm personal dosimeter to monitor for any malfunction of the source exposure mechanism that may result in an exposed or partially exposed source. The instrument or dosimeter shall be checked with a dedicated check source for proper operation at the beginning of each day of use. The licensee shall keep a record as described in 180 NAC 7-056.04, item 4.
6. A licensee shall promptly repair or replace the radiation monitor if it is inoperable.

7-056.05 A licensee shall construct or equip each teletherapy room to permit continuous observation of the patient or the human research subject from the teletherapy unit console during irradiation.

7-057 POSSESSION OF SURVEY INSTRUMENT: A licensee authorized to use radioactive material in a teletherapy unit shall possess either a portable radiation detection survey instrument capable of detecting dose rates over the range 1  $\mu$ Sv (0.1 millirem) per hour to 500  $\mu$ Sv (50 millirems) per hour or a portable radiation measurement survey instrument capable of measuring dose rates over the range 10  $\mu$ Sv (1 millirem) per hour to 10 mSv (1000 millirems) per hour. The instruments shall be operable and calibrated in accordance with 180 NAC 7-020.

7-058 DOSIMETRY EQUIPMENT

7-058.01 A licensee shall have a calibrated dosimetry system available for use. To satisfy this requirement, one of the following two conditions shall be met:

1. The system shall have been calibrated by the National Institute of Standards and Technology or by a calibration laboratory accredited by the American Association of Physicists in Medicine (AAPM). The calibration shall have been performed within the previous two years and after any servicing that may have affected system calibration; or
2. The system shall have been calibrated within the previous four years; 18 to 30 months after that calibration, the system shall have been intercompared at an intercomparison meeting with another dosimetry system that was calibrated within

the past 24 months by the National Institute of Standards and Technology or by a calibration laboratory accredited by the AAPM. The intercomparison meeting shall be sanctioned by a calibration laboratory or radiologic physics center accredited by the AAPM. The results of the intercomparison meeting must have indicated that the calibration factor of the licensee's system had not changed by more than 2 percent. The licensee shall not use the intercomparison result to change the calibration factor. When intercomparing dosimetry systems to be used for calibrating cobalt-60 teletherapy units, the licensee shall use a teletherapy unit with a cobalt-60 source. When intercomparing dosimetry systems to be used for calibrating cesium-137 teletherapy units, the licensee shall use a teletherapy unit with a cesium-137 source.

7-058.02 The licensee shall have available for use a dosimetry system for spot-check measurements. To satisfy this requirement, the system may be compared with a system that has been calibrated in accordance with 180 NAC 7-058.01. This comparison shall have been performed within the previous year and after each servicing that may have affected system calibration. The spot-check system shall be the same system used to meet the requirement in 180 NAC 7-058.01.

7-058.03 The licensee shall maintain a record of each calibration, intercomparison, and comparison for the duration of the license. For each calibration, intercomparison, or comparison, the record shall include the date, the model numbers and serial numbers of the instruments that were calibrated, intercompared, or compared as required by 180 NAC 7-058.01 and 7-058.02, the correction factors that were determined, the names of the individuals who performed the calibration, intercomparison, or comparison, and evidence that the intercomparison meeting was sanctioned by a calibration laboratory or radiologic physics center accredited by the AAPM.

#### 7-059 FULL CALIBRATION MEASUREMENTS

7-059.01 A licensee authorized to use a teletherapy unit for medical use shall perform full calibration measurements on each teletherapy unit:

1. Before the first medical use of the unit; and
2. Before medical use under the following conditions:
  - a. Whenever spot-check measurements indicate that the output differs by more than 5 percent from the output obtained at the last full calibration corrected mathematically for radioactive decay;
  - b. Following replacement of the source or following reinstallation of the teletherapy unit in a new location; and
  - c. Following any repair of the teletherapy unit that includes removal of the source or major repair of the components associated with the source exposure assembly; and
3. At intervals not exceeding one year.

7-059.02 To satisfy the requirement of 180 NAC 7-059.01, full calibration measurements shall include determination of:

1. The output within 3 percent for the range of field sizes and for the distance or range of distances used for medical use;
2. The coincidence of the radiation field and the field indicated by the light beam localizing device;
3. The uniformity of the radiation field and its dependence on the orientation of the useful beam;
4. Timer accuracy, constancy, and linearity over the range of use;
5. "On-off" error; and
6. The accuracy of all distance measuring and localization devices in medical use.

7-059.03 A licensee shall use the dosimetry system described in 180 NAC 7-058.01 to measure the output for one set of exposure conditions. The remaining radiation measurements required by 7-059.02, item 1. may then be made using a dosimetry system that indicates relative dose rates.

7-059.04 A licensee shall make full calibration measurements required by 180 NAC 7-059.01 in accordance with either the procedures recommended by the Scientific Committee on Radiation Dosimetry of the American Association of Physicists in Medicine that are described in Physics in Medicine and Biology Vol. 16, No. 3, 1971, pp. 379-396, or by Task Group 21 of the Radiation Therapy Committee of the American Association of Physicists in Medicine that are described in Medical Physics Vol. 10, No. 6, 1983, pp. 741-771, and Vol. 11, No. 2, 1984, p.213. Both of these documents are incorporated herein by reference and available for viewing at the Department of Health and Human Services Regulation and Licensure, 301 Centennial Mall South, 3rd floor, Lincoln, Nebraska 68509-5007.

7-059.05 A licensee shall correct mathematically the outputs determined in 180 NAC 7-059.02, item 1. for physical decay for intervals not exceeding one month for cobalt-60 and intervals not exceeding six months for cesium-137.

7-59.06 Full calibration measurements required by 180 NAC 7-059.01 and physical decay corrections required by 180 NAC 7-059.05 shall be performed by a teletherapy physicist.

7-059.07 A licensee shall maintain a record of each calibration for the duration of the license. The record shall include the date of the calibration, the manufacturer's name, model number, and serial number for both the teletherapy unit and the source, the model numbers and serial numbers of the instruments used to calibrate the teletherapy unit, tables that describe the output of the unit over the range of field sizes and for the range of distances used in radiation therapy, a determination of the coincidence of the radiation field and the field indicated by the light beam localizing device, an assessment of timer, linearity and constancy, the calculated "on-off" error, the estimated accuracy of each distance measuring or localization device, and the signature of the teletherapy physicist.

#### 7-060 PERIODIC SPOT-CHECKS

7-060.01 A licensee authorized to use teletherapy units for medical use shall perform output spot-checks on each teletherapy unit at intervals not to exceed one month.

7-060.02 To satisfy the requirement of 180 NAC 7-060.01, spot-checks shall include determination of:

1. Timer constancy and timer linearity over the range of use;
2. On-off error;
3. The coincidence of the radiation field and the field indicated by the light beam localizing device;
4. The accuracy of all distance measuring and localization devices used for medical use;
5. The output for one typical set of operating conditions; and
6. The difference between the measurement made in 180 NAC 7-060.02, item 5. and the anticipated output, expressed as a percentage of the anticipated output (i.e., the value obtained at last full calibration corrected mathematically for physical decay).

7-060.03 A licensee shall use the dosimetry system described in 180 NAC 7-058 to make the spot-check required in 180 NAC 7-060.02, item 5.

7-060.04 A licensee shall perform spot checks required by 180 NAC 7-060.01 through 7-060.03 in accordance with procedures established by the radiological physicist. The teletherapy physicist does not need to actually perform the output spot-check measurements.

7-060.05 A licensee shall have the teletherapy physicist review the results of each output spot-check within 15 days. The teletherapy physicist shall promptly notify the licensee in writing of the results of each output spot check. The licensee shall keep a copy of each written notification for three years.

7-060.06 A licensee authorized to use a teletherapy unit for medical use shall perform safety spot-checks of each teletherapy facility at intervals not to exceed one month.

7-060.07 To satisfy the requirement of 180 NAC 7-060.06, safety spot-checks shall assure proper operation of:

1. Electrical interlocks at each teletherapy room entrance;
2. Electrical or mechanical stops installed for the purpose of limiting use of the primary beam of radiation (restriction of source housing angulation or elevation, carriage or stand travel, and operation of the beam on-off mechanism);
3. Beam condition indicator lights on the teletherapy unit, on the control console, and in the facility;
4. Viewing systems;
5. Treatment room doors from inside and outside the treatment room; and
6. Electrically assisted treatment room doors with the teletherapy unit electrical power turned "off".

7-060.08 A licensee shall arrange for prompt repair of any system identified in 180 NAC 7-060.06 and 7-060.07 that is not operating properly, and shall not use the teletherapy unit following door interlock malfunction until the interlock system has been repaired.

7-060.09 A licensee shall maintain a record of each spot-check required by 180 NAC 7-060.01, 7-060.02, 7-060.03, 7-060.06 and 7-060.07 for three years. The record shall include the date of the spot-check, the manufacturer's name, model number, and serial number for both the teletherapy unit and source, the manufacturer's name, model number and serial number of the instrument used to measure the output of the teletherapy unit, an assessment of timer linearity and constancy, the calculated on-off error, a determination of the coincidence of the radiation field and the field indicated by the light beam localizing device, the calculated on-off error, the determined accuracy of each distance measuring or localization device, the difference between the anticipated output and the measured output, notations indicating the operability of each entrance door electrical interlock, each electrical or mechanical stop, each beam condition indicator light, the viewing system and doors, and the signature of the individual who performed the periodic spot-check.

#### 7-061 RADIATION SURVEYS FOR TELETHERAPY FACILITIES

7-061.01 Before medical use, after each installation of a teletherapy source, and after making any change for which an amendment is required by 180 NAC 7-054, item 1 through item 4, the licensee shall perform radiation surveys with an operable radiation measurement survey instrument calibrated in accordance with 180 NAC 7-020 to verify that:

1. The maximum and average radiation levels at one meter from the teletherapy source with the source in the off position and the collimators set for a normal treatment field do not exceed 100  $\mu$ Sv (10 millirems) per hour and 20  $\mu$ Sv (2 millirems) per hour, respectively; and
2. With the teletherapy source in the on position with the largest clinically available treatment field and with a scattering phantom in the primary beam of radiation, that:
  - a. Radiation levels in restricted areas are not likely to cause personnel exposures in excess of the limits specified in 180 NAC 4-006 and
  - b. Radiation levels in unrestricted areas do not exceed the limits specified in 180 NAC 4-014.

7-061.02 If the results of the surveys required in 180 NAC 7-061.01 indicate any radiation levels in excess of the respective limit specified in that part, the licensee shall lock the control in the off position and not use the unit:

1. Except as may be necessary to repair, replace, or test the teletherapy unit, the teletherapy unit shielding, or the treatment room shielding; or
2. Until the licensee has received a specific exemption pursuant to 180 NAC 4-013 from the Agency.
3. A licensee shall maintain a record of the radiation measurements made following installation of a source for the duration of the license. The record shall include the

date of the measurements, the reason the survey is required, the manufacturer's name, model number and serial number of the teletherapy unit, the source, and the instrument used to measure radiation levels; each dose rate measured around the teletherapy source while in the off position and the average of all measurements, a plan of the areas surrounding the treatment room that were surveyed, the measured dose rate at several points in each area expressed in  $\mu\text{Sv}$  (millirems) per hour, the calculated maximum level of radiation over a period of one week for each restricted and unrestricted area, and the signature of the Radiation Safety Officer.

#### 7-062 SAFETY SPOT CHECKS FOR TELETHERAPY FACILITIES

7-062.01 A licensee shall promptly check all systems listed in 180 NAC 7-060.06 and 7-060.07 for proper function after each installation of a teletherapy source and after making any change for which an amendment is required by 180 NAC 7-054, item 1 through item 4.

7-062.02 If the results of the safety spot checks required in 180 NAC 7-062.01 indicate the malfunction of any system specified in 180 NAC 7-060.06 and 7-060.07, the licensee shall lock the control console in the off position and not use the unit except as may be necessary to repair, replace, or check the malfunctioning system.

7-062.03 A licensee shall maintain a record of the safety spot checks following installation of a source for three years. The record shall include notations indicating the operability of each entrance door interlock, each electrical or mechanical stop, each beam condition indicator light, the viewing system and doors, and the signature of the Radiation Safety Officer.

7-063 MODIFICATION OF TELETHERAPY UNIT OR ROOM BEFORE BEGINNING A TREATMENT PROGRAM: If the survey required by 180 NAC 7-061 indicates that an individual in an unrestricted area may be exposed to levels of radiation greater than those permitted by 180 NAC 4-014, before beginning the treatment program the licensee shall:

7-063.01 Either equip the unit with stops or add additional radiation shielding to ensure compliance with 180 NAC 4-014.03;

7-063.02 Perform the survey required by 180 NAC 7-061 again; and

7-063.03 Include in the report required by 180 NAC 7-064 the results of the initial survey, a description of the modification made to comply with 180 NAC 7-063.01, and the results of the second survey; or

7-063.04 Request and receive a license amendment under 180 NAC 4-014.03 that authorized radiation levels in unrestricted areas greater than those permitted by 180 NAC 4-014.01, item 2.

7-064 REPORTS OF TELETHERAPY SURVEYS, CHECKS, TESTS, AND MEASUREMENTS: A licensee shall furnish a copy of the records required in 180 NAC 7-061 through 7-063 and the output from the teletherapy source expressed in roentgens, coulombs/kilogram, rads, or grays per hour at

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one meter from the source as determined during the full calibration required in 180 NAC 7-059 to the Agency within 30 days following completion of the action that initiated the record requirement.

7-065 FIVE-YEAR INSPECTION

7-065.01 A licensee shall have each teletherapy unit fully inspected and serviced during teletherapy source replacement or at intervals not to exceed five years, whichever comes first, to assure proper functioning of the source exposure mechanism.

7-065.02 This inspection and servicing shall only be performed by persons specifically licensed to do so by the Agency, the U.S. Nuclear Regulatory Commission, or an Agreement State.

7-065.03 A licensee shall maintain a record of the inspection and servicing for the duration of the license. The record shall contain the inspector's name the inspector's license number, the date of inspection, the manufacturer's name and model number and serial number for both the teletherapy unit and source, a list of components inspected, a list of components serviced and the type of service, a list of components replaced, and the signature of the inspector.

SPECIFIC REQUIREMENTS FOR TRAINING

7-066 TRAINING AND EXPERIENCE: The training and experience requirements for individuals using radioactive materials in 180 NAC 7-066 are as follows:

7-066.01 Radiation Safety Officer: The licensee shall require an individual fulfilling the responsibilities of the Radiation Safety Officer to be an individual who:

1. Is certified by:
  - a. American Board of Health Physics in Comprehensive Health Physics;
  - b. American Board of Radiology;
  - c. American Board of Nuclear Medicine;
  - d. American Board of Science in Nuclear Medicine;
  - e. Board of Pharmaceutical Specialties in Nuclear Pharmacy;
  - f. American Board of Medical Physics in radiation oncology physics;
  - g. Royal College of Physicians and Surgeons of Canada in nuclear medicine;
  - h. American Osteopathic Board of Radiology; or
  - i. American Osteopathic Board of Nuclear Medicine; or
2. Has had classroom and laboratory training and experience as follows:
  - a. Two-Hundred (200) hours of classroom and laboratory training that includes:
    - (1) Radiation physics and instrumentation;

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- (2) Radiation protection;
  - (3) Mathematics pertaining to the use and measurement of radioactivity;
  - (4) Radiation biology; and
  - (5) Radiopharmaceutical chemistry; and
- b. One year of full time experience as a radiation safety technologist at a medical institution under the supervision of the individual as the Radiation Safety Officer on an Agency, U.S. Nuclear Regulatory Commission or an Agreement State license that authorizes the medical use of radioactive material; or
3. Be an authorized user identified on the licensee's license.

7-066.02 Training for Uptake, Dilution, and Excretion Studies. The licensee shall require the authorized user of a radiopharmaceutical in 180 NAC 7-034 to be a physician who:

1. Is certified in:
  - a. Nuclear medicine by the American Board of Nuclear Medicine; or
  - b. Diagnostic radiology by the American Board of Radiology; or
  - c. Diagnostic radiology or radiology by the American Osteopathic Board of Radiology; or
  - d. Nuclear medicine by the Royal College of Physicians and Surgeons of Canada; or
  - e. American Osteopathic Board of Nuclear Medicine in nuclear medicine; or
2. Has had classroom and laboratory training in basic radioisotope handling techniques applicable to the use of prepared radiopharmaceuticals, and supervised clinical experience as follows:
  - a. Forty (40) hours of classroom and laboratory training that includes:
    - (1) Radiation physics and instrumentation;
    - (2) Radiation protection;
    - (3) Mathematics pertaining to the use and measurement of radioactivity;
    - (4) Radiation biology; and
    - (5) Radiopharmaceutical chemistry; and
  - b. Twenty (20) hours of clinical experience under the supervision of an authorized user and includes:
    - (1) Examining patients or human research subjects and reviewing their case histories to determine their suitability for radioisotope diagnosis, limitations, or contraindications;
    - (2) Selecting an appropriate radiopharmaceutical and measuring the dosages;
    - (3) Administering dosages to patients or human research subjects using syringe radiation shields;

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- (4) Collaborating with the authorized user in the interpretation of radioisotope test results; and
  - (5) Patient or human research subject follow-up; or
- c. Has successfully completed a six-month training program in nuclear medicine as part of a training program that has been approved by the Accreditation Council for Graduate Medical Education and that included classroom and laboratory training, work experience, and supervised clinical experience in all topics identified in 180 NAC 7-066.02, item 2.b.

7-066.03 Training for Imaging and Localization Studies. The licensee shall require the authorized user of a radiopharmaceutical, generator, or reagent kit in this group to be a physician who:

1. Is certified in:
  - a. Nuclear medicine by the American Board of Nuclear Medicine; or
  - b. Diagnostic radiology by the American Board of Radiology; or
  - c. Diagnostic radiology or radiology by the American Osteopathic Board of Radiology; or
  - d. Nuclear medicine by the Royal College of Physicians and Surgeons of Canada; or
  - e. American Osteopathic Board of Nuclear Medicine; or
2. Has had classroom and laboratory training in basic radioisotope handling techniques applicable to the use of prepared radiopharmaceuticals, generators, and reagent kits, supervised work experience, and supervised clinical experience as follows:
  - a. Two-Hundred (200) hours of classroom and laboratory training that includes:
    - (1) Radiation physics and instrumentation;
    - (2) Radiation protection;
    - (3) Mathematics pertaining to the use and measurement of radioactivity;
    - (4) Biological effects of radiation; and
    - (5) Radiopharmaceutical chemistry; and
  - b. Five-Hundred (500) hours of work experience under the supervision of an authorized user that includes:
    - (1) Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;
    - (2) Calibrating dose calibrators and diagnostic instruments and performing checks for proper operation of survey meters;
    - (3) Calculating and safely preparing patient or human research subject dosages;

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- (4) Using administrative controls to prevent the misadministration of radioactive material;
  - (5) Using procedures to contain spilled radioactive material safely and using proper decontamination procedures; and
  - (6) Eluting technetium-99m from generator systems, measuring and testing the eluate for molybdenum-99 and alumina contamination, and processing the eluate with reagent kits to prepare technetium-99m labeled radiopharmaceuticals; and
- c. Five-Hundred (500) hours of clinical experience under the supervision of an authorized user that includes:
- (1) Examining patients or human research subjects and reviewing their case histories to determine their suitability for radioisotope diagnosis, limitations, or contraindications;
  - (2) Selecting an appropriate radiopharmaceutical and measuring the dosages;
  - (3) Administering dosages to patients or human research subjects using syringe radiation shields;
  - (4) Collaborating with the authorized user in the interpretation of radioisotope test results; and
  - (5) Patient or human research subject follow-up; or
3. Has successfully completed a six-month training program in nuclear medicine that has been approved by the Accreditation Council for Graduate Medical Education and that included classroom and laboratory training, work experience, and supervised clinical experience in all the topics identified in 180 NAC 7-066.03, item 2.

NOTE: The requirements specified in 180 NAC 7-066.03, item 2.a., 7-066.03, item 2.b., and 7-066.03, item 2.c. may be satisfied concurrently if all three are included in the training program. Each physician named in Item 4 of Form NRH-5A (Medical/Teletherapy) must complete a separate Form NRH-5A (Medical/Teletherapy) Supplement A (Training and Experience, Authorized User or Radiation Safety Officer) and Form NRH-5A (Medical/Teletherapy) Supplement B (Preceptor Statement).

7-066.04 Training for Therapeutic Use of Unsealed Radioactive Material: The licensee shall require the authorized user of unsealed radioactive material in 180 NAC 7-040 to be a physician who:

1. Is certified by:
  - a. The American Board of Nuclear Medicine; or
  - b. The American Board of Radiology in radiology, therapeutic radiology or radiation oncology; or
  - c. Nuclear medicine by the Royal College of Physicians and Surgeons of Canada; or

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- d. The American Osteopathic Board of Radiology after the effective date of Title 180; or
2. Has had classroom and laboratory training in basic radioisotope handling techniques applicable to the use of therapeutic unsealed radioactive materials, and supervised clinical experience as follows:
  - a. Training in basic radioisotope handling techniques of eighty (80) hours, including
    - (1) Radiation physics and instrumentation;
    - (2) Radiation protection;
    - (3) Mathematics pertaining to the use and measurement of radioactivity; and
    - (4) Radiation biology; and
  - b. Supervised clinical experience under the supervision of an authorized user at a medical institution that includes:
    - (1) Use of Iodine-131 for diagnosis of thyroid function and the treatment of hyperthyroidism or cardiac dysfunction 10 (ten) individuals; and
    - (2) Use of Iodine-131 for treatment of thyroid carcinoma in 3 (three) individuals.
    - (3) Use of Phosphorous-32 for treatment of polycythemia vera, leukemia and /or bone metastases in 3 (three) individuals.
    - (4) Use of Colloidal Phosphorous-32 for intracavitary treatment in 3 (three) individuals.
    - (5) Use of Colloidal Gold-198 for intracavitary treatment in 3 (three) individuals.
    - (6) Use of Strontium-89 for intracavitary treatment in 3 (three) individuals.
    - (7) Any radioactive material in a radiopharmaceutical for a diagnostic use involving measurements of uptake, dilution, or excretion for which the Food and Drug Administration (FDA) has accepted a "Notice of Claimed Investigational Exemption for a New Drug" (IND) or approved a "New Drug Application" (NDA), or an approved "Product License Approval" (PLA).

7-066.05 Training For On-Site Physician: The on-site physician shall have a minimum of forty (40) hours of formal training in basic radiological handling techniques.

7-066.06 Training for Use of Brachytherapy Sources: The licensee shall require the authorized user of a brachytherapy source listed in 180 NAC 7-046 for therapy to be a physician who is:

1. Certified in:
  - a. Radiology, therapeutic radiology or radiation oncology by the American Board of Radiology;

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- 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"; or
  - d. Therapeutic radiology by the Canadian Royal College of Physicians and Surgeons; or
2. Is in the active practice of therapeutic radiology, has had classroom and laboratory training in radioisotope handling techniques applicable to the therapeutic use of brachytherapy sources, supervised work experience, and supervised clinical experience as follows:
- a. Two-Hundred (200) hours of classroom and laboratory training that includes:
    - (1) Radiation physics and instrumentation
    - (2) Radiation protection
    - (3) Mathematics pertaining to the use and measurement of radioactivity
    - (4) Radiation biology
  - b. Five-Hundred (500) hours of work experience under the supervision of an authorized user at a medical institution that includes:
    - (1) Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;
    - (2) Checking survey meters for proper operation;
    - (3) Preparing, implanting, and removing sealed sources;
    - (4) Maintaining running inventories of material on hand;
    - (5) Using administrative controls to prevent the misadministration of radioactive material; and
    - (6) Using emergency procedures to control radioactive material; and
  - c. Three years of supervised clinical experience that includes one year in a formal training program approved by the Residency Review Committee for Radiology of the Accreditation Council for Graduate Medical Education or the Committee on Postdoctoral Training of the American Osteopathic Association, and an additional two years of clinical experience in therapeutic radiology under the supervision of an authorized user at a medical institution that includes:
    - (1) Examining individuals and reviewing their case histories to determine their suitability for brachytherapy treatment, and any limitations or contraindications;
    - (2) Selecting the proper brachytherapy sources and dose and method of administration;
    - (3) Calculating the dose; and
    - (4) Post-administration follow-up and review of case histories in collaboration with the authorized user.

7-066.07 Training for Ophthalmic Use of Strontium-90: The licensee shall require the authorized user of only Strontium-90 for ophthalmic radiotherapy to be a physician who is in the active practice of therapeutic radiology or ophthalmology, and has had classroom and laboratory training in basic radioisotope handling techniques applicable to the use of Strontium-90 for ophthalmic radiotherapy, and a period of supervised clinical training in ophthalmic radiotherapy as follows:

1. Twenty-Four (24) hours of classroom and laboratory training that includes:
  - a. Radiation physics and instrumentation;
  - b. Radiation protection;
  - c. Mathematics pertaining to the use and measurement of radioactivity; and
  - d. Radiation biology;
  
2. Supervised clinical training in ophthalmic radiotherapy under the supervision of an authorized user at a medical institution that includes the use of Strontium-90 for the ophthalmic treatment of five individuals that includes:
  - a. Examination of each individual to be treated;
  - b. Calculation of the dose to be administered;
  - c. Administration of the dose; and
  - d. Follow-up and review of each individuals case history.

7-066.08 Training for Use of Sealed Sources for Diagnosis: The licensee shall require the authorized user of a sealed source in a device listed in 180 NAC 7-044 to be a physician, dentist, or podiatrist who:

1. Is certified in:
  - a. Radiology, diagnostic radiology, or therapeutic radiology by the American Board of Radiology;
  - b. Nuclear medicine by the American Board of Nuclear Medicine; or
  - c. Diagnostic radiology or radiology by the American Osteopathic Board of Radiology; or
  - d. Nuclear medicine by the Royal College of Physicians and Surgeons of Canada; or
  
2. Has had 8 hours of classroom and laboratory training in basic radioisotope handling techniques specifically applicable to the use of the device that includes:
  - a. Radiation physics, mathematics pertaining to the use and measurement of radioactivity, and instrumentation;
  - b. Radiation biology;
  - c. Radiation protection; and
  - d. Training in the use of the device for the uses requested.

7-066.09 Training for Teletherapy: The licensee shall require the authorized user of a sealed source listed in 180 NAC 7-052 in a teletherapy unit to be:

1. A physician who is authorized to practice medicine in Nebraska.
2. Certified in:
  - a. Radiology, therapeutic radiology or radiation oncology by the American Board of Radiology;
  - b. Radiation oncology by the American Osteopathic Board of Radiology; or
  - c. Radiology, with specialization in radiotherapy, as a British "Fellow of the Faculty of Radiology" or "Fellow of the Royal College of Radiology"; or
  - d. Therapeutic radiology by the Canadian Royal College of Physicians and Surgeons; or
3. Is in the active practice of therapeutic radiology, and has had classroom and laboratory training in basic radioisotope techniques applicable to the use of a sealed source in a teletherapy unit, supervised work experience, and supervised clinical experience as follows:
  - a. Two-Hundred (200) hours of classroom and laboratory training that includes:
    - (1) Radiation physics and instrumentation;
    - (2) Radiation protection;
    - (3) Mathematics pertaining to the use and measurement of radioactivity; and
    - (4) Radiation biology;
  - b. Five-Hundred (500) hours of work experience under the supervision of an authorized user at a medical institution that includes:
    - (1) Review of the full calibration measurements and periodic spot checks;
    - (2) Preparing treatment plans and calculating treatment times;
    - (3) Using administrative controls to prevent misadministrations;
    - (4) Implementing emergency procedures to be followed in the event of the abnormal operation of a teletherapy unit or console; and
    - (5) Checking and using survey meters; and
  - c. Three years of supervised clinical experience that includes one year in a formal training program approved by the Residency Review Committee for Radiology of the Accreditation Council for Graduate Medical Education or the Committee on Postdoctoral Training of the American Osteopathic Association and an additional two years of clinical experience in therapeutic radiology under the supervision of an authorized user at a medical institution that includes:
    - (1) Examining individuals and reviewing their case histories to determine their suitability for teletherapy treatment, and any limitations or contraindications;
    - (2) Selecting the proper dose and how it is to be administered;
    - (3) Calculating the teletherapy doses and collaborating with the authorized user in the review of patients' or human research subjects' progress and consideration of the need to modify originally

prescribed doses as warranted by individuals' reaction to radiation;  
and

- (4) Post-administration follow-up and review of case histories.

7-066.10 Training for Teletherapy Physicist: The licensee shall require the teletherapy physicist to be an individual who:

1. Is certified by the American Board of Radiology in:
  - a. Therapeutic radiological physics;
  - b. Roentgen ray and gamma ray physics;
  - c. X-ray and radium physics; or
  - d. Radiological Physics; or
2. Is certified by the American Board of Medical Physics in radiation oncology physics; or
3. Holds a master's or doctor's degree in physics, biophysics, radiological physics or health physics, and has completed one year full time training in therapeutic radiological physics and a an additional year of full time experience under the supervision of a teletherapy physicist at a medical institution that includes the tasks listed in 180 NAC 7-024, 7-059, 7-060, and 7-061.

7-066.11 Physician Training in a Three Month Program: A physician who, before the effective date of Title 180, began a three month nuclear medicine training program approved by the Accreditation Council for Graduate Medical Education and has successfully completed the program need not comply with the requirements of 180 NAC 7-066.02 or 7-066.03.

7-066.12 Recentness of Training: The training and experience specified in this subpart must have been obtained within 7 years preceding the date of application or the individual must have had related continuing education and experience since the required training and experience was completed.

7-066.13 Training And Experience Requirements For Nuclear Medicine Technologists:

1. The licensee shall require that a technologist who uses any radiopharmaceutical, generator, or reagent kit in 180 NAC 7-036 be an individual who:
  - a. Is certified in nuclear medicine by the:
    - (1) American Registry of Radiologic Technologists; or
    - (2) Nuclear Medicine Technology Certification Board; or
  - b. Has completed an integrated program of full-time training and experience that includes classroom and laboratory training in basic radioisotope handling techniques applicable to the use of prepared radiopharmaceuticals, generators, and reagent kits, supervised handling experience, and supervised clinical experience as follows:
    - (1) 200 hours of classroom and laboratory training that include:

- (a) Radiation physics and instrumentation;
  - (b) Radiation protection policy, management, procedures, and regulations;
  - (c) Mathematics of radiation and radioactivity;
  - (d) Radiopharmaceutical chemistry;
  - (e) Imaging technology; and
  - (f) Radiation biology.
- (2) Supervised handling experience under the supervision of an authorized user or practicing technologist that includes:
- (a) Ordering, receiving, and unpacking radioactive materials safely and performing the related radiation surveys;
  - (b) Calibrating dose calibrators and diagnostic instruments and performing checks for proper operation of survey meters;
  - (c) Calculating and safely preparing stock radiopharmaceuticals and individual dosages.
  - (d) Using administrative controls to prevent the misadministration of radioactive material;
  - (e) Containing spilled radioactive material and decontaminating; and
  - (f) Eluting technetium-99m from generator systems, assaying and testing the eluate for molybdenum-99 and alumina contamination, processing the eluate with reagent kits to prepare technetium-99m labeled radiopharmaceuticals; and assaying radiopharmaceuticals to determine the portion of radioactivity bound to the radiopharmaceutical.
- (3) Supervised clinical experience under the supervision of an authorized user that includes:
- (a) Reviewing the case histories of individuals to determine their suitability for radioisotope diagnosis, limitations, or contraindications;
  - (b) Identifying radiopharmaceuticals for clinical procedures and calculating and measuring the dosages;
  - (c) Administering dosages to individuals and using syringe radiation shields; and
  - (d) Acquiring and manipulating diagnostic data.

7-066.14 Training And Experience Requirements For Radiation Therapists:

1. The licensee shall require that a radiation therapist who uses any source of radiation for therapy listed in 180 NAC 6 , 7 or 9 be an individual who:
  - a. Is certified in radiation therapy technology by the American Registry of Radiologic Technologists; or
  - b. Has completed an integrated program of full-time training and experience that includes classroom and laboratory training applicable to the use of a source of radiation, supervised work experience, and supervised clinical experience as follow:

- (1) 200 hours of classroom and laboratory training that include:
  - (a) Radiation physics and instrumentation;
  - (b) Radiation protection policy, management, procedures, and regulations;
  - (c) Mathematics of radiation and radioactivity; and
  - (d) Radiation biology;
  
- (2) Supervised work experience under the supervision of an authorized user or practicing radiation therapist that includes:
  - (a) Review of the full calibration measurements and periodic spot checks as appropriate;
  - (b) Preparing treatment plans for prescriptions and calculating treatment times;
  - (c) Using administrative controls to prevent misadministrations;
  - (d) Implementing emergency procedures to be followed in the event of the abnormal operation of equipment; and
  - (e) Checking and using survey meters; and
  
- (3) Supervised clinical experience under the supervision of an authorized user or a practicing radiation therapist, that includes:
  - (a) Reviewing the case histories of individuals to determine their suitability for treatment, and any limitations or contraindications;
  - (b) Selecting the proper doses and how it is to be administered;
  - (c) Reviewing calculations of radiation source doses for accuracy and completeness; and monitoring patients or human research subjects reaction to radiation, and bringing discrepancies to the authorized user's attention.
  - (d) Application of radiation to individuals, including the use of beam modifying devices, based on the instructions in the individual's chart; and
  - (e) Making and reviewing records of the medical use of radiation.

7-066.15 Training for an Authorized Nuclear Pharmacist: The licensee shall require the authorized nuclear pharmacist to be a pharmacist who:

1. Has current board certification as a nuclear pharmacist by the Board of Pharmaceutical Specialties; or
2. Has completed seven-hundred (700) hours in structured educational program consisting of both:
  - a. Didactic training in the following areas:
    - (1) Radiation physics and instrumentation;
    - (2) Radiation protection;
    - (3) Mathematics pertaining to the use and measurement of radioactivity;
    - (4) Chemistry of radioactive material for medical use; and
    - (5) Radiation biology; and

- b. Supervised experience in a nuclear pharmacy involving the following:
  - (1) Shipping, receiving, and performing related radiation surveys;
  - (2) Using and performing checks for proper operation of dose calibrators, and survey meters, and if appropriate, instruments used to measure alpha- or beta-emitting radionuclides
  - (3) Calculating, assaying and safely preparing dosages for individuals;
  - (4) Using administrative controls to avoid mistakes in the administration of radioactive material;
  - (5) Using procedures to prevent or minimize contamination and using proper decontamination procedures; and
- 3. Has obtained written certification, signed by a preceptor authorized nuclear pharmacist, that the above training has been satisfactorily completed and that the individual has achieved a level of competency sufficient to independently operate a nuclear pharmacy.

7-66.16 Training for Experienced Nuclear Pharmacists: A licensee may apply for and must receive a license amendment identifying an experienced nuclear pharmacist as an authorized nuclear pharmacist before it allows this individual to work as an authorized nuclear pharmacist. A pharmacist who has completed a structured educational program as specified in 180 NAC 7-066.15, item 2. before the effective date of, and who is working in a nuclear pharmacy as an experienced nuclear pharmacist. An experienced nuclear pharmacist need not comply with the requirements on preceptor statement (180 NAC 7-066.15, item 3.) and recentness of training (180 NAC 7-066.12) to qualify as an authorized nuclear pharmacist.

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NEBRASKA DEPARTMENT OF HEALTH AND HUMAN SERVICES REGULATION AND LICENSURE  
DIVISION OF PUBLIC HEALTH ASSURANCE  
RADIOACTIVE MATERIALS PROGRAM

**APPLICATION FOR RADIOACTIVE MATERIAL LICENSE - Medical or Teletherapy**

INSTRUCTIONS - (Use additional sheets where necessary.)

Medical Application - Complete Items 1. through 26.

Teletherapy Application - Complete Items 1. through 26, as applicable and Supplement C.

Retain one copy for your files and submit original application to: Department of Health and Human Services Regulation and Licensure, Division of Public Health Assurance, 301 Centennial Mall South, P.O. Box 95007, Lincoln, NE 68509-5007.

Upon approval of this application, the applicant will receive a Radioactive Material License, issued in accordance with the requirements contained in Title 180, Regulations for Control of Radiation and the Nebraska Radiation Control Act.

<b>1.a Legal Name and Street address of Applicant (Institution, Firm, Hospital, Person, etc.)</b>  Applicant Name: _____  Address: _____ _____ _____  City, State Zip +4: _____  Telephone #: _____  FAX #: _____  eMail Address: _____																										
<b>1.b Street address(es) at which Radioactive Material will be used. (If different than 1.a)</b>  (1) <u>Permanent</u> Address: _____ _____ City, State Zip+4: _____  (2) <u>Temporary Job Sites Throughout Nebraska?</u> <input type="checkbox"/> Yes <input type="checkbox"/> No																										
<b>2. Person to Contact Regarding this Application</b>  _____  Telephone #: _____	<b>3. This is an application for:</b>  <input type="checkbox"/> New License <input type="checkbox"/> Amendment to License No. _____ <input type="checkbox"/> Renewal of License No. _____																									
<b>4. Individual User(s)</b> (Name and Title of individual(s) who will use or directly supervise use of, Radioactive Materials. Complete NRH-5A, Supplement A and B for each individual listed.)  <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; border-bottom: 1px solid black;">First Name + Middle Initial</th> <th style="text-align: left; border-bottom: 1px solid black;">Last Name</th> <th style="text-align: left; border-bottom: 1px solid black;">Title</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td></tr> </tbody> </table>	First Name + Middle Initial	Last Name	Title																						<b>5. Radiation Safety Officer (RSO)</b> (Name and Title of Individual designated as Radiation Safety Officer.)  _____  Telephone #: _____  Attach documentation of his/her training and experience as in NRH-5A, Supplement A.)  <div style="text-align: center; border: 1px solid black; padding: 5px; margin: 10px auto; width: 80%;">*Agency Use Only*</div>  <div style="text-align: center; border: 1px solid black; padding: 5px; margin: 10px auto; width: 80%;">Date Received Stamp</div>	
First Name + Middle Initial	Last Name	Title																								

<b>6. Radioactive Material Data</b>			
<b>6. Radioactive Material for Medical Use</b>			
Radioactive Material Listed In:	Items Desired (X)	Maximum Possession Limits (In millicuries)	
Title 180 NAC 3-008.09 for Invitro Studies			
Title 180 NAC 7-034.01			
Title 180 NAC 7-036			
Title 180 NAC 7-040			
Title 180 NAC 7-044			
Title 180 NAC 7-046			
<b>Additional Items</b>			
Xenon-133 as gas or gas in saline for blood flow studies and pulmonary function studies			
Technetium-99m aerosolized DTPA for pulmonary function studies			
High dose rate remote afterloading brachytherapy device			
<b>6.b. Radioactive Material for Uses not Listed in Item 6.a.</b>			
6.b.(1) <u>Element and Mass Number</u>	6.b.(2) <u>Chemical or Physical Form (Make and Model if sealed source)</u>	6.b.(3) <u>Maximum Activity Requested (Expressed as Curies, Millicuries, or Microcuries)</u>	6.b.(4) <u>Use of Each Form (If sealed source, also give Make and Model Number of the storage and/or device in which sealed source will be stored and/or used)</u>

### Instructions for Items 7. Through 23.

For Items 7. through 23., check the appropriate box(es) and submit a detailed description of all the requested information. Begin each Item on a separate sheet, identifying the Item number and the date of the application in the lower right hand corner of each page. If you indicate that you will follow an Appendix to the *Guide for Preparation of Applications for Medical Programs 7.0*, do not submit the pages, but specify the revision number and date of the *Guide*.

The Most current *Guide* is: Revision: \_\_\_\_\_ Date: \_\_\_\_\_

**7. Radiation Safety Committee**

- Names and Specialities attached; AND
- Duties as in Appendix B; OR
- Equivalent Duties attached

**8. Training and Experience**

- Supplements A and B attached for each individual user; AND
- Supplement A attached for RSO

**9. Instrumentation**

- Appendix C Form attached; OR
- List by Name and Model Number

**10. Calibration of Instruments**

**a. Survey Instruments**

- Appendix D Procedures followed; OR
- Equivalent Procedures attached

AND

**b. Dose Calibrator**

- Appendix D Procedures followed; OR
- Equivalent Procedures attached

**11. Facilities and Equipment**

- Description or diagram attached; OR
- See Supplements C - Teletherapy Requirements

**12. Personnel Training Program**

- Description of training attached

**13. Procedures for Ordering and Receiving Radioactive Materials**

- Detailed Information Attached

**14. Procedures for Safely Opening Packages Containing Radioactive Materials**

- Appendix F Procedures followed; OR
- Equivalent Procedures attached

**15. General Rules for the safe use of Radioactive Material**

- Appendix G Procedures followed; OR
- Equivalent Procedures attached

**16. Emergency Procedures**

- Appendix H Procedures followed; OR
- Equivalent Procedures attached

**17. Area Survey Procedures**

- Appendix I Procedures followed; OR
- Equivalent Procedures attached

**18. Waste Disposal**

- Appendix J Form attached; OR
- Equivalent Information attached

**19. Therapeutic Use of Radiopharmaceuticals**

- Appendix K Procedures followed; OR
- Equivalent Procedures attached

**20. Therapeutic Use of Sealed Sources**

- Detailed Information attached; AND
- Appendix L Procedures followed; OR
- Equivalent Procedures attached

**21. Procedures and Precautions for use of Radioactive Gases (e.g., Xenon-133)**

- Detailed Information attached

**22. Procedures and Precautions for Use of Radioactive Material in Animals**

- Detailed Information attached

**23. Procedures and Precautions for Use of Radioactive Material Specified in Item 6.b.**

- Detailed Information attached

<b>24. Personnel Monitoring Devices</b> (Check and/or complete as appropriate)		
Type	Supplier/Service Company	Exchange Frequency
<b>24.a. Whole Body</b> <input type="checkbox"/> Film Badge <input type="checkbox"/> TLD <input type="checkbox"/> DOSL <input type="checkbox"/> Other: (Specify)		<input type="checkbox"/> Monthly <input type="checkbox"/> Quarterly <input type="checkbox"/> Other: (Specify)
<b>24.b. Finger</b> <input type="checkbox"/> Film Badge <input type="checkbox"/> TLD <input type="checkbox"/> Other: (Specify)		<input type="checkbox"/> Monthly <input type="checkbox"/> Quarterly <input type="checkbox"/> Other: (Specify)
<b>24.c. Wrist</b> <input type="checkbox"/> Film Badge <input type="checkbox"/> TLD <input type="checkbox"/> Other: (Specify)		<input type="checkbox"/> Monthly <input type="checkbox"/> Quarterly <input type="checkbox"/> Other: (Specify)
<b>24.d. Other (Specify)</b>		
<b>25. Private Practice Applicants Only</b>		
<b>25.a. Hospital Agreeing to accept patients containing Radioactive Material:</b> Name: _____ Mailing Address: _____ _____ City, State Zip+4: _____		
<b>25.b.</b> Attach a copy of the agreement letter signed by the hospital administrator.		
<b>25.c.</b> When requesting Therapy Procedures, attach a copy of Radiation Safety Precautions to be taken and list available radiation detection instruments.		

## **26. CERTIFICATION**

**(This Item must be completed by applicant.)**

The applicant and any official executing this document on behalf of the applicant named in Item 1.a., certify that this application is prepared in conformity with the Nebraska Department of Health and Human Services Regulation and Licensure, Title 180, Regulations for Control of Radiation and that all information contained herein, including any supplements attached hereto, is true and correct to the best of our knowledge and belief.

\_\_\_\_\_  
*Applicant Name From Item 1.a.*

By: \_\_\_\_\_ Date: \_\_\_\_\_  
*Signature*

\_\_\_\_\_  
*Print Name and Title of certifying official authorized to act on behalf of the applicant*

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APPLICATION FOR RADIOACTIVE MATERIAL LICENSE  
Medical or Teletherapy

**SUPPLEMENT A**

**Training and Experience**  
**Authorized User or Radiation Safety Officer (RSO)**

<b>1. Name of Individual</b>  <input type="checkbox"/> Authorized User <input type="checkbox"/> Radiation Safety Officer	<b>2. Physician who is licensed to dispense drugs in the practice of medicine in Nebraska?</b>  <input type="checkbox"/> YES <input type="checkbox"/> NO			
<b>3. Certification</b>				
<b>3.a. Specialty Board</b>	<b>3.b. Category</b>	<b>3.c. Month and Year Certified</b>		
<b>4. Training Received in Basic Radioisotope Handling Techniques</b>				
	<u>Location and Dates of Training</u>	<u>Clock Hours in Lecture or Laboratory</u>	<u>Clock Hours of Supervised Laboratory Experience</u>	
<b>4.a. Radiation Physics and Instrumentation</b>				
<b>4.b. Radiation Protection</b>				
<b>4.c. Mathematics Pertaining to the Use and Measurement of</b>				
<b>4.d. Biological Effects of Radiation</b>				
<b>4.e. Radiopharmaceutical Chemistry</b>				
<b>5. Experience with Radiation</b> (Actual Use of Radioisotopes or Equivalent Experience)				
<u>Isotope</u>	<u>Maximum Activity</u>	<u>Where Experience Was Gained</u>	<u>Months/Years</u>	<u>Type of Use</u>

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APPLICATION FOR RADIOACTIVE MATERIAL LICENSE  
Medical or Teletherapy

**SUPPLEMENT B**  
**Preceptor Statement**

Supplement B must be completed by the applicant physician's preceptor. If more than one preceptor is necessary to document experience, obtain a separate statement from each.

<b>1. Full Name and Street Address of Applicant Physician</b>			
Full Name:			
Address:			
City, State Zip+4			
<b>2. Clinical Training and Experience with Radiation</b> (Actual Use of Radioisotopes)			
<u>Isotope</u>	<u>Conditions Diagnosed or Treated</u>	<u>Number of Cases Involving Personal Participation<sup>1</sup></u>	<u>Comments<sup>2</sup></u>
<b>I-125 or I-131</b>	Diagnosis of Thyroid Function		
	Determination of Blood and Blood Plasma Volume		
	Liver Function Studies		
	Fat Absorption Studies		
	Kidney Function Studies		
	In vitro Studies		
	<b>Other</b>		
<b>I-125</b>	Detection of Thrombosis		
<b>I-131</b>	Thyroid Imaging		
<b>P-32</b>	Eye Tumor Localization		
<b>Se-75</b>	Pancreas Imaging		
<b>Yb-169</b>	Cisternography		
<b>Xe-133</b>	Blood Flow Studies and Pulmonary Function Studies		
	<b>Other</b>		
<b>Tc-99m</b>	Brain Imaging		
	Cardiac Imaging		
	Thyroid Imaging		
	Salivary Gland Imaging		
	Blood Pool Imaging		
	Placenta Localization		
	Liver and Spleen Imaging		
	Lung Imaging		
Bone Imaging			

<b>2. Clinical Training and Experience with Radiation</b> (Actual Use of Radioisotopes)		
Other		
P-32 (Soluble)	Treatment of Polycythemia Vera, Leukemia, and Bone Metastases	
P-32 (Colloidal)	Intracavitary Treatment	
I-131	Diagnosis of Thyroid Function	
	Treatment of Hyperthyroidism	
Au-198	Intracavitary Treatment	
Co-60 or Cs-137	Interstitial Treatment	
	Intracavitary Treatment	
I-125 or Ir-192	Interstitial Treatment	
Ra-226	Intracavitary Treatment	
	Interstitial Treatment	
	Superficial Treatment	
Co-60 or Cs-137	Teletherapy Treatment	
Sr-90	Treatment of Eye Disease	
	Radiopharmaceutical Preparation	
Mo-99/Tc-99m	Generator	
Sn-113/In-113m	Generator	
Tc-99m	Reagent Kits	
X-Ray and Accelerator Therapy	Courses of Therapy Treatment	
Other		

<sup>1</sup> Key to column

Personal Participation should consist of:

1. Supervised examination of patients to determine the suitability for radioisotope diagnosis and/or treatment and recommendation for prescribed dosage.
2. Collaboration in dose calibration and actual administration of dose to the patient including calculation of the radiation dose, related measurements, and plotting of data.
3. Adequate period of training to enable physician to manage radioactive patients and follow patients through diagnosis and/or course of treatment.

<sup>2</sup> Additional information or comments may be submitted in duplicate on separate sheets.  
duplicate on separate sheets.

**3. Dates and Total Number of Hours Received in Clinical Radioisotope Training**

(Submit in duplicate on separate sheets)

**4. Training and Experience Obtained Under the Supervision of:**

Supervisor's  
Name:

Institution  
Name:

Address

City, State  
Zip+4

Radioactive material License Number(s):

**5. Preceptor's Verification**

Preceptor's  
Name: \_\_\_\_\_  
(Type or Print)

Preceptor's  
Name: \_\_\_\_\_  
(Type or Print)

\_\_\_\_\_  
(Date)

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APPLICATION FOR RADIOACTIVE MATERIAL LICENSE  
Medical or Teletherapy

SUPPLEMENT C

Requirements Specific to Teletherapy

**1. Facilities and Equipment**

- Description and drawing of facilities attached; **AND**
- Description of patient viewing and communicating systems attached; **AND**
- Description of area safeguards attached

**2. Beam Stops**

- Description of stops used to restrict beam orientation attached

**3. Shielding Evaluation**

- Evaluation of proposed shielding attached

**4. Operating and Emergency Procedures**

- Description of operating procedures attached; **AND**
- Copy of emergency procedures attached

**5. Instruction of Personnel**

- Training program and schedule in Appendix A followed; **OR**
- Description of instruction program for employees attached

**6. Leak Tests of Sealed Sources**

- Description of leak test procedures attached

**7. Teletherapy Physicist (Use only if individual fails to meet 180 NAC 7-066.10 requirements)**

- Statement of qualifications of the physicist who will perform teletherapy calibrations attached.

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NEBRASKA HEALTH AND HUMAN SERVICES  
REGULATION AND LICENSURE

180 NAC 8

TITLE 180 CONTROL OF RADIATION

CHAPTER 8 RADIATION SAFETY REQUIREMENTS FOR ANALYTICAL X-RAY EQUIPMENT

8-001	Scope and Authority .....	1
8-002	Definitions .....	1
8-003	Equipment Requirements .....	1
8-004	Area Requirements .....	3
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NEBRASKA HEALTH AND HUMAN SERVICES  
REGULATION AND LICENSURE

180 NAC 8

TITLE 180 CONTROL OF RADIATION

CHAPTER 8 RADIATION SAFETY REQUIREMENTS FOR ANALYTICAL X-RAY EQUIPMENT

8-001 SCOPE AND AUTHORITY

8-001.01 180 NAC 8 provides special requirements for analytical x-ray equipment. The regulations are authorized by and implement the Nebraska Radiation Control Act, Neb. Stat. Rev. sections 71-3501 to 3519.

8-001.02 The requirements of this 180 NAC 8 are in addition to, and not in substitution for applicable requirements in 180 NAC 1, 2, 3, 4, 10, 15, 17 and 18.

8-002 DEFINITIONS: As used in 180 NAC 8, the following definitions apply:

Analytical x-ray equipment means equipment used for x-ray diffraction or fluorescence analysis.

Analytical x-ray system means a group of components utilizing x or gamma rays to determine the elemental composition or to examine the microstructure of materials.

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

Local components mean part of an analytical x-ray system and include areas that are struck by x-rays such as radiation source housing, port and shutter assemblies, collimators, sample holders, cameras, goniometers, detectors and shielding, but do not include power supplies, transformers, amplifiers, readout devices, and control panels.

Normal operating procedures mean step-by-step instructions necessary to accomplish the analysis. These procedures shall include sample insertion and manipulation, equipment alignment, routine maintenance by the registrant or licensee, and data recording procedures which are related to radiation safety.

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

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

8-003 EQUIPMENT REQUIREMENTS:

8-003.01 Safety Device. A device which prevents the entry of any portion of an individual's body into the primary x-ray beam path or which causes the beam to be shut off upon entry into its path shall be provided on all open-beam configurations. A registrant or licensee may apply to the Agency for an exemption from the requirement of a safety device. Such exemption shall be granted provided that the Agency makes a finding that the exemption will not constitute a significant risk to the health and safety of the public. Such application shall include:

1. A description of the various safety devices that have been evaluated;
2. The reason each of these devices cannot be used; and
3. A description of the alternative methods that will be employed to minimize the possibility of an accidental exposure, including procedures to assure that operators and others in the area will be informed of the absence of safety devices.

8-003.02 Warning Devices

8-003.02A. Open-beam configurations shall be provided with a readily discernible indication of:

1. X-ray tube status (ON-OFF) located near the radiation source housing, if the primary beam is controlled in this manner; and/or
2. Shutter status (OPEN-CLOSED) located near each port on the radiation source housing, if the primary beam is controlled in this manner.

8-003.02B. Warning devices shall be labeled so that their purpose is easily identified. On equipment installed after June 27, 1983, warning devices shall have fail-safe characteristics.

8-003.03 Ports: Unused ports on radiation source housings shall be secured in the closed position in a manner which will prevent casual opening.

8-003.04 Labeling: All analytical x-ray equipment shall be labeled with a readily discernible sign or signs bearing the radiation symbol and the words:

1. "CAUTION - HIGH INTENSITY X-RAY BEAM," or words having a similar intent, on the x-ray source housing; and
2. "CAUTION RADIATION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED," or words having a similar intent, near any switch that energizes an x-ray tube if the radiation source is an x-ray tube; or
3. "CAUTION - RADIOACTIVE MATERIAL," or words having a similar intent, on the source housing in accordance with 180 NAC 4-031 if the radiation source is a radionuclide.

8-003.05 Shutters: On open-beam configurations installed after June 27, 1983, 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.

8-003.06 Warning Lights

8-003.06A. An easily visible warning light labeled with the words "X-RAY ON," or words having a similar intent, shall be located:

1. Near any switch that energizes an x-ray tube and shall be illuminated only when the tube is energized; or
2. In the case of a radioactive source, near any switch that opens a housing shutter, and shall be illuminated only when the shutter is open.

8-003.06B. On equipment installed after June 27, 1983, warning lights shall have fail-safe characteristics.

8-003.07 Radiation Source Housing: Each radiation source housing shall be subject to the following requirements:

1. Each x-ray tube housing shall be equipped with an interlock that shuts off the tube if it is removed from the radiation source housing or if the housing is disassembled.
2. Each radioactive source housing or port cover or each x-ray tube housing shall be so constructed that, with all shutters closed, the radiation measured at a distance of 5 cm from its surface is not capable of producing a dose in excess of 0.025 mSv (2.5 mrem) in one hour. For systems utilizing x-ray tubes, this limit shall be met at any specified tube rating.

8-003.08 Generator Cabinet. Each x-ray generator shall be supplied with a protective cabinet which limits leakage radiation measured at a distance of 5 cm from its surface such that it is not capable of producing a dose in excess of 2.5 uSv (0.25 mrem) in one hour.

8-004 AREA REQUIREMENTS

8-004.01 Radiation Levels: The local components of an analytical x-ray system shall be located and arranged and shall include sufficient shielding or access control such that no radiation levels exist in any area surrounding the local component group which could result in a dose to an individual present therein in excess of the dose limits given in 180 NAC 4-013. For systems utilizing x-ray tubes, these levels shall be met at any specified tube rating.

8-004.02 Surveys

1. Radiation surveys, as required by 180 NAC 4-021, of all analytical x-ray systems sufficient to show compliance with 180 NAC 8-004.01 shall be performed:

- a. Upon installation of the equipment and at least once every 12 months thereafter;
  - b. Following any change in the initial arrangement, number, or type of local components in the system;
  - c. Following any maintenance requiring the disassembly or removal of a local component in the system;
  - d. During the performance of maintenance and alignment procedures if the procedures require the presence of a primary x-ray beam when any local component in the system is disassembled or removed;
  - e. Any time a visual inspection of the local components in the system reveals an abnormal condition; and
  - f. Whenever personnel monitoring devices show a significant increase over the previous monitoring period or the readings are approaching the limits specified in 180 NAC 4-005.
2. Radiation survey measurements shall not be required if a registrant or licensee can demonstrate compliance to the satisfaction of the Agency with 180 NAC 8-004.01 in some other manner.

8-004.03 Posting: Each area or room containing analytical x-ray equipment shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words "CAUTION X-RAY EQUIPMENT" or words having a similar intent in accordance with 180 NAC 4-031.

#### 8-005 OPERATING REQUIREMENTS

8-005.01 Procedures: Normal operating procedures shall be written and available to all analytical x-ray equipment workers. No individual shall be permitted to operate analytical x-ray equipment in any manner other than that specified in the procedures unless such individual has obtained written approval of the radiation safety officer.

8-005.02 Bypassing: No individual shall bypass a safety device or interlock unless such individual has obtained the approval of the radiation safety officer. Such approval shall be for a specified period of time. When a safety device or interlock 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.

8-005.03 Repair or Modification of X-Ray Tube Systems: Except as specified in 180 NAC 8-005.02, no operation involving removal of covers, shielding materials or tube housing or modifications to shutters, collimators, or beam stops shall be performed without ascertaining that the tube is off and will remain off until safe conditions have been restored. The main switch, rather than interlocks, shall be used for routine shutdown in preparation for repairs.

8-005.04 Radioactive Source Replacement, Testing, or Repair: Radioactive source housing shall be opened for source replacement, leak testing, or other maintenance or repair procedures only by individuals authorized to specifically conduct such procedures under a license issued by the U.S. Nuclear Regulatory Commission or an Agreement State.

8-006 PERSONNEL REQUIREMENTS

8-006.01 Instruction: No individual shall be permitted to operate or maintain analytical x-ray equipment unless such individual has received instruction in and demonstrated competence as to:

1. Identification of radiation hazards associated with the use of the equipment;
2. Significance of the various radiation warning and safety devices, and interlocks incorporated into the equipment, or the reasons they have not been installed on certain pieces of equipment and the extra precautions required in such cases;
3. Proper operating procedures for the equipment;
4. Recognition of symptoms of an acute localized exposure;
5. Proper procedures for reporting an actual or suspected exposure; and
6. Has met the training requirements specified in 180 NAC 15-028.

8-006.02 Personnel Monitoring

1. Finger or wrist dosimetric devices shall be provided to and shall be used by:
  - a. Analytical x-ray equipment workers using systems having an open-beam configuration and not equipped with a safety device; and
  - b. Personnel maintaining analytical x-ray equipment if the maintenance procedures require the presence of a primary x-ray beam when any local component in the analytical x-ray system is disassembled or removed.
2. Reported dose values shall not be used for the purpose of determining compliance with 180 NAC 4-005 unless evaluated by a qualified expert as specified in 180 NAC 15-013.03.

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180 NAC 9

TITLE 180 CONTROL OF RADIATION

CHAPTER 9 RADIATION SAFETY REQUIREMENTS FOR PARTICLE ACCELERATORS

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9-003	General Operating Requirements for the Issuance of a Registration for Particle Accelerators .....	1
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9-005	Operator Qualifications .....	2
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180 NAC 9

TITLE 180 CONTROL OF RADIATION

CHAPTER 9 RADIATION SAFETY REQUIREMENTS FOR PARTICLE ACCELERATORS

9-001 SCOPE AND AUTHORITY:

9-001.01 180 NAC 9 establishes procedures for the registration and use of particle accelerators. The regulations are authorized by and implement the Nebraska Radiation Control Act, Neb. Stat. Rev. sections 71-3501 to 3519.

9-001.02 In addition to the requirements of 180 NAC 9, all registrants are subject to the requirements of 180 NAC 1, 2, 4, 10, 15, 17 and 18. Registrants engaged in industrial radiographic operations are subject to the requirements of 180 NAC 5. Registrants engaged in the healing arts are subject to the requirements of 180 NAC 6 and/or 180 NAC 7. Registrants whose operations result in the production of radioactive material are subject to the requirements of 180 NAC 3.

REGISTRATION PROCEDURE

9-002 REGISTRATION REQUIREMENTS: No person shall receive, possess, use, transfer, own, or acquire a particle accelerator except as authorized in a registration issued pursuant to 180 NAC 2.

9-003 GENERAL OPERATING REQUIREMENTS FOR THE ISSUANCE OF A REGISTRATION FOR PARTICLE ACCELERATORS: In addition to the requirements of 180 NAC 2, registration application for use of a particle accelerator will be approved only if the Agency determines that:

1. The applicant has appointed a radiation safety officer;
2. The applicant has established a radiation safety committee to approve, in advance, proposals for use of a particle accelerator(s);
3. The applicant's proposed or existing equipment, facilities and operating and emergency procedures are adequate to protect health and minimize danger to public health and safety or property as required in 180 NAC 9-004 through 9-010;
4. The applicant is qualified by reason of training and experience to use the accelerator in question for the purpose requested in accordance with 180 NAC 9 and 180 NAC 4 and 10 in such a manner as to minimize danger to public health and safety or property;
5. The issuance of the registration will not be inimical to the health and safety of the public, and the applicant satisfies any applicable special requirement in 180 NAC 9-004, and
6. The applicant and/or the applicant's staff has training and experience in the use of particle accelerators as specified in 180 NAC 15.

9-004 HUMAN USE OF PARTICLE ACCELERATORS: In addition to the requirements of 180 NAC 2, a registration for use of a particle accelerator in the healing arts will be issued only if:

1. The applicant has appointed a radiation safety committee of at least three members to oversee the use of the particle accelerator, and to review the institution's radiation safety program. Membership of the committee should include at least the following: an authorized user, a representative of the institution's management and the Radiation Safety Officer.
2. The individuals designated on the application as the users have training and experience as designated in 180 NAC 15-005 in deep therapy techniques or in the use of particle accelerators to treat humans; and
3. The individuals designated on the application as the users are physicians.
4. Any applicant employing Radiation Therapists to perform radiation therapy procedures shall require that they have training and experience requirements as specified in 180 NAC 15-021.

#### RADIATION SAFETY REQUIREMENTS FOR THE USE OF PARTICLE ACCELERATORS

9-005 OPERATOR QUALIFICATIONS: No person shall operate an accelerator until they meet the training requirements of 180 NAC 15-024 (accelerators under 1 MeV) or 180 NAC 15-025 (non-human use accelerators above 1 MeV).

#### 9-006 LIMITATIONS

1. No registrant shall permit any individual to act as an operator of a particle accelerator until such individual:
  - a. Has been instructed in radiation safety and shall have demonstrated an understanding thereof;
  - b. Has received copies of and instruction in 180 NAC 9 and the applicable requirements of 180 NAC 4 and 10, pertinent registration conditions and the registrant's operating and emergency procedures, and shall have demonstrated understanding thereof; and
  - c. Has demonstrated competence to use the particle accelerator, related equipment, and survey instruments which will be employed.
2. The radiation safety committee or the radiation safety officer shall have the authority to terminate the operations at a particle accelerator facility if such action is deemed necessary to minimize danger to public health and safety or property.

#### 9-007 SHIELDING AND SAFETY DESIGN REQUIREMENTS

9-007.01 A radiological physicist as specified in 180 NAC 15-013.01 or 15-013.02 shall be consulted in the design of a particle accelerator installation, shall submit a plan review prior to construction and shall perform a radiation survey when the accelerator is first capable of producing radiation. A copy of the survey results shall be submitted to the Agency for review.

9-007.02 Each particle accelerator installation shall be provided with such primary and/or secondary barriers as are necessary to assure compliance with 180 NAC 4-005 and 4-013.

#### 9-008 PARTICLE ACCELERATOR CONTROLS AND INTERLOCK SYSTEMS

9-008.01 Instrumentation, readouts and controls on the particle accelerator control console shall be clearly identified and easily discernible.

9-008.02 Each entrance into a target room or other high radiation area shall be provided with a safety interlock(s) that shuts down the machine under conditions of barrier penetration.

9-008.03 When a safety interlock system has been tripped, it shall only be possible to resume operation of the accelerator by manually resetting controls at the position where the safety interlock has been tripped, and lastly at the main control console.

9-008.04 Each safety interlock shall be on a circuit which shall allow its operation independently of all other safety interlocks.

9-008.05 All safety interlocks shall be designed so that any defect or component failure in the safety interlock system prevents operation of the accelerator.

9-008.06 A scram button or other emergency power cutoff switch shall be located and easily identifiable in all high radiation areas. Such a cutoff switch shall include a manual reset so that the accelerator cannot be restarted from the accelerator control console without resetting the cutoff switch.

#### 9-009 WARNING DEVICES

9-009.01 Each location designated as a high radiation area, and each entrance to such location, shall be equipped with easily observable warning lights that operate when, and only when, radiation is being produced.

9-009.02 Except in facilities designed for human exposure, each high radiation area shall have an audible warning device which shall be activated for 15 seconds prior to the possible creation of such high radiation area. Such warning device shall be clearly discernible in all high radiation areas and all radiation areas.

9-009.03 Barriers, temporary or otherwise, and pathways leading to high radiation areas shall be identified in accordance with 180 NAC 4-031.

#### 9-010 OPERATING PROCEDURES

9-010.01 Particle accelerators, when not in operation, shall be secured to prevent unauthorized use.

9-010.02 The safety interlock system shall not be used to turn off the accelerator beam except in an emergency.

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180 NAC 9

9-010.03 All safety and warning devices, including interlocks, shall be checked for proper operation at intervals not to exceed six months. Results of such tests shall be maintained at the accelerator facility for inspection by the Agency.

9-010.04 Electrical circuit diagrams of the accelerator and the associated interlock system shall be kept current and maintained for inspection by the Agency and shall be available to the operator at each accelerator facility.

9-010.05 If, for any reason, it is necessary to intentionally bypass a safety interlock or interlocks, such action shall be:

1. Authorized by the radiation safety committee and/or radiation safety officer;
2. Recorded in a permanent log and a notice posted at the accelerator control console; and
3. Terminated as soon as possible.

9-010.06 A copy of the current operating and emergency procedures shall be maintained at the accelerator control panel.

9-011 RADIATION MONITORING REQUIREMENTS

9-011.01 There shall be available at each particle accelerator facility appropriate portable monitoring equipment which is operable and has been appropriately calibrated, for the radiation being produced at the facility. Such equipment shall be tested for proper operation daily and calibrated at intervals not to exceed one year and after each servicing and repair.

9-011.02 A radiation protection survey shall be performed, and documented by a radiological physicist as specified in 180 NAC 15-013.01 or 15-013.02, when changes have been made in shielding, operation, equipment, or occupancy of adjacent areas.

9-011.03 Radiation levels in all high radiation areas shall be continuously monitored. The monitoring devices shall be electronically independent of the accelerator control and safety interlock systems and capable of providing a readout at the control panel.

9-011.04 All area monitors shall be calibrated at intervals not to exceed one year and after each servicing and repair.

9-011.05 Whenever applicable, periodic surveys shall be made to determine the amount of airborne particulate radioactivity present.

9-011.06 Whenever applicable, periodic smear surveys shall be made to determine the degree of contamination.

9-011.07 All surveys shall be made in accordance with the written procedures established by a radiological physicist as specified in 180 NAC 15-013.01 or 15-013.02, or the radiation safety officer.

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9-011.08 Records of all radiation protection surveys, calibration and instrumentation tests, shall be maintained at the accelerator facility for inspection by the Agency.

9-012 VENTILATION SYSTEMS

9-012.01 Ventilation systems shall be provided to ensure that personnel entering any area where airborne radioactivity may be produced will not be exposed to airborne radioactive material in excess of those limits specified in 180 NAC 4, Appendix 4-B, Table I.

9-012.02 A registrant, as required by 180 NAC 4-014, shall not vent, release or otherwise discharge airborne radioactive material to an unrestricted area which exceed the limits specified in 180 NAC 4, Appendix 4-B, Table II, except as authorized pursuant to 180 NAC 4-038 or 4-014. For purposes of 180 NAC 9-012.02, concentrations may be averaged over a period of not greater than one year. Every reasonable effort should be made to maintain releases of radioactive material to unrestricted areas as far below these limits as is reasonably achievable.

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180 NAC 10

TITLE 180 CONTROL OF RADIATION

CHAPTER 10 NOTICES, INSTRUCTIONS AND REPORTS TO WORKERS: INSPECTIONS

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FORM(S)

Form NRH-3 Notice to Employees

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180 NAC 10

TITLE 180 CONTROL OF RADIATION

CHAPTER 10 NOTICES, INSTRUCTIONS AND REPORTS TO WORKERS: INSPECTIONS

10-001 SCOPE AND AUTHORITY:

10-001.01 180 NAC 10 establishes requirements for notices, instructions and reports by licensees or registrants to individuals engaged in activities under a license or registration and options available to such individuals in connection with Agency inspections of licensees or registrants to ascertain compliance with the provisions of the Act and regulations, orders and licenses issued there under regarding radiological working conditions. The regulations are authorized by and implement the Nebraska Radiation Control Act, Neb. Stat. Rev. sections 71-3501 to 3519.

10.001.02 The regulations in 180 NAC 10 apply to all persons who receive, possess, use, own or transfer sources of radiation licensed by or registered with the Agency pursuant to 180 NAC 2, 3, 5, 6, 7, 8, 9, 11, 12, 13 and 14.

10-002 POSTING OF NOTICES TO WORKERS

10-002.01 Each licensee or registrant shall post current copies of the following documents:

1. The regulations in 180 NAC 10 and 180 NAC 4;
2. The license, certificate of registration, conditions or documents incorporated into the license by reference and amendments thereto;
3. The operating procedures applicable to activities under the license or registration; and
4. Any notice of violation involving radiological working conditions, proposed imposition of civil penalty, or order issued pursuant to 180 NAC 17 and any response from the licensee or registrant.

10-002.02 If posting of a document specified in 180 NAC 10-002.01, items 1., 2., or 3. is not practicable, the licensee or registrant may post a notice which describes the document and states where it may be examined.

10-002.03 Agency Form NRH-3, "Notice to Employees" shall be posted by each licensee or registrant wherever individuals work in or frequent any portion of a restricted area.

10-002.04 Agency documents posted pursuant to 180 NAC 10-002.01, item 4., shall be posted within 2 working days after receipt of the documents from the Agency; the licensee's or registrant's response, if any, shall be posted within 2 working days after dispatch from the licensee or registrant. Such documents shall remain posted for a minimum of 5 working days or until action correcting the violation has been completed, whichever is later.

10-002.05 Documents, notices or forms posted pursuant to 180 NAC 10-002 shall appear in a sufficient number of places to permit individuals engaged in work under the license or registration to observe them on the way to or from any particular work location to which the document applies, shall be conspicuous, and shall be replaced if defaced or altered.

### 10-003 INSTRUCTIONS TO WORKERS

10-003.01 All individuals who in the course of employment are likely to receive in a year an occupational dose in excess of 100 mrem (1 mSv) shall be:

1. Kept informed of the storage, transfer, or use of radiation and/or radioactive material;
2. Instructed in the health protection problems associated with exposure to radiation and/or radioactive material, precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed;
3. Instructed in, and required to observe, to the extent within the worker's control, the applicable provisions of Title 180 and licenses for the protection of personnel from exposures to radiation or radioactive material;
4. Instructed of their responsibility to report promptly to the licensee or registrant any condition which may lead to, constitute, or cause a violation of the Act, Title 180, and licenses or unnecessary exposure to radiation or radioactive material;
5. Instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material; and
6. Advised as to the radiation exposure reports which workers shall be furnished pursuant to 180 NAC 10-004.

10-003.02 In determining those individuals subject to the requirements of 180 NAC 10-003.01, licensees or registrants must take into consideration assigned activities during normal and abnormal situations involving exposure to radiation and/or radioactive material which can reasonably be expected to occur during the life of a licensee or registrant's facility. The extent of these instructions must be commensurate with potential radiological health protection problems present in the work place and shall be performed annually.

10-003.03 Records of the instructions to workers required by 180 NAC 10-003 shall be maintained by the licensee and/or registrant until reviewed by the Agency.

### 10-004 NOTIFICATIONS AND REPORTS TO INDIVIDUALS

10-004.01 Radiation exposure data for an individual and the results of any measurements, analyses, and calculations of radioactive material deposited or retained in the body of an individual shall be reported to the individual as specified in 180 NAC 10-004. The information reported shall include data and results obtained pursuant to Title 180, orders, or license conditions, as shown in records maintained by the licensee or registrant pursuant to 180 NAC 4-050. Each notification and report shall:

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1. Be in writing;
2. Include appropriate identifying data such as the name of the licensee or registrant, the name of the individual, and the individual's identification number, preferably social security number;
3. Include the individual's exposure information; and
4. Contain the following statement:

"This report is furnished to you under the provisions of 180 NAC 10. You should preserve this report for further reference."

10-004.02 Each licensee or registrant shall furnish each worker annually a written report of the worker's dose as shown in records maintained by the licensee or registrant pursuant to 180 NAC 4-050.

10-004.03 Each licensee or registrant shall furnish a written report of the worker's exposure to sources of radiation at the request of a worker formerly engaged in activities controlled by the licensee or registrant. The report shall include the dose record for each year the worker was required to be monitored pursuant to 180 NAC 4-022. Such report shall be furnished within 30 days from the date of request, or within 30 days after the dose of the individual has been determined by the licensee or registrant, whichever is later. The report shall cover the period of time that the worker's activities involved exposure to sources of radiation and shall include the dates and locations of work under the license or registration in which the worker participated during this period.

10-004.04 Each licensee or registrant shall furnish to each worker a report of the worker's results of any measurements, analyses and calculations of radioactive material deposited or retained in the body. Such report shall be furnished to the worker within 30 days of such determination by the licensee or registrant.

10-004.05 When a licensee or registrant is required pursuant to 180 NAC 4-056, 4-057, or 4-058 to report to the Agency any exposure of an individual to sources of radiation, the licensee or the registrant shall also provide the individual a written report on the exposure data included therein. Such reports shall be transmitted at a time not later than the transmittal to the Agency.

10.004.06 At the request of a worker who is terminating employment with the licensee or registrant in work involving exposure to radiation or radioactive material, during the current year, each licensee or registrant shall provide at termination to each such worker, or to the worker's designee, a written report regarding the radiation dose received by that worker from operations of the licensee or registrant during the current year or fraction thereof. If the most recent individual monitoring results are not available at that time, a written estimate of the dose shall be provided together with a clear indication that this is an estimate.

10-005 PRESENCE OF REPRESENTATIVES OF LICENSEES OR REGISTRANTS AND WORKERS DURING INSPECTION

10-005.01 Each licensee or registrant shall afford to the Agency at all reasonable times opportunity to inspect materials, machines, activities, facilities, premises, and records pursuant to Title 180.

10-005.02 During an inspection, Agency inspectors may consult privately with workers as specified in 180 NAC 10-006. The licensee or registrant may accompany Agency inspectors during other phases of an inspection.

10-005.03 If, at the time of inspection, an individual has been authorized by the workers to represent them during Agency inspections, the licensee or registrant shall notify the inspectors of such authorization and shall give the workers' representative an opportunity to accompany the inspectors during the inspection of physical working conditions.

10-005.04 Each workers' representative shall be routinely engaged in work under control of the licensee or registrant and shall have received instructions as specified in 180 NAC 10-003.

10-005.05 Different representatives of licensees or registrants and workers may accompany the inspectors during different phases of an inspection if there is no resulting interference with the conduct of the inspection. However, only one workers' representative at a time may accompany the inspectors.

10-005.06 With the approval of the licensee or registrant and the workers' representative, an individual who is not routinely engaged in work under control of the licensee or registrant, for example, a consultant to the licensee or registrant or to the workers' representative, shall be afforded the opportunity to accompany Agency inspectors during the inspection of physical working conditions.

10-005.07 Notwithstanding the other provisions of 180 NAC 10-005, Agency inspectors are authorized to refuse to permit accompaniment by any individual who deliberately interferes with a fair and orderly inspection. With regard to any area containing proprietary information, the workers' representative for that area shall be an individual previously authorized by the licensee or registrant to enter that area.

#### 10-006 CONSULTATION WITH WORKERS DURING INSPECTIONS

10-006.01 Agency inspectors may consult privately with workers concerning matters of occupational radiation protection and other matters related to applicable provisions of Title 180 and licenses to the extent the inspectors deem necessary for the conduct of an effective and thorough inspection.

10-006.02 During the course of an inspection any worker may bring privately to the attention of the inspectors, either orally or in writing, any past or present condition which the worker has reason to believe may have contributed to or caused any violation of the Act, Title 180, or license condition, or any unnecessary exposure of an individual to sources of radiation under the licensee's or registrant's control. Any such notice in writing shall comply with the requirements of 180 NAC 10-007.01.

10-006.03 The provisions of 180 NAC 10-006.02 shall not be interpreted as authorization to disregard instructions pursuant to 180 NAC 10-003.

#### 10-007 REQUESTS BY WORKERS FOR INSPECTIONS

10-007.01 Any worker or representative of workers who believes that a violation of the Act, Title 180 or license conditions exists or has occurred in work under a license or registration to radiological working conditions in which the worker is engaged, may request an inspection by giving notice of the alleged violation to the Agency. Any such notice shall be in writing, shall set forth the specific grounds for the notice, and shall be signed by the worker or representative of the workers. A copy shall be provided to the licensee or registrant by the Agency no later than at the time of inspection except that, upon the request of the worker giving such notice, his name and the name of individuals referred to therein shall not appear in such copy or on any record published, released, or made available by the Agency, except for good cause shown.

10-007.02 If, upon receipt of such notice, the Agency determines that the complaint meets the requirements set forth in 180 NAC 10-007.01, and that there are reasonable grounds to believe that the alleged violation exists or has occurred, he shall cause an inspection to be made as soon as practicable, to determine if such alleged violation exists or has occurred. Inspections pursuant to 180 NAC 10-007 need not be limited to matters referred to in the complaint.

10-007.03 No licensee, registrant, or contractor or subcontractor of a licensee or registrant shall discharge or in any manner discriminate against any worker because such worker has filed any complaint or instituted or caused to be instituted any proceeding under Title 180 or has testified or is about to testify in any such proceeding or because of the exercise by such worker on behalf of himself or others of any option afforded by 180 NAC 10.

#### 10-008 INSPECTIONS NOT WARRANTED; INFORMAL REVIEW

10-008.01 Review of determination that no inspection is warranted.

1. If the Agency determines, with respect to a complaint under 180 NAC 10-007, that an inspection is not warranted because there are no reasonable grounds to believe that a violation exists or has occurred, the Agency shall notify the complainant in writing of such determination. The complainant may obtain review of such determination by submitting a written statement of position to the Director of Regulation and Licensure, who will provide the licensee or registrant with a copy of such statement by certified mail, excluding, at the request of the complainant, the name of the complainant. The licensee or registrant may submit an opposing written statement of position to the Director of Regulation and Licensure, will provide the complainant with a copy of such statement by certified mail.
2. Upon the request of the complainant, the Director of Regulation and Licensure, may hold an informal conference in which the complainant and the licensee or registrant may orally present their views. An informal conference may also be held

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at the request of the licensee or registrant, but disclosure of the identity of the complainant will be made only following receipt of written authorization from the complainant. After considering all written and oral views presented, the Director of Regulation and Licensure, shall affirm, modify, or reverse the determination of the Agency and furnish the complainant and the licensee or registrant a written notification of the decision and the reason therefor.

10-008.02 If the Agency determines that an inspection is not warranted because the requirements of 180 NAC 10-007.01 have not been met, he shall notify the complainant in writing of such determination. Such determination shall be without prejudice to the filing of a new complaint meeting the requirements of 180 NAC 10-007.01.

Department of Health and Human Services Regulation and Licensure  
Public Health Assurance Division  
301 Centennial Mall South  
Lincoln, Nebraska 68509

## **NOTICE TO EMPLOYEES**

Standards for Protection Against Radiation; Notices,  
Instructions and Reports to Workers; Inspections

In Title 180, Regulations for Control of Radiation, the Nebraska Department of Health and Human Services Regulation and Licensure has established standards for your protection against radiation hazards and has established certain provisions for the options of workers engaged in work under an agency license or registration.

### **YOUR EMPLOYER'S RESPONSIBILITY:**

Your Employer is Required to:

1. Apply these regulations to work involving sources of radiation.
2. Post or otherwise make available to you a copy of Title 180, Nebraska Regulations for Control of Radiation, and the operating procedures which apply to work you are engaged in, and explain their provisions to you.
3. Post any Notice of Violation involving radiological working conditions, proposed imposition of civil penalties or orders.

### **YOUR RESPONSIBILITY AS A WORKER:**

You should familiarize yourself with those provisions of Title 180, Nebraska Regulations for Control of Radiation and operating procedures which apply to the work in which you are engaged. You should observe their provisions for your own protection and protection of your co-worker.

### **WHAT IS COVERED BY THESE REGULATIONS:**

1. Limits on exposure to radiation and radioactive material in restricted and unrestricted areas;
2. Measures to be taken after accidental exposure;
3. Personnel monitoring, surveys and equipment;
4. Caution signs, labels, and safety interlock equipment;
5. Exposure records and reports; and
6. Options for workers regarding Agency Inspections; and
7. Related matters.

### **REPORTS ON YOUR RADIATION EXPOSURE HISTORY:**

1. The Title 180, Regulations for Control of Radiation require that your employer give you a written report if you receive an exposure in excess of any applicable limit as set forth in the regulations or in any license. The basic limits for exposure to employees are set forth in 180 NAC 4-005, 4-011 and 4-012. These sections specify limits on exposure to radiation and exposure to concentrations of radioactive material in air.
2. If you work where personnel monitoring is required:
  - (a) Upon your request, your employer must give you a written report of your radiation exposures upon termination of your employment; and
  - (b) Your employer must advise you annually of your exposure to radiation.

### **INSPECTIONS:**

All licensed or registered activities are subject to inspection by representatives of the Department of Health and Human Services Regulation and Licensure, Public Health Assurance Division. In addition, any worker or representative of workers who believes that there is a violation of the Nebraska Radiation Control Act, the regulations issued thereunder, or the terms of the employer's license or registration with regard to radiological working conditions in which the worker is engaged, may request an inspection by sending a notice of the alleged violation to the Department of Health and Human Services Regulation and Licensure. The request must set forth the specific grounds for the notice, and must be signed by the worker as representative of the workers. During inspections, Agency inspectors may confer privately with workers, and any worker may bring to the attention of the inspectors any past or present condition which he/she believes contributed to or caused any violation as described above.

### **POSTING REQUIREMENTS**

Copies of this notice must be posted in a sufficient number of places in every establishment where employees are employed in activities licensed or registered, pursuant to 180 NAC 2 and 180 NAC 3 by the Nebraska Department of Health and Human Services Regulation and Licensure, to permit employees working in or frequenting any portion of a restricted area to observe a copy on the way to or from their place of employment.

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180 NAC 11

TITLE 180 CONTROL OF RADIATION

CHAPTER 11 REQUIREMENTS FOR RADON AND RADON PROGENY  
MEASUREMENT AND MITIGATION SERVICES

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FORMS

Radon Specialist or Technician License Application  
Radon Business License Application

ATTACHMENTS

Attachment 11-1 EPA 402-R-92-003 Protocols for Radon Decay Product Measurements  
in Homes  
Attachment 11-2 EPA 402-R-93-078 Radon Mitigation Standards (RMS)

**NOTE:** If you have any questions about 180 NAC 11 please contact:

Department of Health and Human Services Regulation and Licensure  
Public Health Assurance Division  
Environmental Disease & Vector Surveillance – Radon Program  
P.O. Box 95007  
Lincoln, NE 68509  
(402)471-0594

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TITLE 180

CONTROL OF RADIATION

CHAPTER 11

REQUIREMENTS FOR RADON AND RADON PROGENY  
MEASUREMENT AND MITIGATION SERVICES

### 11-001 SCOPE AND AUTHORITY

11-001.01 180 NAC 11 provides for the licensure of radon measurement specialists, radon measurement technicians, radon measurement businesses, radon mitigation specialists, radon mitigation technicians, and radon mitigation businesses. The regulations are authorized by and implement the Nebraska Radiation Control Act, Neb. Stat. Rev. sections 71-3501 to 3519.

11-001.02 In addition to the requirements of 180 NAC 11, all licensees are subject to 180 NAC 1, 4, 10, 17 and 18; and 3-010, 3-011.02 and 3-011.03, 3-018, 3-019, 3-020 and 3-021.

11-002 DEFINITIONS: As used in 180 NAC 11, the following definitions apply.

Diagnostic Tests means tests performed or procedures used to determine appropriate radon mitigation systems for a building.

Mitigation means any action taken to reduce radon or radon progeny concentrations in the indoor atmosphere or to prevent entry of radon or radon progeny into the atmosphere, to include but not be limited to, application of materials, installation of systems, or any repair or alteration of a building or design.

Mitigation System means any system or materials installed for the purpose of reducing radon or radon progeny concentrations.

Picocurie per liter (pCi/l) means 2.22 transformations per minute of radioactive material per liter of air.

Radon means the radioactive noble gas radon-222 (Rn-222) and as used in these regulations includes radon progeny (see 180 NAC 11-002.12).

Radon Measurement Business means a person, including a laboratory, who analyzes or tests for and measures radon or radon progeny concentrations and which employs one or more radon measurement specialist.

Radon Measurement Specialist means an individual who performs radon or radon progeny measurements; or provides professional advice on radon or radon progeny measurements, health

risks, radon-related exposure, radon entry routes, or other radon-related activities; and may perform the duties of a radon measurement technician.

Radon Measurement Technician means an individual who performs radon or radon progeny measurement activities or provides information on test results.

Radon Mitigation Business means a person that mitigates radon.

Radon Mitigation Specialist means an individual who designs mitigation systems, or an individual who performs and evaluates diagnostic tests to determine appropriate radon or radon progeny mitigation systems and may perform the duties of a radon mitigation technician.

Radon Mitigation Technician means an individual who installs or supervises the installation of radon or radon progeny mitigation systems on existing buildings.

Radon Progeny means the short-lived radionuclides formed as a result of the decay of radon-222, including polonium-218, lead-214, bismuth-214, and polonium-214.

Working Level (WL) means the concentration of short-lived radon progeny that will result in 1.3E + 5 million electron volts of potential alpha particle energy per liter of air.

#### 11-003 EXEMPTIONS

11-003.01 The licensure requirements of 180 NAC 11 shall not apply to:

1. Individuals measuring or mitigating the premises in which they reside.
2. Federal, state, county and local health departments and their employees who provide professional advice on radon measurement or mitigation activities in the course of their assigned duties.
3. County extension agents and specialists of the Cooperative Extension Service of the University of Nebraska who provide professional advice on radon measurement or mitigation activities in the course of their assigned duties.

#### 11-004 GENERAL PROVISIONS

11-004.01 Beginning on October 30, 1996, no person may provide services for the measurement or mitigation of the presence of radon in the State of Nebraska unless such person has been licensed as provided in 180 NAC 11. These regulations in no way exempt any person from other state or local occupational licensure requirements.

11-004.02 Any person who is informed of the results of radon measurements must also be informed of the date of the test, name, and license number of the person who made the measurements.

11-004.03 No license shall be approved unless the following conditions have been met:

1. The applicant has not been found to be in violation of the Act, or 180 NAC 11 and has not had a license or certification terminated.
2. The applicant has filed an accurate and complete license application with the license fee.
3. The applicant is qualified to perform the activities for which she/he is seeking licensure, including the training and experience required in 180 NAC 11 and that

the applicant's proposed equipment and procedures are adequate to minimize danger to the public health and safety or property and are in compliance with municipal, county, state and federal laws and regulations.

11-004.04 Requirements for continued licensure shall include, at a minimum, the following conditions:

1. The licensee shall conduct his/her activities as described in the approved license and in accordance with provisions of the Act, all sections of these regulations, and all other related municipal, county, state, and federal laws and regulations.
2. The licensee shall allow authorized representatives of the Agency to have access during normal business hours to his/her facilities, offices and files for inspection and examination of radon-related records and test procedures. The licensee shall also allow authorized representatives of the Agency to accompany him/her while performing any radon measurement or mitigation activities for the purpose of inspecting these activities, with the approval of the property owner or resident on whose property such activity is being performed.
3. The licensee shall remain in compliance with the Act, and 180 NAC 11. Any changes in the information provided in the original or renewal application, including changes in licensed personnel, shall be submitted as an amendment request to the Agency for approval prior to implementation.

11-004.05 A license will be valid for one year following the date of issuance. No radon measurement or mitigation activity shall be conducted after the expiration of the term of the license.

11-004.06 An application for annual license renewal shall be made on the same form, as that required for initial licensure and shall be accompanied by the fee specified in 180 NAC 11-015. A license renewal shall be issued or denied according to the criteria set forth in 180 NAC 11.

11-004.07 Applications for initial and renewal license shall be submitted along with the fees specified in 180 NAC 11-015 to the Department of Health and Human Services Regulation and Licensure, P.O. Box 95007, Lincoln, NE 68509-5007. Checks or money orders shall be made payable to Department of Health and Human Services Regulation and Licensure.

11-004.08 All applications should clearly label any information considered proprietary and segregate such information from non-proprietary information to the extent possible (Neb. Rev. Stat. Subsection 84-712.05(3) and Neb. Rev. Stat. Subsection 87-502).

#### 11-005 LICENSE REQUIREMENTS FOR RADON MEASUREMENT SPECIALISTS

11-005.01 The following qualifications are required for licensure as a radon measurement specialist:

1. The individual shall submit an application that contains the following information to the Agency, along with the fee specified in 180 NAC 11-015.
  - a. Applicant name, mailing address (including city, state, ZIP) and phone number.
  - b. Radon related education, training and experience (including copies of certificates or letters of successful completion).

2. The individual shall have one year's experience in radiation or radioactivity measurements or any combination of two years of relevant college education or relevant work experience.
  - a. Relevant college education means a curriculum in physical sciences, biological sciences or engineering. Upon application the Agency may approve a related discipline.
  - b. Relevant work experience means the use of equipment to conduct measurement or analysis of a technical or environmental nature.
3. The individual shall have successfully completed a training course and passed an examination on radon measurements, approved by the Agency.
4. The individual shall participate in a radon proficiency program that the Agency has determined to meet the requirements of 180 NAC 11-012.

#### 11-006 LICENSE REQUIREMENTS FOR RADON MEASUREMENT TECHNICIANS

11-006.01 The following qualifications are required for licensure as a radon measurement technician.

1. The individual shall submit an application that contains the following information to the Agency, along with the fee specified in 180 NAC 11-015.
  - a. Applicant name, mailing address (including city, state, ZIP) and phone number.
  - b. Radon related education, training and experience (including copies of certificates or letters of successful completion).
2. The individual shall have at least six months of experience in radiation or radioactivity measurements or any combination of one year of relevant college education or relevant work experience.
  - a. Relevant college education means a curriculum in physical sciences, biological sciences or engineering. Upon application the Agency may approve a related discipline.
  - b. Relevant work experience means the use of equipment to conduct measurement or analysis of a technical or environmental nature.
3. The individual shall have successfully completed a training course and passed an examination on radon measurements approved by the Agency.
4. The individual shall participate in a radon proficiency program that the Agency has determined to meet the requirements of 180 NAC 11-012.

#### 11-007 LICENSE REQUIREMENTS FOR RADON MITIGATION SPECIALIST

11.007.01 The following qualifications are required for licensure as a radon mitigation specialist:

1. The individual shall submit an application that contains the following information to the Agency, along with the fee specified in 180 NAC 11-015.

- a. Applicant name, mailing address (including city, state, ZIP) and phone number.
  - b. Radon related education, training and experience (including copies of certificates or letters of successful completion).
2. The applicant shall possess any combination of two years of relevant college education or relevant work experience.
    - a. Relevant college education means a curriculum in architecture, engineering, physical sciences, or related disciplines. A year of college education shall consist of a minimum of 24 credit hours or equivalent.
    - b. Relevant work experience means the design, construction and renovation of buildings, or associated heating, ventilation, and air conditioning systems.
  3. The individual shall have successfully completed a training course and passed an examination on radon measurement and mitigation approved by the Agency.
  4. The individual shall participate in a radon proficiency program that the Agency has determined to meet the requirements of 180 NAC 11-012.

#### 11-08 LICENSE REQUIREMENTS FOR RADON MITIGATION TECHNICIANS

11-008.01 The following qualifications are required for licensure as a radon mitigation technician.

1. The individual shall submit an application that contains the following information to the Agency, along with the fee specified in 180 NAC 11-015.
  - a. Applicant name, mailing address (including city, state, ZIP) and phone number.
  - b. Radon related education, training and experience (including copies of certificates or letters of successful completion).
2. The individual shall have attained a minimum of one year experience in the building or construction trades. For purposes of 180 NAC 11, experience in the installation of mitigation systems under the supervision of a radon mitigation specialist shall qualify as building experience.
3. The individual shall have successfully completed a training course and passed examination on radon mitigation approved by the Agency.

#### 11-009 LICENSE REQUIREMENTS FOR RADON MEASUREMENT BUSINESSES

11-009.01 The following are the requirements for licensure as a radon measurement business:

1. Submission of an application for a license which contains the Applicant name, business name, mailing address (including city, state, ZIP) and phone number to the Agency, along with the fee specified in 180 NAC 11-015.
2. Description of all radon and radon measurement techniques or related services to be offered, including the purpose of each measurement service, the type and

purpose of measurement equipment to be used in performing the service, and an explanation of how that equipment and procedure will meet the intended purpose.

3. Identification of radon measurement specialists and radon measurement technicians to be used by the applicant. An applicant shall maintain on staff or retain as a consultant a radon measurement specialist. All radon testing will be performed only by radon measurement specialists or radon measurement technicians. This shall include the initial placement and final retrieval of all measurement devices. The radon measurement specialist shall direct the applicant's measurement activities and shall review, approve, sign, and submit monthly reports to the Agency containing the information specified in 180 NAC 11-013.01, inform clients of radon levels in accordance with the provisions of 180 NAC 011-013, assess quality assurance and quality control measures, evaluate operating procedures, and ensure compliance with state and federal regulations. The radon measurement specialist shall be present during scheduled visits by the Agency and shall physically observe each radon measurement technician in the performance of his/her measurement duties at least once each calendar quarter to ensure adequate supervision. If no radon measurements are performed during an entire calendar quarter by any of the radon measurement technicians working for a radon measurement business, the visit and observation by the specialist are not required for that quarter. The absence of radon measurements must be reported monthly to the Agency. The quarterly visit and observations by the specialist must be resumed within the same calendar quarter in which measurement activities are resumed. The interval between visits and observations by the specialist shall not exceed one year.
4. If a radon measurement business loses its radon measurement specialist, the radon measurement business shall notify the agency in writing within five business days. The radon measurement business shall obtain another radon measurement specialist within 30 days of the loss of the radon measurement specialist. Under this provision, the certified radon measurement business shall not operate more than 60 days in any one calendar year without a radon measurement specialist.
5. Identification of the analytical laboratory to be used that has been determined proficient by the Agency. The radon measurement business shall notify the Agency in writing within five business days of any change in the analytical laboratory used.
6. Development, disclosure, and adherence to a plan of quality control for each service and technique provided by the applicant to assure the reliability and validity of radon measurements.
7. Disclosure of all sample reporting forms mailed to clients, including any guidance provided concerning the need for further measurement or mitigation.
8. Disclosure of copies of current publications and advertisements of radon-related services made by the applicant.
9. Development, disclosure, and adherence to a health and safety program to determine employees' exposure to radon during the course of employment. Such

a program shall include measures to keep each employee's exposure as low as reasonably achievable.

10. Maintenance of the following records for five years:
  - a. Records of all radon tests performed;
  - b. Records of instrument calibrations and quality control;
  - c. Records of participation in a proficiency program;
  - d. Records of employee exposure;
  - e. Copies of licenses for radon measurement specialists and radon measurement technicians employed or used as consultants.

#### 11-010 LICENSE REQUIREMENTS FOR RADON MITIGATION BUSINESSES

11-010.01 The following are the requirements for licensure as a radon mitigation business:

1. Submission of an application for a license which contains the Applicant name, business name, mailing address (including city, state, ZIP) and phone number to the Agency, along with the fee specified in 180 NAC 11-015.
2. Description of all mitigation materials and systems offered, diagnostic tests performed, and other related services offered.
3. Identification of the radon mitigation specialists and radon mitigation technicians to be used by the business.
4. Identification of procedures and instrumentation used to perform diagnostic tests.
5. Disclosure of all reporting forms mailed to clients.
6. Disclosure of copies of current publications and advertisements of radon-related services made by the applicant.
7. Development, disclosure, and adherence to a health and safety program to limit employees' exposure to radon during the course of their employment. Such a program shall include measures to keep each employee's exposure as low as reasonably achievable.
8. The radon mitigation business shall maintain on staff or retain as a consultant a radon mitigation specialist. The radon mitigation specialist shall direct the applicant's mitigation activities, and shall review, approve, sign, and submit monthly reports to the Agency containing the information specified in 180 NAC 11-013.04, evaluate operating procedures, ensure compliance with state and federal regulations, and be responsible for evaluating diagnostic tests in a building and designing mitigation systems. The mitigation specialist shall be present during scheduled visits by the agency and shall physically observe each radon mitigation technician in the performance of his/her mitigation duties at least once each calendar quarter to ensure adequate supervision.
9. If a radon mitigation business loses its radon mitigation specialist, the radon mitigation business shall notify the agency in writing within five business days. The radon mitigation business shall obtain another radon mitigation specialist within 30 days of the loss. Under this provision, the radon mitigation business shall not operate more than 60 days in any one calendar year without a radon mitigation specialist. If no radon mitigation activities are performed during an entire calendar quarter by any of the radon mitigation technicians working for a radon mitigation business, the visit and observation by the specialist are not required for that quarter. The absence of radon mitigation activities must be reported monthly to the Agency. The quarterly visit and observations by the

- specialist must be resumed within the same calendar quarter in which mitigation activities are resumed. The interval between visits and observations by the specialist shall not exceed one year.
10. The radon mitigation business shall assure that radon mitigation system installations are performed under the supervision of a radon mitigation specialist or radon mitigation technician.
  11. The radon mitigation business shall provide all warranty information on the reduction of the radon level, or the proper functioning of mitigation equipment in writing to clients. If a firm warrants a system, the warranty must be honored and the precise coverage shall be explicitly stated in the contract offered to the client. Nothing in 180 NAC 011-010.01, item 11. shall limit warranties applicable to any client pursuant to any state or federal law.
  12. The radon mitigation business shall maintain at a minimum the following records for five years:
    - a. Records of all mitigation work performed, including client name, address, initial and follow-up test results, diagnostic test results, a description of each mitigation system and materials installed, post-mitigation measurements including method of measurement and all pertinent dates.
    - b. Records of mitigation plans developed and signed by a radon mitigation specialist.
    - c. Records of all instrument calibrations and warranted equipment installed.
    - d. Copies of the licenses for radon mitigation specialists and radon mitigation technicians employed or used as consultants.

#### 11-011 MITIGATION SYSTEM INSTALLATION REQUIREMENTS

11-011.01 The mitigation specialist shall review and assess the quality of any previous radon measurements made by or for the client and ascertain whether or not these measurements were made in accordance with the requirements of 180 NAC 11-009.01, item 5 or 11-012.01. If the mitigation specialist determines that the procedures outlined in the regulations were not followed, the mitigation specialist shall advise the client of this and retesting shall be recommended.

11-011.02 The radon mitigation specialist or radon mitigation technician shall perform visual and diagnostic tests as appropriate before system installation to determine the appropriate mitigation system to be installed. Observations made during visual inspections shall be documented.

11-011.03 In dwellings with levels exceeding 100 pCi/l, the mitigation specialist shall advise the client of temporary measures that can be used to reduce occupant exposure until a permanent mitigation system is installed. This may include temporary measures such as natural ventilation, or mechanical ventilation with unconditioned outside air, or limiting the occupants' exposure by minimizing the time spent in areas of the home with elevated radon levels, or any measures which effectively minimize occupant exposure.

1. The mitigation specialist shall not install a temporary radon reduction system in lieu of a permanent mitigation system.
2. Temporary radon reduction systems shall be labeled as such. The notice shall contain the following information:

- a. The system should not be removed until a permanent mitigation system can be installed,
  - b. The permanent mitigation system should be installed within 30 days after the installation date of the temporary system, and
  - c. The mitigation business' name, license number, phone number, and the installation date.
3. If the equipment is not easily labeled, the notice shall be posted on the electric service panel, or other prominent location.

11-011.04 The mitigation business shall provide the following information to the client prior to initiating any work:

1. The mitigation business license number,
2. The scope of the work to be completed,
3. A statement indicating any known hazards associated with chemicals used in or as part of the installation,
4. A statement indicating compliance with provisions of the Act, Title 180, and all other related municipal, county, state and federal laws and regulations,
5. A statement indicating any required maintenance by the homeowner,
6. An estimate of the installation cost and annual operating cost of the system, and
7. Written instructions on the operation and maintenance of each component of the mitigation system.

11-011.05 The mitigation system shall be installed as a permanent, integral part of the building, unless an exemption is applied for and approved by the Agency. A permanent mitigation system shall include the following:

1. A mechanism to monitor system performance.
2. A label on all visible portions of the mitigation system to identify their function, including the system power or disconnect switch. One central label shall be placed on the mitigation system, electric panel or other prominent location and include a system description, a contact name and phone number.
3. If the mitigation system is designed to use fans for depressurization beneath a slab or membrane or within a block wall or drain tile system, the following conditions must be met:
  - a. The depressurization system fans shall not be installed in the conditioned (heated/cooled) space of a building, or in any basement, crawlspace, or other interior location directly beneath a conditioned space of a building.
  - b. Exhaust vents from depressurization system fans shall discharge according to all of the following requirements:
    - (1) The discharge point shall be ten feet or more above ground level,
    - (2) The discharge point shall be ten feet or more, measured directly (line-of-sight) from any window, door, or other openings in the structure (e.g., operable skylights or air intakes),
    - (3) The discharge point shall be ten feet or more away from any private or public access, and
    - (4) The discharge point shall be ten feet or more from any opening into an adjacent building.

11-011.06 The radon mitigation business shall ensure that each building is tested for radon levels before and after mitigation work is performed. Such tests shall be of sufficient type, duration and consistency to allow for comparison of before and after mitigation radon levels, and shall be performed by a radon measurement specialist. The post-mitigation test shall be started no sooner than 24 hours, nor longer than two weeks after mitigation. The results of both the pre-mitigation and the post-mitigation tests shall be sent to the Agency within 30 days. The mitigation business shall recommend retesting at least every two years. All measurements shall be conducted in accordance with the requirements of 180 NAC 11-012.01.

#### 11-012 RADON PROFICIENCY PROGRAM REQUIREMENTS

##### 11-012.01 Radon Measurement Proficiency

1. Require applicants to:
  - a. Submit and follow an approved quality assurance and quality control plan for the measurement device, including the use of duplicates, blanks, and spikes as described in the Protocols for Radon and Radon Decay Product Measurements in Homes, Publication No. EPA 402-R-93-003, June 1993, attached hereto as Attachment Number 11-1 and incorporated herein by this reference, and Indoor Radon and Radon Decay Product Measurement Device Protocols, Publication No. EPA 402-R-92-004, July 1992, incorporated herein by this reference and available for viewing at the Department of Health and Human Services Regulation and Licensure, 301 Centennial Mall South, 3rd Floor, Lincoln, Nebraska 68509-5007.
  - b. Have and use standard operating procedures (SOPs).
  - c. Provide proof of calibration(s) prior to use of the device.
2. Contain a requirement for continuing education.

##### 11-012.02 Radon Mitigation Proficiency:

1. Require applicants to follow the Radon Mitigation Standards, Publication No. EPA 402-R-93-078, October 1993 (Revised April 1994), attached hereto as Attachment Number 11-2 and incorporated herein by this reference.
2. Contain a requirement for continuing education.

#### 11-013 REPORTING REQUIREMENTS

11-013.01 A radon measurement business must submit to the Agency, by the 30th of each month, the results of all available radon measurements performed in the State of Nebraska during the previous month.

1. Residential radon measurement reports shall contain the following:
  - a. Name of property owner, street address (including city, state, and Zip Code) and phone number.
  - b. Type of building, type of foundation, type of heating system, number of lived-in stories, and number of livable stories.

- c. Name of person performing measurement, testing dates, total time of measurement in hours, location of test device (including story and room), type of test device, and radon test results.
  - d. Name and license number of radon measurement business and radon measurement specialist.
2. Nonresidential radon measurement reports shall contain the following:
- a. Name of facility, type of facility, street address (including city, state, and Zip Code) and phone number, name of contact person, name and phone number of property owner.
  - b. Number of buildings per address, number of stories, number of occupied stories, type of foundation, type of HVAC system.
  - c. Name of person performing measurement, testing dates, total time of measurement in hours, location of test device (including story and room), type of test device, and radon test results.
  - d. Name and license number of radon measurement business and radon measurement specialist.

11-013.02 Radon measurement businesses and radon mitigation businesses shall report test results for radon to the client. Radon results shall be reported in picocuries per liter. Radon progeny results shall be reported in working levels.

11-013.03 In addition, the radon measurement business shall notify the client by telephone and mail within two business days of any measurement with results equal to or greater than 100 pCi/l or 0.5 WL and advise the client to contact the Agency at 1-800-334-9491 or at other telephone numbers provided by the Agency. The results of this measurement shall also be provided to the Agency by phone and mailed within the same two-business day period.

11-013.04 The radon mitigation business shall submit to the Agency, by the 30th day of each month, a report on all mitigation work completed during the previous month, including the floor plans and equipment arrangement of the mitigation system, or modifications of existing systems, and the mitigation fee(s) (per installation) as specified in 180 NAC 11-015.07.

1. Residential radon mitigation reports shall contain the following:
  - a. Name of property owner, street address (including city, state, and Zip Code) and phone number.
  - b. Pre-mitigation testing dates, location of test device (including story and room), type of test device, radon test results, and measurement business responsible for tests (or occupant).
  - c. Post-mitigation testing dates, location of test device (including story and room), type of test device, radon test results, and measurement business responsible for tests (or occupant).
  - d. Date mitigation completed and type of mitigation system(s) installed.
  - e. Name and license number of radon mitigation business and radon mitigation specialist.
  
2. Nonresidential radon mitigation reports shall contain the following:

EFFECTIVE DATE  
JULY 22, 2001

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- a. Name of facility, building street address (including city, state, and Zip Code), name and phone number of contact person, number of stories and number of occupied stories in building; name, address and phone number of property owner.
- b. Pre-mitigation testing dates, location of test device (including story and room), type of test device, radon test results, and measurement business responsible for tests (or occupant).
- c. Post-mitigation testing dates, location of test device (including story and room), type of test device, radon test results, and measurement business responsible for tests (or occupant).
- d. Date mitigation completed and type of mitigation system(s) installed.
- e. Name and license number of radon mitigation business and radon mitigation specialist.

11-014 RECIPROCITY: A person who has a valid license or certification from a state which licenses or certifies persons who measure or mitigate radon in a certification or licensing program with requirements determined by the Agency as comparable with the provisions of this may be licensed by the Agency upon submission of an application as specified in 180 NAC 11-005, 11-006, 11-007, 11-008, 11-009, and 11-010, with a copy of the certification or license from the other state, along with the fee specified in 11-015.

11-015 FEES:

1. Radon Measurement Specialist		
	Initial Application Fee	\$ 50.00
	Annual Renewal Fee	\$ 50.00
2. Radon Measurement Technician		
	Initial Application Fee	\$ 50.00
	Annual Renewal Fee	\$ 50.00
3. Radon Mitigation Specialist		
	Initial Application Fee	\$ 50.00
	Annual Renewal Fee	\$ 50.00
4. Radon Mitigation Technician		
	Initial Application Fee	\$ 50.00
	Annual Renewal Fee	\$ 50.00
5. Radon Measurement Business (Annual) Fee		\$100.00
6. Radon Mitigation Business (Annual) Fee		\$250.00
7. Mitigation Fee per installation		\$ 50.00

# RADON SPECIALIST OR TECHNICIAN LICENSE APPLICATION

PER Title 180, Regulations for Control of Radiation, Chapter 11, Requirements for Radon and Radon  
Progeny Measurement and Mitigation Services.

**APPLICATION FOR:** (Check only one)

- RADON MEASUREMENT SPECIALIST                      180 NAC 11-005
- RADON MEASUREMENT TECHNICIAN                      180 NAC 11-006
- RADON MITIGATION SPECIALIST                      180 NAC 11-007
- RADON MITIGATION TECHNICIAN                      180 NAC 11-008

**TYPE OF LICENSE:** (Check appropriate item)

- NEW LICENSE
- RENEWAL OF LICENSE NUMBER \_\_\_\_\_

**PART I. APPLICANT INFORMATION**

Name \_\_\_\_\_

Permanent Mailing Address \_\_\_\_\_

City \_\_\_\_\_ State \_\_\_\_\_ Zip Code \_\_\_\_\_

Telephone Numbers    Home \_\_\_\_\_                      Work \_\_\_\_\_

E-Mail Address \_\_\_\_\_

**TRAINING:**

Name of Course	Dates of Attendance	Location
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

\* Attach a copy of your certificate or a letter of successful completion.

EXPERIENCE:

Name of Business	Name of Supervisor	Dates Employed

EDUCATION: (If applicable)

College or University	Dates of Attendance	Primary Course of Study Degree

\* Attach a copy of your transcript.

**PART II. CERTIFICATION**

I certify that this application has been prepared in accordance with 180 NAC, Regulations for Control of Radiation and all information contained herein, including any supplements attached hereto, is true and correct to the best of my knowledge and belief.

\_\_\_\_\_  
Signature of Applicant

\_\_\_\_\_  
Date

Send your letter of application, attachments and appropriate fee (See 180 NAC 11-015), with **check(s)** made payable to **Nebraska Department of Health and Human Services Regulation and Licensure** to:

Nebraska Radon Program  
NDHHS-R&L  
P.O. Box 95007  
301 Centennial Mall South  
Lincoln, NE 68509-5007

Omission of any of the required documents or incomplete information will delay review of your application and issuance of a license.

# RADON BUSINESS LICENSE APPLICATION

PER Title, Regulations for Control of Radiation, Chapter 11, Requirements for Radon and Radon Progeny Measurement and Mitigation Services

**APPLICATION FOR:** (Check only one)

**TYPE OF LICENSE:** (Check appropriate item)

RADON MEASUREMENT BUSINESS

NEW LICENSE

RADON MITIGATION BUSINESS

RENEWAL OF LICENSE # \_\_\_\_\_

## PART I. APPLICANT INFORMATION

Name of Applicant \_\_\_\_\_

Name of Business \_\_\_\_\_

Street Address \_\_\_\_\_

City \_\_\_\_\_ State \_\_\_\_\_ Zip Code \_\_\_\_\_

Telephone Numbers Phone \_\_\_\_\_ FAX \_\_\_\_\_

E-Mail Address \_\_\_\_\_

## **PART II. RADON MEASUREMENT BUSINESS**

Analytical Laboratories to Be Used

\_\_\_\_\_  
Name of Laboratory

\_\_\_\_\_  
Name of Laboratory

\_\_\_\_\_  
Street Address

\_\_\_\_\_  
Street Address

\_\_\_\_\_  
City State Zip Code

\_\_\_\_\_  
City State Zip Code

## PART III. ATTACHMENTS

\_\_\_\_\_ Attach a description of all radon measurement techniques and services offered, the purpose of each service, the type of measurement equipment, a summary of the procedure to be used, and an explanation of how that equipment and procedure will meet the intended purpose.

\_\_\_\_\_ Attach a copy of the licenses of all radon measurement specialists and technicians employed or used as consultants.

\_\_\_\_\_ Attach a description of the quality assurance and quality control plans for each service and technique provided.

- \_\_\_\_\_ Attach a sample copy of all reporting forms used to inform clients of measurement results, including any guidance concerning the need for further measurements or mitigation.
- \_\_\_\_\_ Attach a description of the health and safety program to estimate employees' exposure to radon during employment.

PART IV. RADON MITIGATION BUSINESS

**Licensed Radon Measurement Businesses and Specialists to Be Used**

_____			_____		
Name of Laboratory			Name of Laboratory		
_____			_____		
Street Address			Street Address		
_____			_____		
City	State	Zip Code	City	State	Zip Code

PART V. ATTACHMENTS

- \_\_\_\_\_ Attach a description of all mitigation materials and systems offered, diagnostic tests performed, and other related services.
- \_\_\_\_\_ Attach a description of procedures and instruments used to perform diagnostic tests.
- \_\_\_\_\_ Attach a copy of the licenses of all radon mitigation specialists and technicians employed or used as consultants.
- \_\_\_\_\_ Attach a sample copy of each reporting form given to clients.
- \_\_\_\_\_ Attach a description of the health and safety program to estimate employees' exposure to radon during employment.

**PART V. CERTIFICATION**

I certify that this application has been prepared in accordance with 180 NAC 1, Regulations for Control of Radiation and all information contained herein, including any supplements attached hereto, is true and correct to the best of my knowledge and belief.

\_\_\_\_\_  
Signature of Applicant

\_\_\_\_\_  
Date

Send your letter of application, attachments and appropriate fee (See 180 NAC 11-15), with check(s) made payable to **Nebraska Department of Health and Human Services Regulation and Licensure** to:  
Nebraska Radon Program  
NDHHS-R&L  
P.O. Box 95007  
301 Centennial Mall South  
Lincoln, NE 68509-5007

Omission of any of the required documents or incomplete information will delay review of your application and issuance of a license.

JULY 22, 2001

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**ATTACHMENT 11-1**

**EPA 402-R-92-003**

**Protocols for Radon Decay Product Measurements in Homes**

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**EPA 402-R-92-003**

**PROTOCOLS FOR  
RADON AND RADON DECAY PRODUCT  
MEASUREMENTS IN HOMES**

**June 1993**

**U.S. Environmental Protection Agency  
Office of Radiation and Indoor Air (6604J)  
401 M Street, S.W.  
Washington, D.C. 20460**

**180 NAC 11  
Attachment Number 11 - 1**

## Preface

This document, the *Protocols for Radon and Radon Decay Product Measurements in Homes* (EPA 402-R-92-003, May 1993), is a guidance document. However, one condition of participation in the Agency's National Radon Measurement Proficiency Programs for radon measurement and radon reduction (mitigation) proficiency, is conformance with these protocols. Conformance with its companion document, the *Indoor Radon and Radon Decay Product Measurement Device Protocols* (EPA 402-R-92-004, July 1992), is also a condition of participation in the Proficiency Programs.

Together these protocol documents provide the technical support for the Agency's radon policy and guidance to consumers that is contained in, but not limited to, the *Home Buyer's and Seller's Guide to Radon* (EPA 402-R-93-003, March 1993), *A Citizen's Guide to Radon* (EPA 402-K-92-001), and the *Consumer's Guide to Radon Reduction* (EPA 402-K-92-003, August 1992).

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## Section 1: INTRODUCTION

This document presents the U.S. Environmental Protection Agency's (EPA) technical guidance for measuring radon\* concentrations in residences. It contains protocols for measuring radon for the purpose of deciding on the need for remedial action, as presented in the 1992 *Citizen's Guide to Radon* (EPA 402-K-92-001; U.S. EPA 1992a), and in the *Home Buyer's and Seller's Guide to Radon* (EPA 402-R-93-003; U.S. EPA 1993).

The guidance for determining the need for mitigation is different in several key aspects from previously issued recommendations, and this document supersedes a previous report (EPA 520/1-86-014-1) published in February, 1987 (U.S. EPA 1987). The technical basis for these policy changes is supplied in the *Technical Support Document for the 1992 Citizen's Guide to Radon* (EPA 400-R-92-011; U.S. EPA 1992g), and the revised policies are described in *Section 2* of this report.

*Section 3* of this report describes the Agency's recommended protocols for measuring radon for a real estate transaction. This guidance elaborates on Agency recommendations published in the *Home Buyer's and Seller's Guide to Radon* (EPA 402-R-93-003; U.S. EPA 1993). The radon testing guidelines in the *Home Buyer's Guide* were developed specifically to deal with the time-sensitive nature of home purchases and sales and the potential for radon device interference. The guidelines are somewhat different from those in other EPA publications, such as the 1992 *Citizen's Guide to Radon* (EPA 402-K-92-001; U.S. EPA 1992a), which provide radon testing and reduction information for non-real estate situations. Therefore, *Sections 2* and *3* of this document will have different guidance for different situations.

This report is limited to discussions of Agency guidance regarding detector placement, measurement duration, multiple measurements, and the interpretation of measurement results. EPA has also issued a technical report describing measurement techniques, titled *Indoor Radon and Radon Decay Product Measurement Device Protocols* (EPA 520-402-R-92-004) and published in 1992 (U.S. EPA 1992c). That report provides technical information for measuring radon concentrations with continuous radon monitors, alpha track detectors, electret ion chambers, charcoal canisters, unfiltered alpha track detectors, and grab radon techniques; it also provides guidance for measuring radon decay product concentrations with continuous working level monitors, radon progeny integrating sampling units, and grab radon decay product techniques. Copies of the *Indoor Radon and Radon Decay Product Measurement Device Protocols* may be obtained by contacting your State or EPA Regional radon office (*Appendix A*). A list of EPA documents providing guidance on radon measurements appears in Exhibit 1-1.

---

\* The term "radon" refers to radon-222 and its decay products unless otherwise noted.

**Exhibit 1-1**

**EPA Documents\* Providing Guidance on Radon Measurements**

<b>Title of Document</b>	<b>EPA Document Number</b>
<i>A Citizen's Guide to Radon</i> (U.S. EPA 1992a)	EPA 402-K-92-001
<i>Consumer's Guide to Radon Reduction</i> (U.S. EPA 1992b)	EPA 402-K-92-003
<i>Indoor Radon and Radon Decay Product Measurement Device Protocols</i> (U.S. EPA 1992c)	EPA 520-402-R-92-004
<i>Interim Radon Mitigation Standards</i> (U.S. EPA 1992d)	Regional Training Centers (see below)
<i>Home Buyer's and Seller's Guide to Radon</i> (U.S. EPA 1993)	EPA 402-R-93-003
<i>Protocols for Radon and Radon Decay Product Measurements in Homes</i>	EPA 402-R-92-003

\* These documents are available from the U.S. Government Printing Office, Superintendent of Documents, Mail Stop: SSOP, Washington, D.C. 20402-9328; from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22151; or your State or EPA Regional radon office.

**EPA Regional Radon Training Centers:**

Eastern Regional Radon Training Center, Rutgers University; (908)-932-2582.

Southern Regional Radon Training Center, Auburn University; (205)-844-6271.

Western Regional Radon Training Center, Colorado State University; (303)-491-7742.

Northern Regional Radon Training Center, University of Minnesota; (612)-624-6786.

This report provides guidelines that are primarily intended to aid State radiation control programs, other organizations conducting indoor radon measurements, and homeowners who want detailed information on radon measurements. The guidelines herein can be adopted as part of a State program or can be provided by States to interested individuals as recommendations. Adherence to these guidelines is a requirement for participation in the National Radon Measurement Proficiency (RMP) Program (EPA 520/1-91-006; U.S. EPA 1991). The method designations used in the RMP Program are listed in Exhibit 1-2. A two-letter code for each method has been adopted, although ATDs (AT), RPISUs (RP), and EICs/ECs (ES or EL) may still be referred to by their traditional acronyms.

EPA recognizes that radon concentrations in buildings may vary over time (Arvela *et al.* 1988, Dudney *et al.* 1990, Fleischer and Turner 1984, Furrer *et al.* 1991, Gesell 1983, Harley 1991, Hess 1985, Martz *et al.* 1991, Nyberg and Bernhardt 1983, Perritt *et al.* 1990, Ronca-Battista and Magno 1988, Steck 1992, Stranden *et al.* 1979, Wilkening and Wicke 1986, Wilson *et al.* 1991). Furthermore, concentrations at different locations in the same house often vary by a factor of two or more (Arvela *et al.* 1988, Furrer *et al.* 1991, George *et al.* 1984, Hess 1985, Keller *et al.* 1984, Put and deMeijer 1988, Steck 1992). EPA has carefully evaluated these findings, as well as other factors (EPA 400-R-92-011; U.S. EPA 1992g), and has developed policies for ensuring that the most representative and useful information is supplied by the measurement results. These guidelines may be evaluated periodically and refined to reflect the increasing knowledge of, and experience with, indoor radon.

EPA recommends that initial measurements be short-term tests performed under closed-building conditions. An initial short-term test, which lasts for two to 90 days, ensures that residents are informed quickly should a home contain very high radon levels. Long-term tests give a better estimate of the year-round average radon level. The closer the long-term test is to 365 days, the more representative it will be of annual average radon levels.

**Exhibit 1-2**

**Radon and Radon Decay Product Measurement Method Abbreviations**

METHOD CATEGORY	Abbreviations	
	Common	RMP Method
Continuous Radon Monitors	CRM	CR
Alpha Track Detectors	ATD	AT
Electret Ion Chambers Short Term Long Term	EIC/EC	ES EL
Activated Charcoal Adsorption Devices (formerly called charcoal canisters)	CC	AC
Charcoal Liquid Scintillation	CLS	LS
Three-day Integrating Evacuated Scintillation Cells		SC
Pump/Collapsible Bag Devices (24 hour sample)		PB
Grab Radon Sampling Scintillation Cells Activated Charcoal Pump-Collapsible Bag		GS GC GB
Unfiltered Track Detectors	UTD	UT
Continuous Working Level Monitors	CWLM	CW
Radon Progeny Integrating Sampling Units	RPISU	RP
Grab Sampling - Working Level		GW

## Section 2: DISCUSSION OF GUIDELINES PRESENTED IN THE CITIZEN'S GUIDE TO RADON

### 2.1 INTRODUCTION AND SUMMARY

The *Citizen's Guide to Radon* (EPA 402-K-92-001; U.S. EPA 1992a) presents a measurement strategy for assessing radon levels in homes for the purpose of determining the need for remedial action. This measurement strategy is intended to reduce the risk to public health from exposure to radon in air in homes. The strategy begins with an initial measurement made to determine whether a home may contain radon concentrations sufficient to cause high exposures to its occupants.

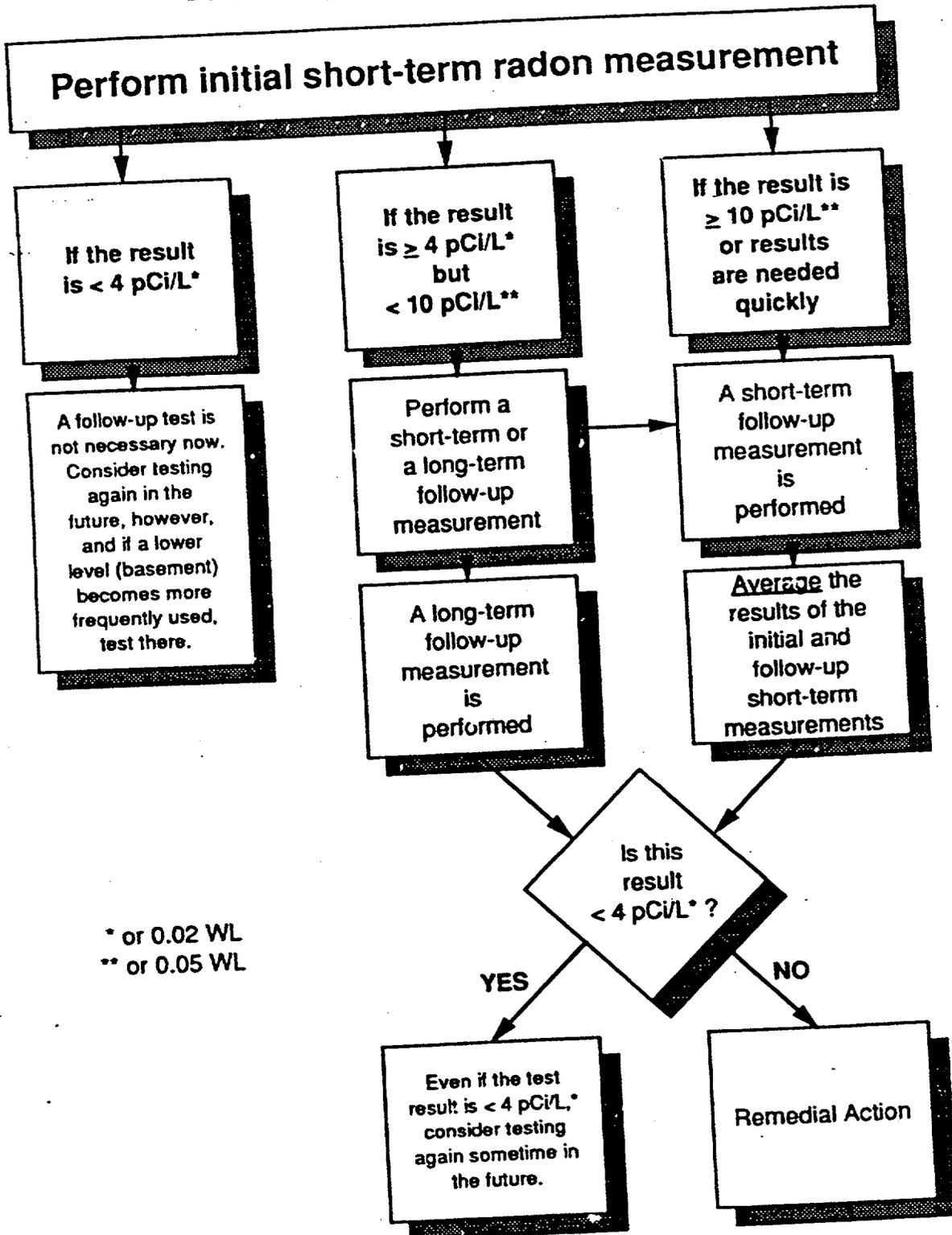
EPA recommends that initial measurements be short-term tests placed in the lowest lived-in level of the home, and performed under closed-building conditions. An initial short-term test ensures that residents are informed quickly should a home contain very high levels of radon. Short-term tests are conducted for two days to 90 days. Closed-building conditions (*Section 2.3.2*) should be initiated at least 12 hours prior to testing for measurements lasting less than four days, and are recommended prior to tests lasting up to a week.

If the short-term measurement result is equal to or greater than 4 picocuries per liter (pCi/L), or 0.02 working levels (WL), a follow-up measurement is recommended. Follow-up measurements are conducted to confirm that radon levels are high enough to warrant mitigation. If the result of the initial measurement is below 4 pCi/L, or 0.02 WL, a follow-up test is not necessary. However, since radon levels change over time, the homeowner may want to test again sometime in the future, especially if living patterns change and a lower level of the house becomes occupied or used regularly.

There are two types of follow-up measurements that may be conducted, and the choice depends, in part, on the results of the initial test. An initial measurement result of 10 pCi/L (or 0.05 WL) or greater should be followed by a second short-term test under closed-building conditions. If the result of the initial measurement is between 4 pCi/L (or 0.02 WL) and 10 pCi/L (or 0.05 WL), the follow-up test may be made with either a short-term or a long-term method. Long-term tests are conducted for longer than 90 days, and give a better estimate of the year-round average radon level. The closer the long-term measurement is to 365 days, the more representative it will be of annual average radon levels. On the other hand, short-term tests yield results more quickly and can be used to make mitigation decisions. If the long-term follow-up test result is 4 pCi/L, or 0.02 WL, or higher, EPA recommends remedial action. If the average of the initial and second short-term results is equal to or greater than 4 pCi/L, or 0.02 WL, radon mitigation is recommended. These recommendations are summarized in Exhibit 2-1.

Exhibit 2-1

Recommended Testing Strategy for Determining the Need for Mitigation in Homes



\* or 0.02 WL  
\*\* or 0.05 WL

In certain instances, such as may occur when measurements are performed in different seasons or under different weather conditions, the initial and follow-up tests may vary by a considerable amount. Radon levels can vary significantly between seasons, so different values are to be expected. The average of the two short-term test results can be used to determine the need for remedial action.

The testing strategy policies presented here allow homeowners to decide on the need for mitigation with a high level of confidence that their decision is correct (EPA 400-R-92-011; U.S. EPA 1992g).

## 2.2 MEASUREMENT LOCATION

Short-term or long-term measurements should be made in the **lowest lived-in level** of the house. The following criteria should be used to select the location of the detectors within a room on this level:

- The measurements should be made in the lowest level which contains a room that is used regularly. Test areas include family rooms, living rooms, dens, playrooms, and bedrooms. A bedroom on the lower level may be a good choice, because most people generally spend more time in their bedrooms than in any other room in the house (Chapin 1974, Moeller and Underhill 1976, Szalai 1972). If there are children in the home, it may be appropriate to measure the radon concentration in their bedrooms or in other areas where they spend a lot of time, such as a playroom, that are situated in the lowest levels of the home.
- In general, measurements should not be made in kitchens, laundry rooms, or bathrooms. The measurements should not be made in a kitchen because of the likelihood that an exhaust fan system and changes in small, airborne particles (caused by cooking) may affect the stability of WL measurements. Measurements should not be made in a bathroom because relatively little time is spent in a bathroom, because high humidities may affect the sensitivity of some detectors, and because of the likelihood that use of a fan may temporarily alter radon or decay product levels.

Although radon in water may be a contributor to the concentration of airborne radon, radon in air should be measured before any diagnostic radon-in-water measurements are made. (Diagnostic measurements may be made in the bathroom; however, such diagnostic measurements should not be used to determine the need for mitigation.)

- A position should be selected where the detector will not be disturbed during the measurement period and where there is adequate room for the device.
- The measurement should not be made near drafts caused by heating, ventilating and air conditioning vents, doors, fans, and windows. Locations near heat, such as on appliances, near fireplaces or in direct sunlight, and areas of high humidity should be avoided.
- Because some detectors are sensitive to increased air motion, fans should not be operated in the test area. Forced air heating or cooling systems should not have the fan operating continuously unless it is a permanent setting.
- The measurement location should not be within 90 centimeters (three feet) of the doors and windows or other potential openings to the outdoors. If there are no doors or windows to the outdoors, the measurement should not be within 30 centimeters (one foot) of the exterior wall of the building.
- The detector should be at least 50 centimeters (20 inches) from the floor, and at least 10 centimeters (four inches) from other objects. For those detectors that may be suspended, an optimal height is in the general breathing zone, such as two to 2.5 meters (about six to eight feet) from the floor.

Sound judgement is required as to what space actually constitutes a room. Measurements made in closets, cupboards, sumps, crawl spaces, or nooks within the foundation should not be used as a representative measurement.

## **2.3 INITIAL MEASUREMENTS**

### **2.3.1 Rationale**

EPA recommends that a homeowner assessing the need for mitigation should first make a short-term test. Short-term measurements can be simple, produce results quickly, and allow the public to make decisions about radon reduction that are cost-effective and protective of human health.

The duration of short-term measurements can range from 48 hours to 90 days, depending upon the method used.

### **2.3.2 Closed-Building Conditions**

Short-term measurements lasting between two and 90 days should be made under closed-building conditions. Closed-building conditions are necessary for short-term measurements in order to stabilize the radon and radon decay product concentrations and increase the reproducibility of the measurement. Windows on all levels and external doors should be kept closed (except during normal entry and exit) during the measurement period. Normal entry and exit include a brief opening and closing of a door, but--to the extent possible--external doors should not be left open for more than a few minutes. In addition, external-internal air exchange systems (other than a furnace) such as high-volume, whole-house and window fans should not be operating. However, attic fans intended to control attic and not whole building temperature or humidity should continue to operate. Combustion or make-up air supplies must not be closed.

In addition to maintaining closed-building conditions during the measurement, closed-building conditions for 12 hours prior to the initiation of the measurement are a required condition for measurements lasting less than four days, and are recommended prior to measurements lasting up to a week in duration. Normal operation of permanently installed energy recovery ventilators (also known as heat recovery ventilators or air-to-air heat exchangers) may also continue during closed-building conditions. In houses where permanent radon mitigation systems have been installed, these systems should be functioning during the measurement period.

Closed-building conditions will generally exist as normal living conditions in northern areas of the country when the average daily temperature is low enough so that windows are kept closed. Depending on the geographical area, this can be the period from late fall to early spring. In some houses, the most stable radon levels occur during late fall and early spring, when windows are kept closed but the house heating system (which causes some ventilation and circulation) is not used. Available information about variations of indoor radon levels in a particular area can be used to choose a measurement time when the radon concentrations are most stable.

It may be necessary, however, to make measurements during mild weather, when closed-building conditions are not the normal living conditions. It will then be necessary to establish some more rigorous means to ensure that closed-building conditions exist prior to and during the measurements.

Those performing measurements in southern areas that do not experience extended periods of cold weather should evaluate seasonal variations in living conditions and identify if there are times of the year when closed-building conditions normally exist. Ideally, measurements should be conducted during those times. The closed-building conditions must be verified and maintained more rigorously when they

are not the normal living conditions. Air conditioning systems that recycle interior air can be operated during the closed-building conditions when radon measurements are being made. However, homeowners should be aware that any air circulation system can alter the radon decay product concentration without significantly changing the radon concentration.

Short-term tests lasting just two or three days should not be conducted during unusually severe storms or periods of unusually high winds. Severe weather will affect the measurement results in several ways. First, a high wind will increase the variability of radon concentration because of wind-induced differences in air pressure between the building interior and exterior. Second, rapid changes in barometric pressure increase the chance of a large difference in the interior and exterior air pressures, consequently changing the rate of radon influx. Weather predictions available on local news stations can provide sufficient information to determine if these conditions are likely. While unusual variations between radon measurements may be due to weather or other effects, the measurement system should be checked for possible problems.

During any short-term test, closed-house conditions should be maintained as much as possible while the test is in progress. In tests lasting less than four days (96 hours), closed-house conditions should be maintained for at least 12 hours before starting the test. In tests lasting between four and seven days, closed-house conditions should be maintained while the test is in progress; while recommended, the 12 hour closed-house condition before the start of the is not required. In tests lasting more than seven days and less than 90 days, closed-house conditions should be maintained as much as possible while the test is in progress.

### **2.3.3 Interpretation of Initial Measurement Results**

If the initial measurement result is less than 4 pCi/L, or 0.02 WL, follow-up measurements are probably not needed. There is a relatively low probability that mitigation is warranted if the result is less than 4 pCi/L or 0.02 WL (EPA 400-R-92-011; U.S. EPA 1992g). Even if the measurement result is less than 4 pCi/L, or 0.02 WL, however, a homeowner may want to test again sometime in the future. If the occupants' living patterns change or renovations are made to the home and they begin using a lower level (such as a basement) as a living area, a new test should be conducted on that level.

The average year-round residential indoor radon level is estimated to be about 1.3 pCi/L, and about 0.4 pCi/L of radon is normally found in outside air. The U.S. Congress has set a long-term goal that indoor radon levels be no more than outdoor levels. There is some risk of lung cancer from radon levels below 4 pCi/L, and EPA recommends that the homeowner consider reducing the radon level if the average of the first and second short-term measurements or if a long-term follow-up measurement is between 2 and 4 pCi/L (0.01 and 0.02 WL). While it is not yet

technologically achievable for all homes to have their radon levels reduced to outdoor levels, the radon levels in some homes today can be reduced to 2 pCi/L or below.

If the result of the short-term measurement is equal to or greater than 4 pCi/L, or 0.02 WL, the occupant should conduct a follow-up measurement using a short-term or long-term test, as described in *Section 2.4*.

## **2.4 FOLLOW-UP MEASUREMENTS**

### **2.4.1 Rationale**

The purpose of a follow-up measurement is to provide the homeowner with enough information to make an informed decision on whether to mitigate to reduce radon levels. The follow-up measurement, whether it is short-term or long-term, provides an additional piece of information to confirm that radon levels are high enough to warrant mitigation. There are two major reasons why a second measurement is necessary. First and most important, radon levels fluctuate over time (see *Section 1*), and a second short-term measurement, when averaged with the first test result, will provide a more representative value for the average radon level during the period of the test. If a long-term follow-up measurement is conducted, that result should provide an even more representative value for the long-term average radon concentration. The second reason for making a follow-up measurement prior to mitigation is that there is a small chance of laboratory or technician error in all measurements, including radon measurements, and a second test will serve as a check on the first.

Homes tested using the protocol in this section should not be mitigated on the basis of a single short-term test. A follow-up test is necessary for mitigation decision-making regardless of the initial test result.

### **2.4.2 Short-Term and Long-Term Follow-Up Testing**

Follow-up testing should be conducted in the same location as the first measurement (see *Section 2.2*).

A follow-up test can be conducted with either a short-term or long-term measurement device. Long-term tests (> 90 days) will produce a reading that is more likely to represent the home's year-round average radon level than a short-term test. However, if the initial test result is high (for example, greater than about 10 pCi/L, or 0.05 WL) or if results are needed quickly, EPA recommends a second short-term test. This will allow the homeowners to obtain information necessary to decide quickly on the need for mitigation. If the result of the initial measurement is between 4 pCi/L and 10 pCi/L (or between 0.02 WL and 0.05 WL), then either a short-term or long-term test can be taken.

If the long-term follow-up test result is 4 pCi/L, or 0.02 WL, or higher, then EPA recommends remedial action. Likewise, if the average of the initial and second short-term results is equal to or greater than 4 pCi/L, or 0.02 WL, radon mitigation is recommended. These recommendations are summarized in Exhibit 2-1.

As with the initial short-term test, the second short-term test should be conducted under closed-building conditions (*Section 2.3.2*). These conditions, however, are not necessary for long-term tests (those lasting longer than 90 days).

## Section 3: DISCUSSION OF GUIDELINES PRESENTED IN THE HOME BUYER'S AND SELLER'S GUIDE TO RADON

### 3.1 INTRODUCTION

The unique nature of a real estate transaction, involving multiple parties and financial interests, presents radon measurement issues not encountered in non-real estate testing. EPA's objectives for issuing recommended protocols for radon measurements made for real estate transactions are intended to reduce misunderstanding and protect public health in several ways. First, EPA seeks to provide home buyers, sellers, real estate agents, and testing organizations with a common basis of understanding of the recommended procedures for radon measurements. Second, the widespread implementation of this guidance will produce results that are reliable indicators of the need for mitigation. A significant proportion of radon measurements are conducted as part of real estate transactions, and all aspects of these transactions are carefully scrutinized, so specific guidance from EPA can help to ensure good quality measurements. When the results are interpreted properly and the appropriate remedial action is taken, these protocols will assist the buyer and seller in reducing the risk to the occupants from radon exposure. The availability of a nationally-recognized protocol for measurement and for the interpretation of the measurement results will greatly assist home buyers, sellers, real estate agents, builders, lenders, and radon measurement experts.

These protocols are designed for use in residences, as described in the EPA document, *Home Buyer's and Seller's Guide to Radon* (EPA 402-R-93-003; U.S. EPA 1993). While that document offers general information on radon and testing, this report presents a more technical description of EPA recommendations, including discussion of guidelines for the interpretation of measurement results. As with all of EPA's policies regarding radon measurements, these guidelines have been developed after review and assistance from the radon measurement community and EPA's Science Advisory Board. Technical information on a variety of radon measurement methods is available in the EPA report titled *Indoor Radon and Radon Decay Product Measurement Device Protocols* (EPA 520-402-R-92-004; EPA 1992c; these and other EPA publications are available from the U.S. Government Printing Office [see Exhibit 1-1], or your State or Regional EPA radon office, see *Appendix A*).

The radon testing guidelines in the *Home Buyer's and Seller's Guide to Radon* have been developed specifically to deal with the time-sensitive nature of home purchases and sales. These guidelines are somewhat different from the guidelines in other EPA publications, such as the 1992 *Citizen's Guide to Radon* (EPA 402-K-92-001; U.S. EPA 1992a), which provide radon testing and reduction information for non-real estate situations.

There are also guidelines in the *Home Buyer's and Seller's Guide to Radon* to deal with the potential for radon test interference. There are approaches that can be used to increase confidence in measurement results by detecting measurement interference. For example, a device that offers a variety of ways to detect tampering

may serve to deter, as well as detect, interference with the device's operation or with proper closed-building measurement conditions. Potential tampering indicators include the ability of a device to record changes in radon levels, temperature, and humidity, or to detect movement of or around the device during the measurement. Refer to Section 3.5 for information and recommendations for interference-resistant testing.

EPA investigated a variety of options for real estate testing. EPA recommends testing in advance of putting the house on the market. A long-term test, which is conducted for longer than 90 days, gives the most representative indication of the annual average radon concentrations in a home. However, for time-sensitive real estate transactions, the *Home Buyer's Guide* offers three short-term testing options. Short-term tests are conducted from two days to 90 days, depending on the measurement device. Based on extensive quantitative analyses to evaluate the frequency with which long-term and short-term testing results lead to the same mitigation decision, EPA and its independent Science Advisory Board concluded that short-term tests can be used to assess whether a home should be remediated.

The reliability of each radon measurement made for a real estate transaction, or for any purpose, is highly dependent upon the existence and documentation of an adequate quality assurance program implemented by both the tester and the analysis laboratory. All the parties involved in the real estate transaction depend upon the testers doing their job. This includes ensuring that the measurements are valid via the performance of quality control measurements and activities, and detecting measurement interference. The protocols outlined in this section were developed by EPA for testers and homeowners adhering to the quality assurance practices summarized in Section 4.4 of this report, and in EPA's *Indoor Radon and Radon Decay Product Measurement Device Protocols* (EPA 520-402-R-92-004; U.S. EPA 1992c).

Three options were determined to be satisfactory and are described here. The availability of three options will allow flexibility on the part of the party purchasing the test. Each of these options will produce results that can be used to determine the need for mitigation.

Both Options 1 and 2 require the use of two measurements made for similar durations. Both measurements should report results in units of pCi/L or both in WL. Similar durations means that the two measurements must be made for a similar time period, with a two-hour grace period. Specific information on measurement methods (listed in Exhibit 3-1) can be found in EPA's *Indoor Radon and Radon Decay Product Measurement Device Protocols* (EPA 520-402-R-92-004; U.S. EPA 1992c).

Exhibit 3-1

Radon and Radon Decay Product Measurement  
Method Categories

A (pCi/L)

B (WL)

AC Activated charcoal adsorption  
integrating

RP Radon progeny  
sampling unit

AT Alpha track detection

CW Continuous working level  
monitoring

LS Charcoal liquid scintillation

CR Continuous radon monitoring

PB Pump-collapsible bag

SC Evacuated scintillation cell  
(three-day integrating)

EL Electret ion chamber: long-term

ES Electret ion chamber: short-term

UT Unfiltered track detection

## 3.2 OPTIONS FOR REAL ESTATE TESTING

### 3.2.1 Option 1: Sequential Testing

Sequential tests should be conducted under conditions that are as similar as possible, in the same location, and using similar devices and durations. Both should produce results in the same units (pCi/L or WL). That is, both methods should be from column A or both from column B of Exhibit 3-1. Any EPA-recognized method may be used. In addition, the results of the first test should not be reported prior to making the second measurement; both measurements should be reported at the same time in order to discourage tampering that may occur if the first test is known to be greater than 4 pCi/L or 0.02 WL. Note that measuring with different methods (e.g., with AC and ES) may increase the potential for differences (e.g., measurement bias) between the results. The results of both measurements should be reported, and the average of the two results should be used to determine the need for mitigation. There will be some variation between the two results, which may be caused by the radon levels fluctuating in response to weather or other factors. If the variation is unusually large, it may be due to weather or other effects, but the measurement system should be checked for possible problems.

### 3.2.2 Option 2: Simultaneous Testing

This option involves the use of two tests, conducted simultaneously and side-by-side, made for similar durations, and producing results in the same units (i.e., both methods should be from column A or both should be from column B of Exhibit 3-1). Any EPA-recognized method may be used. As with Option 1, using different methods for the two measurements (for example, ES and LS) may increase the potential for differences between the two results. The two test results should be averaged to determine the need for remedial action. The collocated devices should be placed four inches (10 centimeters) apart.

Because radon measurements, like any measurements, usually do not produce exactly the same results, even for simultaneous testing, there will usually be a difference between the two results. EPA offers the following guidance to testers for judging when two simultaneous, side-by-side measurements disagree to such an extent that two additional measurements should be performed.

The results of the simultaneous measurements will fall into one of the three categories discussed below and illustrated in Exhibit 3-2.

#### 3.2.2.1 Both Measurement Results Equal To or Greater Than 4 pCi/L (or 0.02 WL)

In this case, the average of the two results will be equal to or greater than 4 pCi/L, or 0.02 WL, and mitigation is recommended. The tester should report both measurement results as well as the average of the two results.

Two simultaneous, side-by-side measurements

Both are < 4 pCi/L\*

Use Exhibit B-3, or, is RPD > 67% ?\*\*

NO-- Provide the individual measurement results and the average value to the client

YES-- Provide the individual measurement results and the average value to the client, and investigate the source of error (see Appendix B)

One is ≥ 4 pCi/L,\* and one is < 4 pCi/L\*

Is the higher result greater than twice the lower result?

NO-- Provide the individual measurement results and the average value to the client

YES-- Provide the individual measurement results and the average value to the client, inform the client of the large discrepancy (see Section 3.2.2.4), and retest

Both are ≥ 4 pCi/L\*

Use Exhibit B-2, or, is RPD > 36% ?\*\*

NO-- Provide the individual measurement results and the average value to the client

YES-- Provide the individual measurement results and the average value to the client, and investigate the source of error (see Appendix B)

\* or 0.02 WL  
\*\* Refer to Appendix B  
RPD = Relative Percent Difference = Difference/Average

### **3.2.2.2 Both Measurement Results Less Than 4 pCi/L (or 0.02 WL)**

In this case, the average of the two measurements will be less than 4 pCi/L, or 0.02 WL, and both measurement results and the average result should be reported to the client.

### **3.2.2.3 One Measurement Result Greater Than 4 pCi/L (or 0.02 WL), and One Measurement Result Less Than 4 pCi/L (or 0.02 WL)**

This is a special situation in which the average of the results is critical. To assist testers in ensuring that the difference between two measurements is small enough so that clients may have confidence in, and understand, the results, EPA offers the following simple guidance.

If the higher result is twice or more the lower result, then the two results are not within a factor of two, and a retest should be conducted. *Section 3.2.2.5* provides language for informing the client that a retest is warranted.

If the higher result is less than twice the lower result, then the two results are within a factor of two, and a retest is not necessary. The results of both measurements and the average of the two results should be reported to the client. (See *Section 4* for more detailed information on quality assurance and quality control procedures.)

### **3.2.2.4 Precision Recommendations**

Measurements near the lower limit of detection (LLD) for the measurement system often have large and varying precision errors, and it is difficult to assign any sort of probability level to very low results.

Simultaneous measurement results that are equal to 4 pCi/L, or 0.02 WL, or greater should, however, exhibit some agreement. An example control chart for the precision that may be expected is shown as Exhibit B-2 in *Appendix B*, which was constructed using an average relative percent difference of 14 percent. (Relative percent difference is defined as the difference divided by the average.) Using Exhibit B-2, a relative percent difference greater than 36 percent should be observed less than one percent of the time. Based upon this, EPA recommends that any side-by-side, simultaneous measurements with results greater than or equal to 4 pCi/L, or 0.02 WL, and which exhibit a relative percent difference greater than 36 percent, be cause for informing the client that the two results do not show good agreement. However, since both results are greater than 4 pCi/L, or 0.02 WL, EPA recommends mitigation in this case. Testers should investigate the source of the error (see *Appendix B*).

Results between 2 pCi/L (or 0.01 WL) and 4 pCi/L (or 0.02 WL), should also exhibit some agreement. The level of agreement expected should be based upon the tester's experience with duplicate measurements made with that technique in this range of radon concentrations. An example control chart for the precision that may

be expected in this region is shown as Exhibit B-3 in *Appendix B*, which was constructed using an average relative percent difference of 25 percent. Using this chart, a relative percent difference between duplicates greater than 67 percent should be observed less than one percent of the time. Based upon this, EPA recommends that any side-by-side, simultaneous measurements with results less than 4 pCi/L, or 0.02 WL, and which exhibit a relative percent difference greater than 67 percent, be cause for informing the client that the two results do not show good agreement, but that both are less than 4 pCi/L, or 0.02 WL, and therefore mitigation is not recommended. Testers should investigate the source of the error (see *Appendix B*).

### **3.2.2.5 Recommended Language for Informing the Client that a Retest is Warranted**

If a retest is warranted (see *Section 3.2.2.3*), EPA recommends that the tester inform the client that EPA provides guidance for how well two measurements should agree, that the measurements performed fall outside the range, and that a retest should be conducted. A retest should consist of measurements performed according to one of the protocols outlined in *Sections 3.2.1, 3.2.2, or 3.2.3*.

### **3.2.3 Option 3: Single Test Option**

This option requires an active continuous monitor (method CR or CW) that has the capability to integrate and record a new result at least hourly. Shorter integration periods and more frequent data logging afford greater ability to detect unusual variations in radon or radon decay product concentrations. The minimum measurement period is 48 hours. The first four hours of data from a continuous monitor may be discarded or incorporated into the result using system correction factors (EPA 520-402-R-92-004; EPA 1992c). There must be at least 44 contiguous hours of usable data to produce a valid average. (The "backing out" of data [i.e., removal of portions imbedded in the two days] to account for weather or other phenomena will invalidate the measurement.) The periodic results should be averaged to produce a result that is reported to the client.

If the monitor cannot integrate over a period of one hour or less, then an additional (secondary) passive or active measurement device must be used. The second measurement, which may be made with a passive or active device, can be used simultaneously or sequentially, as discussed in Options 1 and 2 (*Sections 3.2.1 and 3.2.2*). If the two measurements are performed simultaneously, their results should be evaluated following the guidance in *Section 3.2.2*. If the two measurements were performed sequentially, it can be expected that the two results will be different. As discussed in *Section 3.2.1*, the difference between sequential tests may be due to radon levels fluctuating in response to weather or other factors.

In general, confidence in a radon measurement can be increased by performing another measurement with a second measurement device. However, there are other approaches or features that can be used to increase the confidence of a measurement result obtained using active monitor devices. These approaches include

the use of device self-diagnostic features, and data validation or verification procedures, that could be employed before and/or after the measurement. Examples of such approaches are the use of check sources before and after each measurement, and the use of spectrum readouts. These capabilities are examples, and different technologies may be able to perform other similar self-diagnostic or quality assurance checks. Other features that increase the confidence of a single active test include (but are not limited to) the ability to check air flow rates and voltage meters before and after each measurement. Measurement companies should incorporate such checks into their routine instrument performance checks as part of their standard operating procedures.

Additional features that can increase confidence in measurement results are those that detect measurement interference; these features are discussed in Section 3.5. For example, a device that offers a variety of ways to detect tampering may serve to deter, as well as detect, interference with the device's operation or with proper closed-building measurement conditions. Potential tampering indicators include the ability of a device to record changes in temperature, humidity, or movement of or around the device during the measurement.

Instruments with greater efficiency or sensitivity, or a high signal-to-noise ratio (see *Glossary* for definitions of these terms), can achieve results with a smaller uncertainty than instruments with low efficiency, poor sensitivity, or low signal-to-noise ratio. Greater efficiencies, sensitivities, or a high signal-to-noise ratio may also facilitate tampering detection by being more sensitive to fluctuations in radon levels. There have been recommendations for setting minimum efficiency standards for active devices at 16 counts per hour per pCi/L. EPA plans to conduct research to establish minimum standards in the future for all categories of devices, passive as well as active detectors. The reliability of any type of equipment, however, needs to be established and documented via a complete quality assurance program. This includes routine instrument performance checks prior to and after each measurement, annual calibrations, semi-annual instrument cross-checks, the performance of duplicate measurements in 10 percent of the measurement locations, and frequent background and spiked measurements.

### 3.3 MEASUREMENT LOCATION

EPA recommends that measurements made for a real estate transaction be performed in the **lowest level of the home which is currently suitable for occupancy**. This means the lowest level that is currently lived-in, or a lower level that is not currently used (such as a basement, which a buyer could use for living space without renovations). Measurements should be made in a room that is used regularly, such as a living room, playroom, den, or bedroom. This includes a basement that can be used as a recreation room, bedroom, or playroom. This provides the buyer with the option of using a lower level of the home as part of the living area, with the knowledge that it has been tested for radon.

### 3.4 MEASUREMENT CHECKLIST

EPA presents the following checklist to help ensure that a radon measurement conducted for a real estate transaction is done properly. The seller, or an EPA-listed or State-listed tester, should be able to confirm that all the items in this checklist have been followed. If the tester cannot confirm this, another test should be made.

#### Before the radon test:

- Notify occupants of the importance of proper testing conditions. Give occupants written instructions or a copy of the EPA *Home Buyer's and Seller's Guide to Radon* (EPA 402-R-93-003; U.S. EPA 1993), or a State-required alternative, and explain the directions carefully.
- The radon measurement service and device used should be listed by EPA's National Radon Measurement Proficiency (RMP) Program (EPA 520/1-91-006; U.S. EPA 1991) or listed by your State. Follow the manufacturer's instructions that come with the device.
- If a testing professional conducts the test, only EPA-listed or State-listed individuals should be hired. Their photo identification should be provided to the client or homeowner at the time of, or before, the test, and the contractor's identification number should be clearly visible on the test report.
- The test should include method(s) to prevent or detect interference with testing conditions or with the testing device itself.
- Conduct the radon test for a minimum of 48 hours. Some devices must be exposed for longer than the 48-hour minimum.
- In homes with an active radon reduction system, check that the fan is running at least 24 hours before starting a short-term test lasting less than four days. Air exhaust equipment, like radon reduction system fans and small exhaust fans that typically operate for short periods (e.g., bathroom fan) may be used during the test.
- EPA recommends that short-term radon testing, which lasts for no more than a week in length, be done under closed-building conditions. Closed-building conditions means keeping all windows closed, keeping doors closed except for normal entry and exit, and not operating fans or other machines that bring in air from outside. Note that fans that are part of a radon reduction system or small exhaust fans operating for only short periods of time may run during the test.

- When doing short-term testing lasting less than four days, it is important to maintain closed-building conditions for at least 12 hours before the beginning of the test and for the entire test period. Do not operate fans or other machines that bring in air from the outside.

#### During the radon test:

- Maintain closed-building conditions during the entire time of a short-term test, especially for tests shorter than one week in length.
- Operate the home's heating and cooling systems normally during the test. For tests lasting less than one week, only operate air conditioning units that recirculate interior air.
- Do not disturb the test device at any time during the test.
- If a radon reduction system is in place, make sure the system is working properly and will be in operation during the entire radon test.

#### After a radon test:

- If a high radon level is confirmed, fix the home. Pages 21 to 23 of EPA's *Home Buyer's and Seller's Guide to Radon* (EPA 402-R-93-003; U.S. EPA 1993) recommend the next steps that should be taken, such as contacting a qualified radon reduction contractor to lower the home's radon level.
- The radon tester or homeowner should be able to verify or provide documentation asserting that testing conditions were not violated during the testing period.

### 3.5 INTERFERENCE-RESISTANT TESTING

EPA strongly encourages the use of radon testing devices with interference-resistant features inherent in, or associated with, the device.

Interference with a radon measurement is defined as the altering of test conditions prior to or during the measurement to either change the radon or decay product concentrations or alter the performance of the measurement equipment. The following discussion reviews some of the types of test interferences and methods of detecting and preventing such interferences.

Test interference typically causes measurement results to be different than if all proper test conditions were maintained. False low results have been primarily associated with testing during a real estate transaction, although they also happen when the occupants of the dwelling are not properly informed about the necessary test conditions. Test interference can also inadvertently increase measurement results, although the intent is generally to lower the results.

The current occupant may have an interest in the test results being as low as possible to avoid hindering the sale of the dwelling or incurring the added expense of having to install a mitigation system. The potential for test interference puts the professional radon tester into the position of verifying that the equipment and the required test conditions have been maintained. A measurement result that is below the action guideline may be suspect if the tester cannot verify that the necessary test conditions were maintained.

If the tester arrives at a property and finds windows or doors open, or suspects that closed-building conditions were not maintained for 12 hours prior to arrival, then the tester should extend the test period to account for this condition.

### **3.5.1 Influencing Test Area Concentration**

The primary method of temporarily reducing radon levels is to ventilate the test area with outdoor air. Ventilation will slow down radon entry by both reducing negative pressure in the test area and by diluting the reduced radon concentration. Even small openings of a single window in the test area can have a large effect. Ventilating the floors above the test area has significantly less effect, unless the test area is connected with the ventilated room(s) by an operating central air handling system.

Radon decay product levels are sensitive to air movement. As air movement increases, decay products will plate out on walls and other surfaces, including fans, thereby reducing airborne decay product concentrations. Decay products will be further reduced if the fan also includes a filter. Radon levels are, however, not affected by filtering or air movement.

It is also possible to alter concentrations in a tight room if the heating system is operating in an abnormal fashion. Since this may not be the typical operation of the system, it is, in effect, interfering with normal house conditions.

It is important to recognize that test interference can increase radon or decay product levels, despite intent to lower the results.

### **3.5.2 Equipment Interference**

The primary method of interfering with testing equipment is to move the detector to an area of low radon concentration. Other types of interference vary in their ability to influence different types of detectors. For example, interfering with the air sampling mechanisms can maintain the radon concentration at the time of interference, or cause a large decrease in the reported concentration. Similarly, covering a decay product or charcoal detector could cause a large drop in the reported values, while other types of radon detectors would only show a reduced response time to changes in the test area level. In addition, charcoal detectors are sensitive to heat. Some active radon monitors and open face charcoal canisters are also sensitive to high humidity. Any detector that yields a single result could be turned off or sealed in its container or lid during most of its exposure period.

### **3.5.3 Preventing Interference**

EPA recommends that a radon measurement conducted for a real estate transaction be performed using tamper-resistant testing techniques. It is more advantageous for the tester to take steps to prevent interference rather than to simply detect it. Preventing interference can best be accomplished by:

- Educating the parties to a real estate transaction about the necessary test conditions.
- Including in the standard documentation for each measurement an agreement signed by the parties involved in the real estate transaction listing the necessary test conditions and their agreement not to interfere with the conditions.

The agreement should also state that the tester in their discretion may nullify the test results if it appears that, in their professional judgement, the test results were rendered unreliable.

- Informing the parties that interference with the test conditions may increase the radon levels.
- Informing the parties that the tester is using interference-detecting techniques, and that these allow the detection and documentation of test interference.

### 3.5.4 Interference-Resistant Detectors

The following is a partial list of common equipment and measures that can serve to prevent and/or detect test interference. There may be other methods available. Equipment that offers a combination of tamper-detecting features also offers a greater chance of detecting interference.

- The ability to integrate and record frequent radon measurements over short intervals (an hour or less) is an important tamper detection feature. Continuous (active) monitors that provide frequent measurements can indicate unusual concentration changes that can be indicators of test interference.
- Measuring other parameters may provide additional indicators of test interference, such as a detector tilt indicator or a continuous recording of pump flow rate.
- A motion indicator can also indicate when the detector was approached or moved.
- A simultaneous, several-day continuous measurement of both radon and decay product concentrations will produce a series of equilibrium ratio values. These values can be inspected for unusual swings or abnormal levels, possibly indicating interference.
- Measurement of CO<sub>2</sub> levels can indicate changes in the test area infiltration rate of outdoor air.
- The performance of a grab radon measurement, a grab decay product measurement, or both, before and after a longer-term measurement can offer useful information. For example, the initial and final concentrations and equilibrium ratios can be compared for consistency. Note: The results of measurements lasting less than 48 hours (e.g., grab samples) should not be used as the basis for deciding to fix a home.
- Frequent temperature readings may help to indicate changes in the test area infiltration rate of outdoor air.
- Humidity (as well as temperature) recordings can be especially helpful in identifying potential unusual changes in test conditions that occur during the test period.
- Instruments that do not allow occupants to view preliminary results (via a visible printer or screen) may reduce occupants' interference.

- Placement indicators can also indicate if a detector has been tampered with or moved. The position of the detector should be noted so that, upon retrieval, any handling of the detector can be indicated by a change in its position. A detector may be hung or placed slightly over the edge of its support to discourage covering it. Passive detectors may be hung or suspended in a radon-permeable bag that uses a strap and seal to prevent removing or covering it. Cages can be equipped with a movement indicator to deter handling of the cage or the detector within it.
- Seals can aid in detecting and discouraging test interference, and they are especially important in the absence of other tamper detection measures. Non-sealable caulks and/or tapes can be used to verify that detectors have not been altered or moved, or that windows or non-primary exterior doors have not been opened. Seals alone will not prevent excessive ventilation through primary doors.

Seals should be placed on the lowest operable windows and non-primary exterior doors, as well as between the detector and its support and any other components of the detector that could be tampered with. It may be advisable to place a seal on the furnace control fan switch. It may also be necessary to attach to the caulk seal something fragile that protrudes out, to indicate any handling or covering of the detector.

A number of different products or combination of products can be used for tamper seals. For a seal to be effective, it needs at least the following unique qualities.

- The seal must adhere readily to a multitude of surfaces, and yet be easily removed without marring the surface.
- It needs to be non-resealable or show evidence of disturbance,
- It must be unique enough to prevent easy duplication.
- It should be visible enough to discourage tampering.

The tamper resistance of the seal can be increased by using a caulk over the seal edges or by slicing a large portion of the center of the seal to ensure the seal is broken in case of tampering.

Most paper or plastic tapes and caulks have only some of these qualities. There are, however, a number of seals manufactured specifically for radon testing. It would be advisable to use one of these products and follow the manufacturer's installation recommendations. The best caulking to use as a

seal is a removable weatherstripping caulk. This type of caulking adheres readily to most surfaces, yet comes off easily without leaving a mark or being resealable.

Upon retrieval of the detector, the tester should carefully inspect the following:

- That all closed-building conditions are still being maintained;
- Any changes in the detector placement;
- The condition of all seals; and
- Any abnormal variations in any of the measurements made.

This information should be recorded, as described in *Section 4.3.5*.

## Section 4: GENERAL PROCEDURAL RECOMMENDATIONS

### 4.1 INTRODUCTION

This section outlines basic procedural recommendations for anyone involved in the measurement of radon in homes for both real estate and non-real estate related measurements.

### 4.2 INITIAL CLIENT INTERVIEW

Reasonable efforts should be made to determine whether the home is new and/or occupied, and who will be in charge of the home during the measurement period. Testing organizations should inform the client and other parties to the real estate transaction of:

- The appropriate EPA testing recommendations as outlined in this report, the 1992 *Citizen's Guide to Radon* (EPA 402-K-92-001; U.S. EPA 1992a), or the *Home Buyer's and Seller's Guide to Radon* (EPA 402-R-93-003; U.S. EPA 1993); and
- The types of devices they will be using for that test, and EPA documentation indicating that the testing organization or individual is RMP-listed for that device.

### 4.3 MEASUREMENT RECOMMENDATIONS

#### 4.3.1 Selecting a Measurement Approach

The purpose of the measurements, as well as budget and time constraints, dictate the protocol used. Measurements made for the purpose of assessing the need for mitigation of one's own property should be made according to the guidance discussed in *Section 2* of this document; *Section 3* outlines options for protocols for measurements made for real estate transactions. Organizations that provide consultant services, or place or retrieve devices, should review the protocol options and the clients' needs, and inform clients of the buildings and test period conditions necessary for conducting valid measurements. In some areas, companies may offer different types of radon service agreements. Some agreements allow for a one-time fee that covers both testing, and if needed, radon reduction.

The organizations or individuals performing the measurement service should use only those specific devices or methods for which that organization or individual is listed according to the National RMP Program (EPA 520/1-91-006; U.S. EPA 1991). Adherence to the EPA device protocols, *Indoor Radon and Radon Decay Product*

*Measurement Device Protocols* (EPA 520-402-R-92-004; U.S. EPA 1992c) is a requirement for participation in the RMP Program.

#### **4.3.2 Written Measurement Guidance**

Measurement organizations should provide clients with written measurement instructions that clearly explain the responsibilities of the client and the other parties to the real estate transaction during the test period. Written and verbal guidance should be in accordance with EPA's *Indoor Radon and Radon Decay Product Measurement Device Protocols* (EPA 520-402-R-92-004; U.S. EPA 1992c) and guidance published in the *RMP Program Handbook* (EPA 520/1-91-006; U.S. EPA 1991). At a minimum, the guidance should include the following elements:

- A statement of whether the device measures radon or radon decay products and a discussion of the units in which all results will be reported.

The results of radon decay product measurements should be reported in working levels (WL). If the WL value is converted to a radon concentration and is reported to the homeowner, it should be stated that this approximate conversion is based on a 50 percent equilibrium ratio (unless the actual equilibrium ratio is determined). In addition, the report should indicate that this ratio is an assumed average found in the home environment; any indoor environment may have a different and varying relationship between radon and its decay products.

- A description of closed-building conditions and a stated requirement that these conditions be maintained 12 hours prior to and during all short-term measurements lasting less than four days and preferably for those lasting up to one week.
- Directions that the building's heating, ventilating, and air conditioning (HVAC) system and any existing mitigation system should be normally operated 24 hours prior to and during all measurements.
- A permanent radon reduction system should be fully operational for at least 24 hours prior to testing to determine the mitigation system's effectiveness. The mitigation system is to be operated normally and continuously during the entire measurement period.
- Specific information on the minimum and maximum duration of exposure for the measurement device(s).
- If the client will be performing the test, procedures for placing, retrieving,

and handling the device.

- A written non-interference agreement (see *Sections 3.5.3 and 4.3.4*) to be signed and returned by the parties to the real estate transaction which confirms that they followed all instructions and did not interfere with the conditions or the measurement device.

#### **4.3.3 Conditions for a Valid Measurement**

Measurements should not be conducted if temporary radon reduction measures have been implemented. These include the introduction of unconditioned air into the home or closure of normally accessible areas of the home. In this case, the measurement organization or individual should inform the client and other parties to the real estate transaction that these conditions will invalidate measurement results and decline to conduct a measurement until the conditions have been corrected.

A permanent radon reduction system should be fully operational for at least 24 hours prior to testing to determine the mitigation system's effectiveness. The mitigation system is to be operated normally and continuously during the entire measurement period.

#### **4.3.4 Non-Interference Controls**

The measurement organization should provide parties to a real estate transaction with a written statement that discusses the importance of proper measurement conditions and of not interfering with the measurement device or building conditions. The reader should refer to *Section 3.5.3* for more information on non-interference agreements.

Organizations that place and retrieve devices should, in addition to providing written guidance, take steps to identify attempts to interfere with the measurement device or building conditions. There is increasing use of non-interference agreements signed by parties involved in real estate transactions to help prevent interference with the radon test and test conditions. The reader should refer to *Section 3.5* for more information on tamper-resistant testing.

The signed non-interference agreement, a description of all non-interference controls employed, and a statement addressing any observed breaches of the non-interference agreement/controls should be made part of the permanent measurement documentation for each measurement.

#### **4.3.5 Measurement Documentation**

Measurement organizations should record sufficient information on each measurement in a permanent log to allow for future data comparisons, interpretations, and reporting to clients. EPA recommends that a measurement log be kept with the following information and be maintained for five years. Additional method-specific documentation is outlined in EPA's *Indoor Radon and Radon Decay Product Measurement Device Protocols* (EPA 520-402-R-92-004; U.S. EPA 1992c).

- A copy of the final report, including the measurement results, and the statement outlining any recommendations concerning retesting or mitigation provided to the building occupant or agent.
- The address of the building measured, including zip code.
- The exact locations of all measurement devices deployed. It is advisable to diagram the test area, noting the exact location of the detector.
- Exact start and stop dates and time of the measurement period as required for analysis.
- A description of the device used, including its RMP device identification number and serial number if any.
- A description of the condition of any permanent vents, such as crawl space vents or combustion air supply to combustive appliances.
- The name and RMP identification number (EPA 520/1-91-014-3N; U.S. EPA 1992e) of the service or analysis organizations used to analyze devices.
- The name and RMP identification number (or State license number) of the individual who conducted the test.
- A description of any variations from or uncertainties about standard measurement procedures, closed-building conditions, or other factors that may affect the measurement result.
- A description of any non-interference controls used and copies of signed non-interference agreements.
- A record of any quality control measures associated with the test, such as results of simultaneous or secondary measurements.

## 4.4 QUALITY ASSURANCE IN RADON TESTING

Anyone providing measurement services using radon or radon decay product measurement devices should establish and maintain a quality assurance program. These programs should include written procedures for attaining quality assurance objectives and a system for recording and monitoring the results of the quality assurance measurements described below. EPA offers general guidance on preparing quality assurance plans (QAMS-005/80; U.S. EPA 1980); a draft standard prepared by a radon industry group is also available (AARST 1991). The quality assurance program should include the maintenance of control charts and related statistical data, as described by Goldin (Goldin 1984), by EPA (EPA 600/9-76-005; U.S. EPA 1984), and in *Appendix B* of this document.

### 4.4.1 Calibration Measurements

Calibration measurements are measurements made in a known radon environment, such as a calibration chamber. Detectors requiring analysis, such as charcoal canisters, alpha track detectors, electret ion chambers, and radon progeny integrating samplers are exposed in a calibration chamber and then analyzed. Instruments providing immediate results, such as continuous working level and radon monitors, should be operated in a chamber to establish individual instrument calibration factors.

Calibration measurements must be conducted to determine and verify the conversion factors used to derive the concentration results. These factors are determined normally for a range of concentrations and exposure times, and for a range of other exposure and/or analysis conditions pertinent to the particular device. Determination of these calibration factors is a necessary part of the laboratory analysis, and is the responsibility of the analysis laboratory. These calibration measurement procedures, including the frequency of tests and the number of devices to be tested, should be specified in the quality assurance program maintained by manufacturers and analysis laboratories.

### 4.4.2 Known Exposure Measurements

Known exposure measurements or spiked samples consist of detectors that have been exposed to known concentrations in a radon calibration chamber. These detectors are labeled and submitted to the laboratory in the same manner as ordinary samples to preclude special processing. The results of these measurements are used to monitor the accuracy of the entire measurement system. Suppliers and analysis laboratories should provide for the blind introduction of spiked samples into their measurement processes and the monitoring of the results in their quality assurance programs. **All organizations providing measurement services with passive devices** should conduct spiked measurements at a rate of three per 100

measurements, with a minimum of three per year and a maximum required of six per month. **Providers of measurements with active devices** are required to recalibrate their instruments at least once every 12 months and perform cross-checks with RMP-listed devices at least once every six months. Participation in EPA's National RMP Program will not satisfy the need for annual calibration, as this Program is a performance test, not a calibration procedure.

#### **4.4.3 Background Measurements**

Background measurements are required both for continuous monitors and for passive detectors requiring laboratory analysis. Users of continuous monitors must perform sufficient instrument background measurements to establish a reliable instrument background and to check on instrument operation. For more specific information on how often background measurements should be made, refer to EPA's *Indoor Radon and Radon Decay Product Measurement Device Protocols* (EPA 520-402-R-004; U.S. EPA 1992c).

Passive detectors requiring laboratory analysis require one type of background measurement made in the laboratory and another in the field. Suppliers and analysis laboratories should measure routinely the background of a statistically significant number of unexposed detectors from each batch or lot to establish the laboratory background for the batch and the entire measurement system. This laboratory blank value is subtracted routinely (by the laboratory) from the field sample results reported to the user, and should be made available to the users for quality assurance purposes. In addition to these background measurements, the organization performing the measurements should calculate the lower limit of detection (LLD) for its measurement system (Altshuler and Pasternack 1963, ANSI 1989, U.S. DOE 1990). This LLD is based on the detector and analysis system's background and can restrict the ability of some measurement systems to measure low concentrations.

Providers of passive detectors should employ field controls (called blanks) equal to approximately five percent of the detectors that are deployed, or 25 each month, whichever is smaller. These controls should be set aside from each detector shipment, kept sealed and in a low radon environment, labeled in the same manner as the field samples to preclude special processing, and returned to the analysis laboratory along with each shipment. These field blanks measure the background exposure that may accumulate during shipment and storage, and the results should be monitored and recorded. The recommended action to be taken if the concentrations measured by one or more of the field blanks is significantly greater than the LLD is dependent upon the type of detector. More information is available in EPA's *Indoor Radon and Radon Decay Product Measurement Device Protocols* (EPA 520-402-R-92-004; U.S. EPA 1992c).

#### **4.4.4 Duplicate Measurements**

Duplicate measurements provide a check on the quality of the measurement result, and allow the user to make an estimate of the relative precision. Large precision errors may be caused by detector manufacture, and/or improper data

transcription or handling by suppliers, laboratories, or technicians performing placements. Precision error can be an important component of the overall error, so it is important that all users monitor precision.

Duplicate measurements for both active and passive detectors should be side-by-side measurements made in at least 10 percent of the total number of measurement locations, or 50 each month, whichever is smaller. The locations selected for duplication should be distributed systematically throughout the entire population of samples. Groups providing measurement services to homeowners can do this by providing two measurements, instead of one, to a random selection of purchasers, with the measurements made side-by-side. As with spiked samples introduced into the system as blind measurements, the precision of duplicate measurements should be monitored and recorded in the quality assurance records. The analysis of data from duplicates should follow the methodology described in *Appendix B* of this document. If the precision estimated by the user is not within the precision expected of the measurement method, the problem should be reported to the analysis laboratory and the cause investigated.

#### **4.4.5 Routine Instrument Performance Checks**

Proper functioning of analysis equipment and operator usage require that the equipment and measurement system be subject to routine checks. Regular monitoring of equipment and operators is vital to ensure consistently accurate results. Performance checks of analysis equipment includes the frequent use of an instrument check source. In addition, important components of the device (such as a pump and pump flow rate, battery, or electronics) should be checked prior to each measurement and the results noted in a log. Each user should develop methods for regularly (daily, or at least prior to each measurement) monitoring their measurement system, and for recording and reviewing results.

#### **4.4.6 Quality Assurance Plans**

All organizations should develop, implement, revise periodically, and maintain a detailed quality assurance plan (QAP) appropriate to each device or method used. This is a requirement for participation in EPA's National Radon Measurement Proficiency (RMP) Program. Specific guidance on the necessary quality control measures for each measurement method is provided in EPA's *Indoor Radon and*

*Radon Decay Product Measurement Device Protocols* (EPA 520-402-R-92-004; U.S. EPA 1992c).

Organizations that do not use continuous monitors or do not analyze detectors also need to write and follow a QAP, and conduct quality control measurements. These include duplicate, blank, and spiked measurements as described in Section 4.4. For further information on EPA's RMP Program, please contact:

RMP Program Information Service  
Research Triangle Institute  
3040 Cornwallis Road-Building 7  
P.O. Box 12194  
Research Triangle Park, NC 27709-2194  
(919-541-7131/FAX -7386)

#### 4.5 STANDARD OPERATING PROCEDURES

Organizations performing radon measurements should have a written, device-specific standard operating procedure (SOP) in place for each radon measurement system they use. An SOP must include specific information describing how to operate and/or analyze a particular measurement device. Organizations that analyze devices should develop their own SOP or adapt manufacturer-developed SOPs for their devices. Organizations that receive results from a laboratory should have a device-specific SOP for each brand/model/type of device that they use. All SOPs should be consistent with the appropriate protocol outlined in EPA's *Indoor Radon and Radon Decay Product Measurement Device Protocols* (EPA 520-402-R-92-004; U.S. EPA 1992c).

#### 4.6 PROVIDING INFORMATION TO CONSUMERS

Organizations should provide the customer with the following information:

- Devices that will be placed by the customer must be accompanied by instructions on how to use the device. These instructions should be consistent with EPA's *Indoor Radon and Radon Decay Product Measurement Device Protocols* (EPA 520-402-R-92-004; U.S. EPA 1992c) and include specific information on the minimum and maximum length of time that the device must be exposed.
- The service organization should inform clients about sources of information on mitigation, such as EPA's *Consumer's Guide to Radon Reduction* (EPA 402-K-92-003; U.S. EPA 1992b), and other information

available through their State Radon office. The organizations should also provide any State-required brochures which provide information on mitigation.

- If service organizations distribute the *Consumer's Guide* brochure, it should be reproduced in its entirety.

#### 4.7 REPORTING TEST RESULTS

Organizations should return radon measurement results to clients within a few weeks of retrieving exposed devices or receiving an exposed device which has been delivered for analysis. At a minimum, the client report should contain the following information:

- Measurement results reported in the units that the device measures. Any measurement results based on **radon gas** (pCi/L of air) should be reported to no more than one decimal place, e.g., 4.3 pCi/L. Any measurement result based on **radon decay products** (WL) should be reported to no more than three decimal places, e.g., 0.033 WL. Any conversions from WL to pCi/L or from pCi/L to WL should be presented and explained clearly.

If the WL value is converted to a radon concentration, it should be stated in the report to the homeowner that this approximate conversion is based on a 50 percent equilibrium ratio (unless the actual equilibrium ratio is determined). In addition, the report should indicate that this ratio is typical of the home environment, but that any indoor environment may have a different and varying relationship between radon and its decay products.

- The dates of the measurement period and address of the building tested.
- A description of the device used, its manufacturer, model or type, and the device identification (serial) numbers.
- The name and RMP identification numbers of the organization and individual placing and retrieving the device and the organization analyzing the device, if they are different.
- A statement concerning any observed tampering or deviations from the required test conditions.
- Organizations that offer measurement services with grab sampling

devices should provide clients with written notification stating that grab sample results can be useful diagnostic tools, but should not be used for deciding whether or not to mitigate.

#### **4.8 TEMPORARY RISK REDUCTION MEASURES**

Contractors should refer the occupants of the house and real estate agents to EPA's *Interim Radon Mitigation Standards* (U.S. EPA 1992d) or the *Consumer's Guide to Radon Reduction* (EPA 402-K-92-003; U.S. EPA 1992b) for information on temporary and permanent risk reduction measures.

If any radon reduction efforts are identified during measurement procedures, testers should inform clients and other parties to the real estate transaction that altered conditions during the measurement will invalidate the results and decline to conduct a measurement until the conditions have been corrected.

#### **4.9 RECOMMENDATIONS FOR MITIGATION**

The measurement organization should inform consumers that EPA recommends fixing houses with radon levels equal to or greater than 4 pCi/L, and that EPA recommends in its "Consumer's Guide to Radon Reduction" the use of EPA Radon Contractor Proficiency (RCP)-listed and/or State-listed mitigation contractors to perform the work (EPA 402-K-92-003; U.S. EPA 1992b).

Organizations should refer customers to their State radon office for copies of EPA's "Consumer's Guide to Radon Reduction" (EPA 402-K-92-003; U.S. EPA 1992b) and a list of EPA RCP-proficient and State-listed mitigators.

Homes should also be tested again after they are fixed to be sure that radon levels have been reduced. If the occupants' living patterns changes and they begin occupying a lower level of their home (such as a basement), the home should be retested on that level. In addition, it is a good idea for homes to be retested sometime in the future to be sure radon levels remain low.

#### **4.10 WORKER SAFETY**

Individuals and organizations should comply with all applicable Occupational Safety and Health Administration (OSHA) standards and guidelines relating to occupational worker exposure, health, and safety. Information on worker health and safety contained in EPA or State publications is not considered a substitute for any provisions of the *Occupational Safety and Health Act of 1970* or for any standards issued by OSHA.

## APPENDIX A

### STATE AND EPA REGIONAL RADON OFFICES

#### A.1 STATE RADIATION AND RADON OFFICES

The State radiation and radon offices distribute EPA's radon-related technical and guidance documents.

##### **Alabama**

Division of Radiation Control  
State Department of Public Health  
434 Monroe Street, Room 510  
Montgomery, AL 36130-1701  
(205) 242-5315  
(800) 582-1866 in Alabama

##### **Alaska**

State Department of Health and Social  
Services  
Division of Public Health  
P.O. Box H  
Juneau, AK 99811-0610  
(907) 465-3019  
(800) 478-4845 in Alaska

##### **Arizona**

State Radiation Regulatory Agency  
4814 South 40th Street  
Phoenix, AZ 85040  
(602) 255-4845

##### **Arkansas**

Division of Radiation Control and  
Emergency Management  
State Department of Health  
4815 West Markham Street  
Little Rock, AR 72205-3867  
(501) 661-2301

##### **California**

State Department of Health Services  
Environmental Management Branch  
601 North 7th Street  
P.O. Box 942732  
Sacramento, CA 94234-7320  
(916) 324-2208  
(800) 745-7236 in California

##### **Colorado**

Radiation Control Division  
State Department of Health  
4210 East 11th Avenue  
Denver, CO 80220  
(303) 692-3057  
(800) 846-3986 in Colorado

##### **Connecticut**

State Department of Health Services  
Radon Program  
150 Washington Street  
Hartford, CT 06106-4474  
(203) 566-3122

##### **Delaware**

Office of Radiation Control  
State Bureau of Environmental Health  
Division of Public Health  
P.O. Box 637  
Dover, DE 19903  
(302) 739-5728  
(800) 554-4636 in Delaware

**District of Columbia**  
D.C. Department of Consumer and  
Regulatory Affairs  
614 H Street, N.W.  
Room 1014  
Washington, D.C. 20001  
(202) 727-5728; hotline

**Florida**  
Office of Radiation Control  
State Department of Health and  
Rehabilitative Services  
1317 Winewood Boulevard  
Tallahassee, FL 32399-0700  
(904) 488-1525  
(800) 543-8279 in Florida;  
consumer inquiries only

**Georgia**  
State Department of Human Resources  
878 Peachtree Street  
Room 100  
Atlanta, GA 30309  
(404) 657-6534  
(800) 745-0037 in Georgia

**Guam**  
Guam Environmental Protection Agency  
IT&E Harmon Plaza  
D-107  
130 Rojas Street  
Harmon, Guam 96911  
(617) 646-8863

**Hawaii**  
Radiation Branch  
State Department of Health  
591 Ala Moana Boulevard  
Honolulu, HI 96813-2498  
(808) 586-4700

**Idaho**  
State Department of Health and Welfare  
Bureau of Preventive Medicine  
450 West State Street  
Boise, ID 83720  
(208) 334-6584  
(800) 445-8647 in Idaho

**Illinois**  
State Department of Nuclear Safety  
1301 Knotts Street  
Springfield, IL 62703  
(217) 786-7127  
(800) 325-1245 in Illinois

**Indiana**  
Radiological Health Section  
State Board of Health  
1330 West Michigan Street  
P.O. Box 1964  
Indianapolis, IN 46206  
(317) 633-0150  
(800) 272-9723 in Indiana

**Iowa**  
Radon Control Program  
Bureau of Radiological Health  
State Department of Public Health  
Lucas State Office Building  
Des Moines, IA 50319-0075  
(515) 242-5992  
(800) 383-5992 in Iowa

**Kansas**  
Radiation Control Program  
Environmental Health Services  
State Department of Health and  
Environment  
109 SW 9th Street  
6th Floor, Mills Building  
Topeka, KS 66612  
(913) 296-1561

**Kentucky**

Radiation Control Branch  
Division of Community Safety  
State Department of Health Services  
Cabinet for Human Resources  
275 East Main Street  
Frankfort, KY 40621  
(502) 564-3700

**Louisiana**

Radiation Protection Division  
Louisiana Department of Environmental  
Quality  
P.O. Box 82135  
Baton Rouge, LA 70884-2135  
(504) 925-7042  
(800) 256-2494 in Louisiana

**Maine**

Department of Human Resources  
Division of Health Engineering  
State House, Station 10  
Augusta, ME 04333  
(207) 287-5676  
(800) 232-0842 in Maine

**Maryland**

Radiological Health Program  
State Department of the Environment  
2500 Broening Highway  
Baltimore, MD 21224  
(410) 631-3300  
(800) 872-3666 in Maryland

**Massachusetts**

State Department of Public Health  
Western MA Health Office  
23 Service Center  
Northampton, MA 01060  
(413) 586-7525  
(800) 445-1255

**Michigan**

Division of Radiological Health  
Bureau of Environmental and  
Occupational Health  
State Department of Public Health  
3423 North Logan Street/  
Martin L. King Jr. Blvd.  
P.O. Box 30195  
Lansing, MI 48909  
(517) 335-8190-

**Minnesota**

State Indoor Air Quality Unit  
925 Delaware Street, SE  
P.O. Box 59040  
Minneapolis, MN 55459-0040  
(612) 627-5012  
(800) 798-9050 in Minnesota

**Mississippi**

Division of Radiological Health  
State Department of Health  
3150 Lawson Street  
P.O. Box 1700  
Jackson, MS 39215-1700  
(601) 354-6657  
(800) 626-7739 in Mississippi

**Missouri**

Bureau of Radiological Health  
State Department of Health  
1730 East Elm  
P.O. Box 570  
Jefferson City, MO 65102  
(314) 751-6083  
(800) 669-7236 in Missouri

**Montana**

Occupational Health Bureau  
State Department of Health and  
Environmental Sciences  
Cogswell Building A113  
Helena, MT 59620  
(406) 444-3671

**Nebraska**

Division of Radiological Health  
State Department of Health  
301 Centennial Mall, South  
P.O. Box 95007  
Lincoln, NE 68509  
(402) 471-2168  
(800) 334-9491 in Nebraska

**Nevada**

Radiological Health Section  
State Health Division  
505 East King Street, Room 203  
Carson City, NV 89710  
(702) 687-5394

**New Hampshire**

Bureau of Radiological Health  
State Div. of Public Health Services  
Health and Welfare Building  
Six Hazen Drive  
Concord, NH 03301  
(603) 271-4674; hotline  
(800) 852-3345x4674 in NH

**New Jersey**

Radiation Protection Programs  
Bureau of Environmental Radiation  
Department of Environmental Protection  
and Energy  
CN 415  
729 Alexander Road  
Trenton, NJ 08625-0415  
(609) 987-6396  
(800) 648-0394 in New Jersey

**New Mexico**

Hazardous and Radioactive Materials  
Bureau  
New Mexico Environment Department  
525 Camino De Los Marquez  
P.O. Box 26110  
Santa Fe, NM 87502  
(505) 827-4300

**New York**

Bureau of Environmental Radiation  
Protection  
State Health Department  
Two University Place  
Albany, NY 12203  
(518) 458-6451  
(800) 458-1158 in New York

**North Carolina**

Division of Radiation Protection  
State Department of Environment,  
Health, and Natural Resources  
P.O. Box 27687  
Raleigh, NC 27611-7687  
(919) 571-4141

**North Dakota**

Division of Environmental  
Engineering  
State Department of Health  
1200 Missouri Avenue, Room 304  
P.O. Box 5520  
Bismarck, ND 58502-5520  
(701) 221-5188

**Ohio**

Ohio Department of Health  
Bureau of Radiological Health Services  
246 N. High Street  
P.O. Box 118  
Columbus, OH 43266-0118  
(614) 644-2727  
(800) 523-4439 in Ohio; hotline

**Oklahoma**

Radiation Protection Division  
Oklahoma State Department of Health  
P.O. Box 53551  
Oklahoma City, OK 73152  
(405) 271-5221

**Oregon**

Department of Human Resources  
State Health Division  
1400 SW 5th Avenue  
Portland, OR 97201  
(503) 731-4014

**Pennsylvania**

State Department of Environmental  
Protection  
Bureau of Radiation Protection  
P.O. Box 2063  
Harrisburg, PA 17120  
(717) 783-3595  
(800) 237-2366 in Pennsylvania

**Puerto Rico**

Radiological Health Division  
G.P.O. Call Box 70184  
Rio Piedras, Puerto Rico 00936  
(809) 767-3563

**Rhode Island**

Division of Occupational and  
Radiological Health  
State Department of Health  
206 Cannon Building  
3 Capitol Hill  
Providence, RI 02908  
(401) 277-2438

**South Carolina**

Bureau of Radiological Health  
State Department of Health and  
Environmental Control  
2600 Bull Street  
Columbia, SC 29201  
(803) 734-4631  
(800) 768-0362 in South Carolina

**South Dakota**

State Department of Water and  
Natural Resources  
523 E. Capitol  
Pierre, SD 57501  
(605) 773-3351  
(800) 438-3367

**Tennessee**

State Department of Health and  
Environment  
Division of Air Pollution Control  
701 Broadway, 4th Floor  
Nashville, TN 37247-3101  
828-28861(615) 532-0733  
(800) 232-1139 in Tennessee

**Texas**

Radiological Assessment Program  
Bureau of Radiation Control  
State Department of Health  
1100 West 49th Street  
Austin, TX 78756  
(512) 834-6688

**Utah**

Division of Radiation Control  
Department of Environmental Quality  
160 North 1950 West  
Salt Lake, UT 84114-4850  
(801) 538-6734

**Vermont**

Occupational and Radiological  
Health Operations  
Division of Occupational and  
Radiological Health  
State Department of Health  
10 Baldwin Street,  
Administrative Bldg.  
Montpelier, VT 05602  
(802) 865-7730  
(800) 640-0601 in Vermont

**Virginia**

Bureau of Radiological Health  
State Department of Health  
109 Governor Street  
Richmond, VA 23219  
(804) 786-5932  
(800) 468-0138 in Virginia

**Virgin Islands**

Contact the U.S. EPA, Region 2 in  
New York  
Mail Code 2AWM-RAD  
26 Federal Plaza  
New York, NY 10278  
(212) 264-4110

**Washington**

Division of Radiation Protection  
State Department of Health  
Airdustrial Building 5, LE-13  
Olympia, WA 98504  
(206) 753-4518  
(800) 323-9727 in Washington; hotline

**West Virginia**

Office of Environmental Health  
Services  
Industrial Hygiene Division  
State Bureau of Public Health  
151 11th Avenue  
South Charleston, WV 25303  
(304) 558-3526  
(800) 922-1255 in West Virginia

**Wisconsin**

Radon Program  
Radiation Protection Section  
Division of Health  
State Department of Health and  
Social Services  
P.O. Box 309  
Madison, WI 53701-0309  
(608) 267-4795

**Wyoming**

Environmental Health Programs  
State Department of Health  
Hathway Building, 4th Floor  
(Room 482)  
Cheyenne, WY 82002-0710  
(307) 777-6015  
(800) 458-5847 in Wyoming

## **A.2 EPA REGIONAL RADIATION (RADON) PROGRAM MANAGERS**

There are 10 EPA Regional Program Managers, one for each EPA geographical Region. (Exhibit A-1 of this appendix contains a map showing the States and their EPA Regions.)

### **Region 1**

Radiation Program Manager, Region 1  
U.S. Environmental Protection Agency  
John F. Kennedy Federal Building  
Room 2311  
Boston, MA 02203  
(617) 565-4502

### **Region 2**

Chief, Radiation Branch (AWM-RAD)  
U.S. Environmental Protection Agency  
26 Federal Plaza, Room 1005A  
New York, NY 10278  
(212) 264-4110

### **Region 3**

Radiation Program Manager, Region 3  
Special Program Section (3AM12)  
U.S. Environmental Protection Agency  
841 Chestnut Street  
Philadelphia, PA 19107  
(215) 597-8326

### **Region 4**

Radiation Program Manager, Region 4  
U.S. Environmental Protection Agency  
345 Courtland Street, N.E.  
Atlanta, GA 30365  
(404) 347-3907

### **Region 5**

Radiation Program Manager, Region 5  
(5AR26)  
U.S. Environmental Protection Agency  
230 S. Dearborn Street  
Chicago, IL 60604  
(312) 353-2206

### **Region 6**

Radiation Program Manager, Region 6  
U.S. Environmental Protection Agency  
Chief, Technical Section (6T-ET)  
Air, Pesticides and Toxics Division  
1445 Ross Avenue  
Dallas, TX 75202-2733  
(214) 655-7223

### **Region 7**

Radiation Program Manager, Region 7  
U.S. Environmental Protection Agency  
726 Minnesota Avenue  
Kansas City, KS 66101  
(913) 551-7020

### **Region 8**

Radiation Program Manager, Region 8  
(8AT-RP)  
U.S. Environmental Protection Agency  
999 18th Street, Suite 500  
Denver, CO 80202  
(303) 293-1709

### **Region 9**

Radiation Program Manager, Region 9  
(A-1-1)  
U.S. Environmental Protection Agency  
75 Hawthorne Street  
San Francisco, CA 94105  
(415) 744-1048

### **Region 10**

Radiation Program Manager, Region 10  
(AT-082) U.S. EPA  
1200 Sixth Avenue  
Seattle, WA 98101  
(206) 442-7660

**Exhibit A-1**

**MAP OF EPA REGIONS**

Each of the 50 United States, as well as the District of Columbia, the Virgin Islands, and Puerto Rico, has been assigned to one of 10 Federal Regions. This map shows the Regional assignments for the 50 States. Puerto Rico and the Virgin Islands are assigned to Region 2; the District of Columbia is in Region 3.

## APPENDIX B

### INTERPRETATION OF THE RESULTS OF SIDE-BY-SIDE MEASUREMENTS

#### B.1 ASSESSMENT OF PRECISION

Radon and working level measurements, like all measurements, usually do not produce exactly the same results, even for collocated measurements. It is therefore critical to understand, document, and monitor the variability, or precision, of the measurements. This knowledge and proper documentation will allow you to characterize precision error to clients. Furthermore, the continual monitoring of precision provides a check on every aspect of the measurement system.

The objective of performing simultaneous or duplicate measurements is to assess the precision error of the measurement method, or how well two side-by-side measurements agree. This precision error is the "random" component of error (as opposed to the calibration error, which is systematic). The precision error, or the degree of disagreement between duplicates, can be composed of many factors. These include the error caused by the random nature of counting radioactive decay, slight differences between detector construction (for example, small differences in the amount of carbon in activated carbon detectors), and differences in handling of detectors (for example, differences in accuracy of the weighing process, and variations of analysis among detectors).

There is a variety of ways to quantitatively assess the precision error based on duplicate measurements. It is first necessary to understand that precision is characterized by a distribution; that is, your side-by-side measurements will exhibit a range of differences. There is some chance that any level of disagreement will be encountered, due merely to the statistical fluctuations of counting radioactive decays. The probability of encountering a very large difference between duplicates is smaller than the chance of observing a small difference similar to those that are routinely observed. It is important to recognize that a few high precision errors do not necessarily mean that the measurement system is flawed.

Ideally, the results of duplicates should be assessed in a way that allows for the determination of what level of chance is associated with a particular difference between duplicates. This will allow for the pre-determination of limits for the allowable differences between duplicates before an investigation into the cause of the large differences is made. For example, the **warning level**, or the level of discrepancy between duplicates which triggers an investigation, may be set at a five percent probability. This level is a difference between duplicates that is so large that, when compared with previous precision errors, should only be observed five percent of the time. A **control limit**, where further measurements should cease until the problem is corrected, may be set at one percent probability.

A control chart for duplicates is not as simple as a control chart used to monitor instrument performance, as for a check source. This is because the instrument's response to a check source should be fairly constant with time. Duplicates are performed at various radon concentrations, however, and the total difference between two measurements is expected to increase as radon levels increase.

Use of statistics such as the *relative percent difference* (RPD; difference divided by the mean) or the *coefficient of variation* (COV; standard deviation divided by the mean) can be used in a control chart for duplicate measurements at radon concentrations where the expected precision error is fairly constant in proportion to the mean, e.g., at levels greater than around 4 pCi/L or 0.02 WL. At lower concentrations, for example, between 2 pCi/L (or 0.01 WL) and 4 pCi/L (or 0.02 WL), a control chart may be developed by plotting these same statistics; however, the proportion of the precision error to the mean will be greater than that proportion at levels above 4 pCi/L or 0.02 WL. At concentrations less than about 2 pCi/L, or 0.01 WL, the lower limit of detection may be approached, and the precision error may be so large as to render a control chart not useful.

Example control charts, using three different statistics, are described in the following sections.

## B.2 EXAMPLE CONTROL CHARTS FOR PRECISION

Before a control chart can be developed, it is necessary to know, from a history of making good quality measurements with the exact measurement system (detectors, analysis equipment, and procedures), the level of precision that is routinely encountered when the system is operating well or "in control." It is that "in control" precision error that forms the basis of the control chart, and upon which all the subsequent duplicate measurements will be judged. There are two ways of initially determining this "in control" level. The first, and preferable, way is to perform at least 20 duplicate pairs of measurements at each range of radon concentrations for which a control chart is to be prepared. For example, if you will only assess precision at concentrations greater than 4 pCi/L, or 0.02 WL, you will need at least 20 pairs of measurements at concentrations greater than 4 pCi/L, or 0.02 WL, to assess the "in control" level. The average precision error (RPD or COV) should be the "in control" level.

The second way to initially set the "in control" precision error level is to use a level that has been used by others, and that is recognized by industry and EPA as a goal for precision, for example, a 10 percent COV (corresponding to a 14 percent RPD). After at least 20 pairs of measurements are plotted, it will become apparent

whether the 10 percent COV (or 14 percent RPD) is appropriate for your system. If it is not, a new control chart (using the guidelines below) should be prepared so that the warning and control limits are set at the correct probability limits for your system.

### **B.2.1 Sequential Control Chart Based on Coefficient of Variation**

It can be shown (Iglewicz and Myers 1970, EPA 600/9-76-005; U.S. EPA 1984) that when the expected precision is a constant function of the mean, control limits can be expressed in terms of the COV ( $COV = S/X_m$ ; where  $S$  is the variance or the square of the standard deviation, and  $X_m$  is the mean or average of the two measurements). One method for obtaining percentiles for the distribution of the COV is to apply a chi-squared ( $\chi^2$ ) test:

$$\chi^2_{n-1} = B[(n-1)COV_n^2 / (n + (n-1)COV^2)] \quad \text{(Equation 1)}$$

where  $B = n[1 + (1/COV^2)]$ ;

$COV_n$  = the observed COV of the  $n^{\text{th}}$  pair (the pair that is to be evaluated); and

$COV$  = the "in control" COV. (e.g., 10 percent at levels greater than 4 pCi/L).

For duplicates, where  $n=2$ , Equation 1 becomes

$$\chi^2 = [2 + (2/COV^2)][COV_n^2 / (2 + COV^2)] \quad \text{(Equation 2)}$$

For a value of 0.10 for COV, it further reduces to

$$\chi^2 = 202[COV_n^2 / (2 + COV_n^2)] \quad \text{(Equation 3)}$$

Referring to a  $\chi^2$  chart, you learn that the probability of exceeding a  $\chi^2$  of 3.84 is only five percent. Inserting this value of 3.84 for  $\chi^2$  and solving for  $COV_n$ , produces a  $COV_n$  of 0.20. This level of probability forms the *warning level* shown in Exhibit B-1. The *control limit* corresponds to a  $\chi^2$  of 6.63 and a  $COV_n$  of 0.26, where the probability of exceeding those values is only one percent.

This sequential control chart should be used by plotting results from each pair on the y-axis, and noting the date and measurement numbers on the x-axis.

### **B.2.2 Sequential Control Chart Based on Relative Percent Difference**

The RPD (or percent difference) is another expression of precision error, and is given by

$$RPD = [100|x_1 - x_2|] / [(x_1 + x_2) / 2] \quad (\text{Equation 4})$$

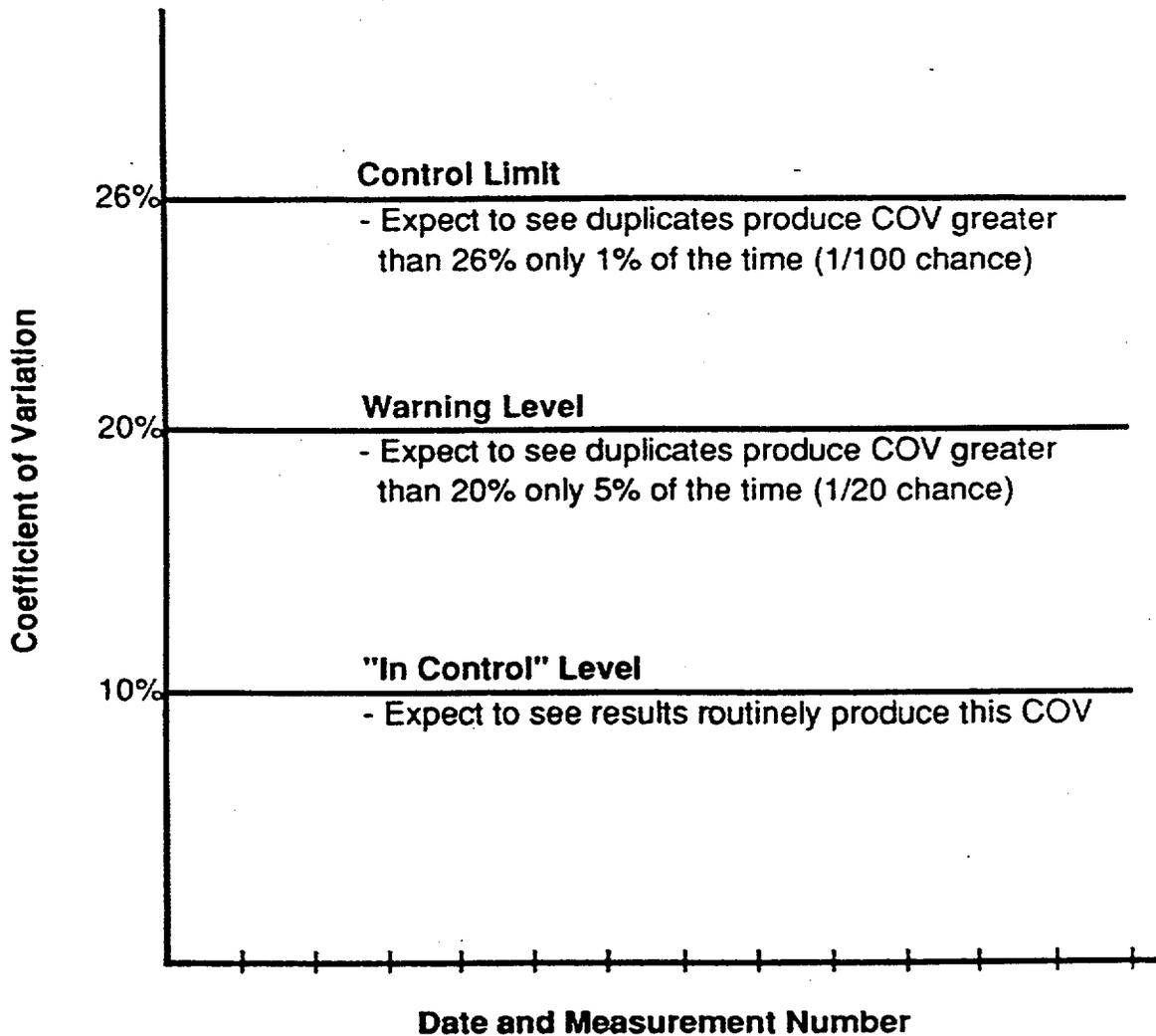
For  $n=2$ ,

$$RPD = COV\sqrt{2} \quad (\text{Equation 5})$$

The control limits for RPD can be obtained simply by multiplying the control limits for COV by the square root of two, or 1.41. These limits are shown in Exhibit B-2. This sequential control chart for RPD should be used in the same way as the control chart for COV, that is, with the vertical scale in units of RPD and the horizontal scale in units of date and measurement numbers.

A control chart using the statistic RPD based on an "in control" level of 25 percent RPD is shown in Exhibit B-3. The *warning level* and *control limit* are set at 50 percent and 67 percent, respectively. Use of these limits may be appropriate for measured radon concentrations less than 4 pCi/L.

**Control Chart\* for Coefficient of Variation (COV)  
Based on an "In Control" Level of 10%  
(For duplicates where average  $\geq 4$  pCi/L or 0.02 WL)**



COV=standard deviation of two measurements divided by their average  
Example: Detector A=5 pCi/L, B=6 pCi/L, COV=13%

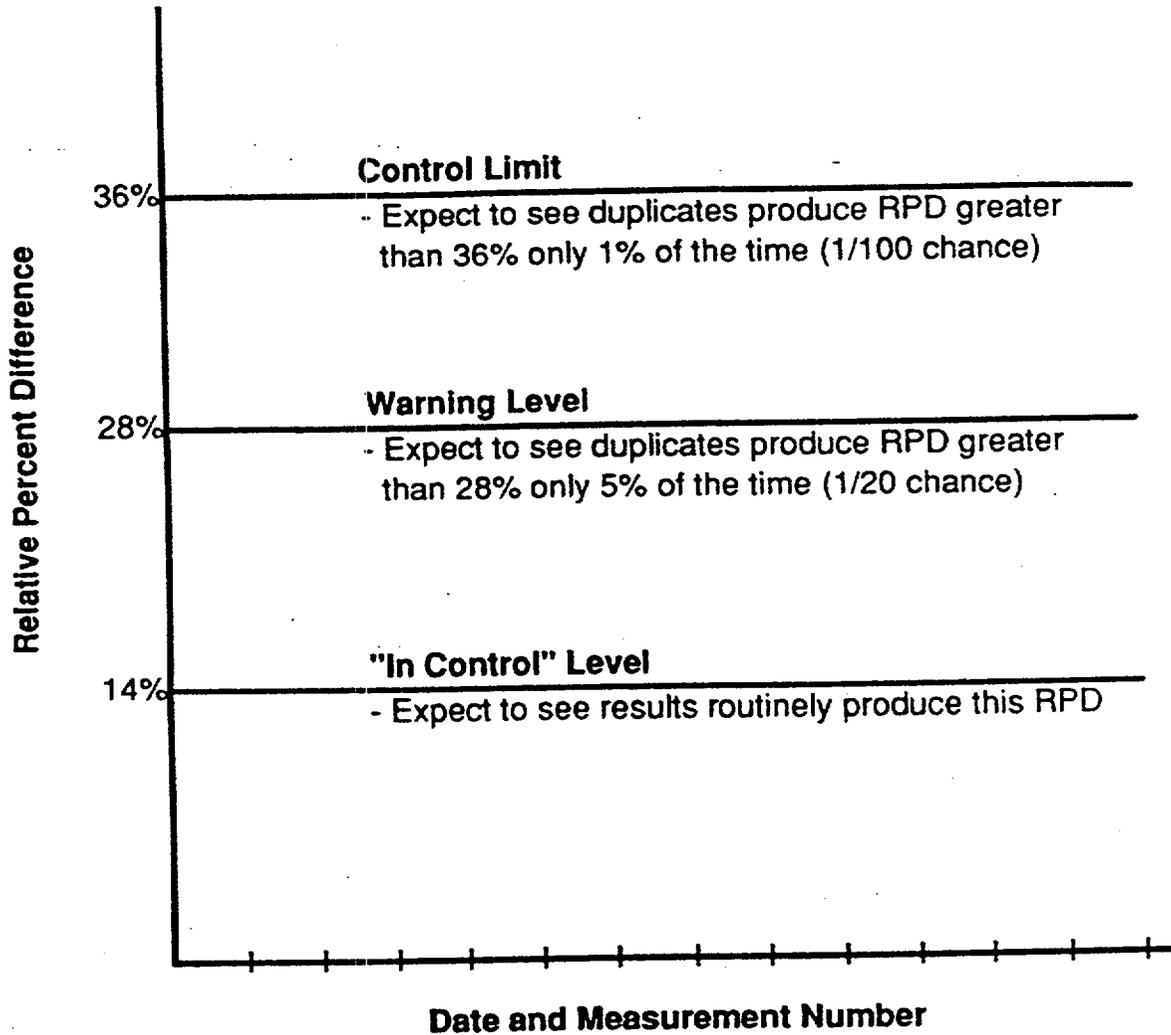
If COV exceeds the control limit--cease measurements until the problem is identified and corrected.

If COV exceeds the warning level--follow guidance in *Section B.3* and see Exhibit B-5.

\*As calculated from guidance provided in "Quality Assurance Handbook for Air Pollution Measurement Systems: Volume I" (EPA 600/9-76-005; U.S. EPA 1984)

Exhibit B-2

Control Chart\* for Relative Percent Difference (RPD)  
Based on an "In Control" Level of 14% (=COV of 10%)  
(For duplicates where average  $\geq 4$  pCi/L or 0.02 WL)



RPD=difference between two measurements divided by their average  
Example: Detector A=5 pCi/L, B=6 pCi/L, RPD=18%

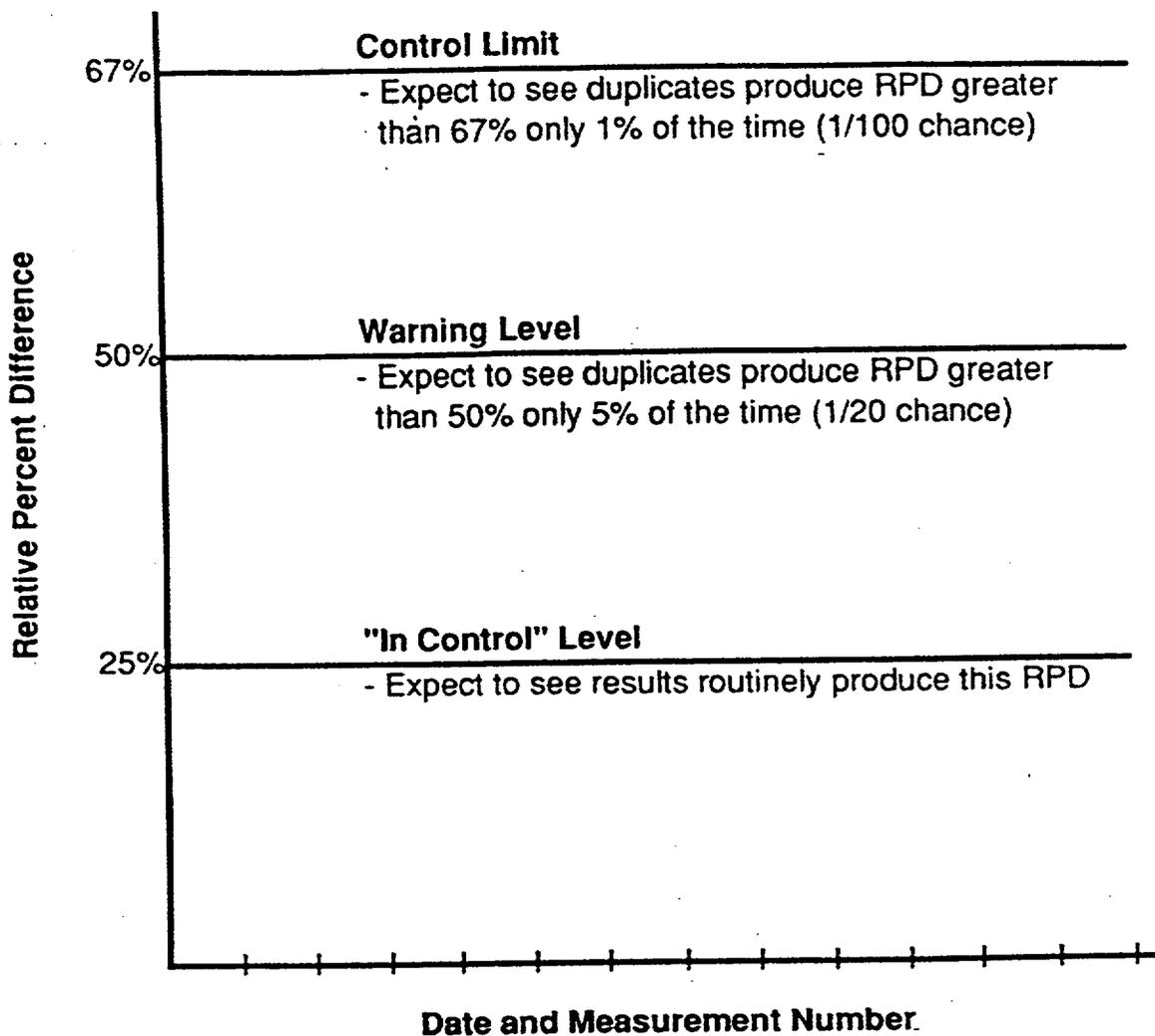
If RPD exceeds the control limit—cease measurements until the problem is identified and corrected.

If RPD exceeds the warning level—follow guidance in *Section B.3* and see Exhibit B-5.

\*As calculated from guidance provided in "Quality Assurance Handbook for Air Pollution Measurement Systems: Volume I" (EPA 600/9-76-005; U.S. EPA 1984)

Exhibit B-3

**Control Chart\* for Relative Percent Difference (RPD)**  
**Based on an "In Control" Level of 25% (=COV of 18%)**  
(For duplicates where average < 4 pCi/L or 0.02 WL)



RPD=difference between two measurements divided by their average  
Example: Detector A=2 pCi/L, B=3 pCi/L, RPD=40%

If RPD exceeds the control limit--cease measurements until the problem is identified and corrected.

If RPD exceeds the warning level--follow guidance in *Section B.3* and see Exhibit B-5.

\*As calculated from guidance provided in "Quality Assurance Handbook for Air Pollution Measurement Systems: Volume I" (EPA 600/9-76-005; U.S. EPA 1984)

### **B.2.3. Range Control Chart**

A range control chart (Goldin 1984) can be constructed to evaluate precision, using the statistics of the range (difference between two measurements) plotted against the average of the two measurements. The control limits are again based on the variability of the measurements, as decided upon from previous results or using an industry standard (e.g., 10 percent).

In this type of control chart, the limits are expressed in terms of the mean range ( $R_m$ ), where, for  $n=2$ ,

$$R_m = 1.128 s(x) \qquad \text{(Equation 6)}$$

where  $s(x)$  is the standard deviation of a single measurement, which reflects counting and other precision errors. Goldin shows that the limits can be expressed as follows:

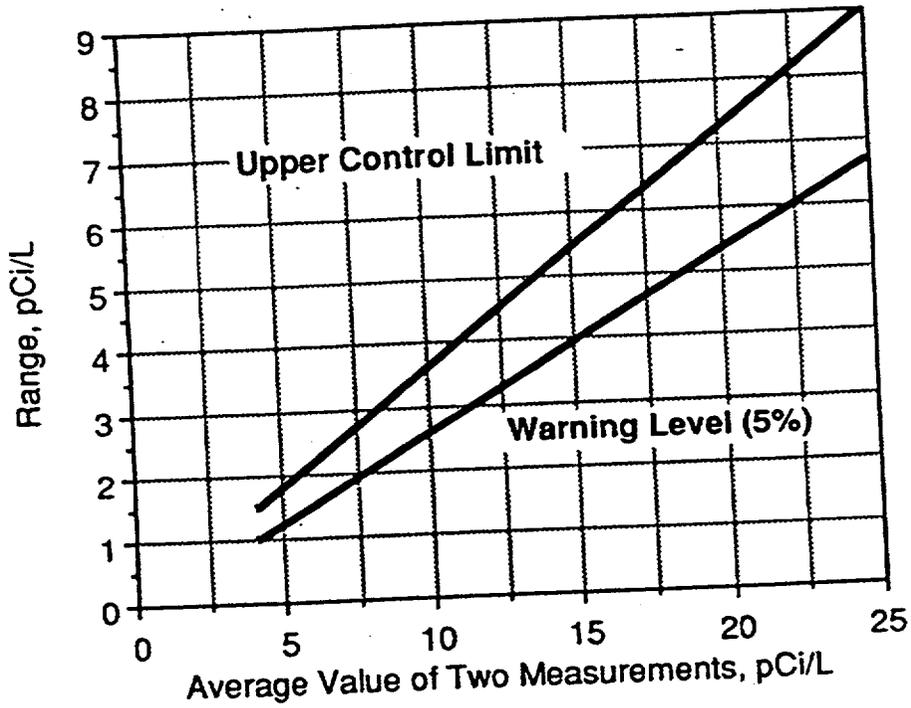
$$\text{Control limit} = 3.69 s(x) \qquad \text{(Equation 7)}$$

$$\text{Warning level} = 2.53 s(x) \qquad \text{(Equation 8)}$$

An example range control chart, using an assumed  $s(x)$  equal to 10 percent of the mean concentration, is shown in Exhibit B-4. The chart is used by plotting the range versus average concentration as duplicate measurements are analyzed.

Exhibit B-4

Range Control Chart to Evaluate Precision  
(Limits Based on  $s(x)=0.1x_m$ )



If results exceed the control limit--cease measurements until the problem is identified and corrected.

If results exceed the warning level--follow guidance in *Section B.3* and see Exhibit B-5.

### B.3 INTERPRETATION OF PRECISION CONTROL CHARTS

The control chart should be examined carefully every time a new duplicate result is plotted. If a duplicate result falls outside the control limit, repeat the analyses if possible. If the repeated analyses also fall outside the control limit, stop making measurements and identify and correct the problem.

If any measurements fall outside the *warning level*, use the table in Exhibit B-5. Refer to the row showing the number of duplicate results outside the *warning level*. If the total number of duplicate results accumulated in the control chart is contained in column A, investigate the cause of the high level of precision error but continue making measurements. If the total number of duplicate results on the chart is contained in column B, stop making measurements until the cause for the high precision error is found, and it is determined that subsequent measurements will not suffer the same high level of precision error.

Note that the example control charts shown here are simplifications of actual conditions, because they are premised on the assumption that the precision error is a constant fraction of the mean concentration. In fact, the total precision error may best be represented by a different function of the mean concentration, for example, the square root of the concentration. The most accurate control chart can be rendered by a range control chart using the measurement uncertainty expressed as the standard deviation,  $s(x)$ , expected at the concentrations where measurements are made. If the precision error is not a constant fraction of the mean, the control limits will not appear as straight lines, but may exhibit changing slope. However, methods discussed here present a conservative way to monitor, record, and evaluate precision error and are very useful for comparing observed precision errors with an industry standard.

**Exhibit B-5**

**Criteria for Taking Action for Measurements Outside the Warning Level\***

Number of Duplicate Results Outside the Warning Level	Total Number of Duplicates	
	Investigate, But Continue Operations	Stop Operations Until Problem is Corrected
	A	B
2	8-19	2-7
3	17-34	8-16
4	29-51	17-28
5	41-67	29-40
6	54-84	41-53
7	67-100	54-66

\* Modified from Goldin (Goldin 1984) and based upon cumulative probability tables of the binomial distribution.

## GLOSSARY

**Accuracy:** The degree of agreement of a measurement (X) with an accepted reference or true value (T); usually expressed as the difference (or bias) between the two values (X - T), or the difference as a percentage of the reference or true value ( $100[X - T]/T$ ), and sometimes expressed as a ratio (X/T).

**Active radon/radon decay product measurement device:** A radon or radon decay product measurement system which uses a sampling device, detector, and analysis system integrated as a complete unit or as separate, but portable, components. Active devices include continuous radon monitors, continuous working level monitors, and grab radon and grab working level measurement systems, but do not include devices such as electret ion chamber devices, activated carbon or other adsorbent systems, or alpha track devices.

**Alpha particle:** Two neutrons and two protons bound as a single particle that is emitted from the nucleus of certain radioactive isotopes in the process of radioactive decay.

**Background instrument (analysis system, or laboratory) count rate:** The nuclear counting rate obtained on a given instrument with a background counting sample. Typical instrument background measurements are:

- Unexposed carbon: for activated carbon measurement systems.
- Scintillation vial containing scintillant and sample known to contain no radioactivity: for scintillation counters.
- Background measurements made with continuous radon monitors exposed only to radon-free air (aged air or nitrogen).

**Background field measurement (blanks):** Measurements made by analyzing unexposed (closed) detectors that accompanied exposed detectors to the field. The purpose of field background measurements is to assess any exposure to the detector caused by radon exposure other than from the concentration in the environment to be measured. Results of background field measurements are subtracted from the actual field measurements before calculating the reported concentration. Background levels may be due to electronic noise of the analysis system, leakage of radon into the detector, detector response to gamma radiation, or other causes.

**Background radiation:** Radiation arising from radioactive materials, the sun, and parts of the universe, other than that under consideration. Background radiation due to cosmic rays and natural radioactivity is always present; background radiation may also be due to the presence of radioactive substances in building materials.

**Becquerel (Bq):** The International System of Units (SI) definition of activity. 1 Bq = 1 disintegration per second.

**Calibrate:** To determine the response or reading of an instrument relative to a series of known values over the range of the instrument; results are used to develop correction or calibration factors.

**Check source:** A radioactive source, not necessarily calibrated, which is used to confirm the continuing consistent and satisfactory operation of an instrument.

**Client:** The individual or parties who hire(s) the radon tester.

**Closed House Conditions:** During any short-term test, closed-house-conditions should be maintained as much as possible while the test is in progress. In tests of less than 4 days duration, closed-house-conditions should be maintained for at least 12-hours before starting the test and for the duration of the test. While closed-house-conditions are not required before the start of tests that are between 4 and 90-days long, closed-house-conditions should be maintained as much as possible.

**Coefficient of variation (COV), relative standard deviation (RSD):** A measure of precision, calculated as the standard deviation ( $s$  or  $\sigma$ ) of a set of values divided by the average ( $X_{ave}$  or  $\mu$ ), and usually multiplied by 100 to be expressed as a percentage.

$$COV = RSD = (s/X_{ave}) \times 100 \text{ for a sample,}$$

or

$$COV' = RSD' = (\sigma/\mu) \times 100 \text{ for a population.}$$

See Relative percent difference.

**Curie (Ci):** A commonly used measurement unit for radioactivity in the United States, specifically the approximate rate of decay for a gram of radium = 37 billion decays per second. A unit of radioactivity equal to  $3.7 \times 10^{10}$  disintegrations per second.

**Duplicate measurements:** Two measurements made concurrently and in the same location, side-by-side. Use to evaluate the precision of the measurement method.

**Efficiency, intrinsic detector:** The relationship between the number of events recorded (counts, voltage lost, tracks) and the number of radioactive particles incident upon the sensitive element of the detector per unit time. Efficiencies for radon detectors are commonly expressed in terms of the calibration factor, which is the number of events (counts) per time (hour or minute) per radon concentration (pCi/L). Methods with high efficiencies will exhibit more counts (signal) per time in response to a given radon level than will a method with a low efficiency.

**Equilibrium ratio, radon:** Equilibrium ratio =  $[WL(100)]/(pCi/L)$ . At complete equilibrium (i.e., at an equilibrium ratio of 1.0), 1 WL of RDPs would be present when the radon concentration was 100 pCi/L. The ratio is never 1.0 in a house. Due to ventilation and plate-out, the RDPs never reach equilibrium in a residential environment. A commonly assumed equilibrium ratio is 0.5 (i.e., the decay products are halfway toward equilibrium), in which case 1 WL would correspond to 200 pCi/L. However, equilibrium ratios vary with time and location, and ratios of 0.3 to 0.7 are commonly observed.

**Equilibrium equivalent concentration (EEC):** The radon concentration in equilibrium with its short-lived progeny, that has the same potential alpha energy per volume as exists in the environment being measured (see working level).

**Exposure time:** The length of time a specific device must be in contact with radon or radon decay products to get an accurate radon measurement. Also called exposure period, exposure parameter, or duration of exposure.

**Gamma radiation:** Short-wavelength electromagnetic radiation of nuclear origin, with a wide range of energies.

**Integrating device:** A device that produces a measurement of the average concentration over a period of time. Also called a time-integrating device.

**Lower limit of detection (LLD):** The smallest amount of sample activity which will yield a net count for which there is confidence at a predetermined level that activity is present. For a five percent probability of concluding falsely that activity is present, the LLD may be approximated by a value of 4.65 times the standard deviation of the background counts (assuming large numbers of counts where Gaussian statistics can be used [ANSI 1989, Pasternack and Harley 1971, U.S. DOE 1990]).

**Lowest level suitable for occupancy:** The lowest level currently lived in or a lower level not currently used, such as a basement, which a prospective buyer could use for living space without renovations. This includes a basement that could be used regularly, as for example a recreation room, bedroom, den, or playroom.

**Lowest lived-in level:** The lowest level or floor of a home that is used regularly, including areas such as family rooms, living rooms, dens, playrooms, and bedrooms.

**Passive radon measurement device:** A radon measurement system in which the sampling device, detector, and measurement system do not function as a complete, integrated unit. Passive devices include electret ion chamber devices, activated carbon or other adsorbent systems, or alpha track devices, but do not include continuous radon/radon decay product monitors, or grab radon/radon decay product measurement systems.

**Picocurie (pCi):** One pCi is one trillionth ( $10^{-12}$ ) of a curie, 0.037 disintegrations per second, or 2.22 disintegrations per minute.

**Picocurie per liter (pCi/L):** A unit of radioactivity corresponding to an average of one decay every 27 seconds in a volume of one liter, or 0.037 decays per second in a liter of air or water.  $1 \text{ pCi/L} = 37 \text{ Bq/m}^3$ .

**Precision:** A measure of mutual agreement among individual measurements made under similar conditions. Can be expressed in terms of the variance, pooled estimate of variance, range, standard deviation at a particular concentration, relative percent difference, coefficient of variation or other statistic.

**Quality assurance:** A complete program designed to produce results which are valid, scientifically defensible, and of known precision, bias, and accuracy. Includes planning, documentation, and quality control activities.

**Quality control:** The system of activities to ensure a quality product, including measurements made to ensure and monitor data quality. Includes calibrations, duplicate, blank, and spiked measurements, interlaboratory comparisons, and audits.

**Radon (Rn):** A colorless, odorless, naturally occurring, radioactive, inert, gaseous element formed by radioactive decay of radium (Ra) atoms. The atomic number is 86. Although other isotopes of radon occur in nature, radon in indoor air is primarily Rn-222.

**Radon chamber:** An airtight enclosure in which operators can induce and control different levels of radon gas and radon decay products. Volume is such that samples can be taken without affecting the levels of either radon or its decay products within the chamber.

**Relative percent difference (RPD):** A measure of precision, calculated by:

$$RPD = [(|X_1 - X_2|)/X_{ave}] \times 100$$

where:

$X_1$  = concentration observed with the first detector or equipment;

$X_2$  = concentration observed with the second detector, equipment, or absolute value;

$|X_1 - X_2|$  = absolute value of the difference between  $X_1$  and  $X_2$ ; and

$X_{ave}$  = average concentration =  $(X_1 + X_2)/2$ .

The RPD and coefficient of variation (COV) provide a measure of precision, but they are not equal. Below are example duplicate radon results and the corresponding values of RPD and COV:

<u>Rn1</u> <u>(pCi/L)</u>	<u>Rn2</u> <u>(pCi/L)</u>	<u>RPD</u> <u>(%)</u>	<u>COV</u> <u>(%)</u>
8	9	12	8
13	15	14	10
17	20	16	11
26	30	14	10
7.5	10	29	20

*Note that the  $RPD/\sqrt{2} = COV$ .*

See **Coefficient of variation (COV)**.

**Relative standard deviation:** See **Coefficient of variation**.

**Sensitivity:** The ability of a radon or WL measurement method to produce reliable measurements at low concentrations. This ability is dependent upon the variability of the background signal (counts not due to radon or WL exposure) which the method records, as well as its efficiency. Methods with stable background rates and high efficiencies will be able to produce reliable

measurements at lower concentrations than methods with variable background rates and low efficiencies. Sensitivity can be expressed in terms of the lower limit of detection or minimum detectable activity.

**Signal-to-noise ratio:** For radon and WL detectors, this term expresses the proportion of the number of counts due to exposure to radon or WL (signal) to the number of counts due to background (noise). Measurement methods with high signal-to-noise ratios will produce more counts due to radon or WL exposure (signal) in proportion to the background counts (noise) than will methods with low signal-to-noise ratios. A method with a high signal-to-noise ratio is more likely to exhibit good sensitivity, i.e., be able to produce reliable measurements at low concentrations.

**Spiked measurements, or known exposure measurements:** Quality control measurements in which the detector or instrument is exposed to a known concentration in a calibration facility and submitted for analysis. Used to evaluate accuracy.

**Standard deviation (s):** A measure of the scatter of several sample values around their average. For a sample, the standard deviation (s) is the positive square root of the sample variance:

$$s = \frac{\sqrt{\sum_{i=1}^n (X_i - X_{ave})^2}}{\sqrt{n - 1}}$$

For a finite population, the standard deviation ( $\sigma$ ) is:

$$\sigma = \frac{\sqrt{\sum_{i=1}^N (X_i - \mu)^2}}{\sqrt{N}}$$

where  $\mu$  is the true arithmetic mean of the population and N is the number of values in the population. The property of the standard deviation that makes it most practically meaningful is that it is expressed in the same units as the observed variable X. For example, the upper 99.5 percent probability limit on differences between two values is 2.77 times the sample standard deviation.

**Standard operating procedure:** A written document which details an operation, analysis, or action whose mechanisms are prescribed thoroughly and which is commonly accepted as the method for performing certain routine or repetitive tasks.

**Statistical control chart (Shewhart control chart):** A graphical chart with statistical control limits and plotted values (for some applications in chronological order) of some measured parameter for a series of samples. Use of the charts provides a visual display of the pattern of the data, enabling the early detection of time trends and shifts in level. For maximum usefulness in control, such charts should be plotted in a timely manner (i.e., as soon as the data are available). See *Appendix B*.

**Statistical control chart limits:** The limits on control charts that have been derived by statistical analysis and are used as criteria for action, or for judging whether a set of data does or does not indicate lack of control. On a means control chart, the warning level (indicating the need for an investigation) may be two standard deviations above and below the mean, and the control limit (indicating the need to halt operations until the problem is identified and corrected) may be three standard deviations above and below the mean.

**Systeme Internationale (SI):** The International System of Units as defined by the Conference of Weights and Measures in 1960.

**Test Interference:** The altering of test conditions prior to or during the measurement in order to change the radon or radon decay product concentrations or the altering of the performance of the measurement equipment.

**Time integrated measurement:** A measurement conducted over a specific time period (e.g., from two days to a year or more) producing results representative of the average value for that period.

**Uncertainty:** The range of values within which the true value is estimated to lie. It is a best estimate of possible error due to both random errors (imprecision) and systematic errors (that produce bias, or inaccuracies).

**Working level (WL):** Any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of  $1.3 \times 10^5$  MeV of potential alpha energy. This number was chosen because it is approximately the alpha energy released from the decay products in equilibrium with 100 pCi of Rn-222. Cumulative exposures are measured in working level months (WLM). In SI units,  $1 \text{ WL} = 3700 \text{ Bq/m}^3$  (EEC).

**Working level months (WLM):**  $(\text{working level} \times \text{hours of exposure}) / (170 \text{ hours/working month})$ . In SI units,  $1 \text{ WLM} = 6 \times 10^5 \text{ Bq-h/m}^3$  (EEC).

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NEBRASKA HEALTH AND HUMAN SERVICES  
REGULATION AND LICENSURE

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**ATTACHMENT 11-2**

**EPA 402-R-93-078**

**Radon Mitigation Standards (RMS)**

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Office of Air and Radiation (6604-J)  
EPA 402-R-93-078  
October 1993  
Revised April 1994

  
RMS RADON MITIGATION  
STANDARDS

# Radon Mitigation Standards (RMS)

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*Editor's Note: The on-line version of this document has been modified slightly from the 1994 printed version to contain hypertext links to online versions of EPA documents and to reflect current program terminology (particularly for EPA's National Radon Proficiency Program).*

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APPENDIX Mitigation Project Record (Form) [Not included]

## **1.0 Background**

The 1988 Indoor Radon Abatement Act (IRAA) required the Environmental Protection Agency (EPA) to develop a voluntary program to evaluate and provide information on contractors who offer radon control services to homeowners. The Radon Contractor Proficiency (RCP) Program was established to fulfill this portion of the IRAA (individuals meeting EPA's National Radon Proficiency Program (RPP) requirements are now known as *Mitigation Service Providers*). In December 1991, EPA published "Interim Radon Mitigation Standards" as initial guidelines for evaluating the performance of radon mitigation contractors under the RCP Program. Over the past six years, the effectiveness of the basic radon mitigation techniques set forth in the "Interim Standards" has been validated in field applications throughout the United States. This experience now serves as the basis for the more detailed and final Radon Mitigation Standards (RMS) set forth in this document.

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## **2.0 Purpose**

The purpose of the RMS is to provide radon mitigation contractors with uniform standards that will ensure quality and effectiveness in the design, installation, and evaluation of radon mitigation systems in detached and attached residential buildings three stories or less in height. The RMS is intended to serve as a model set of requirements which can be adopted or modified by state and local jurisdictions to fulfill objectives of their specific radon contractor certification or licensure programs.

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## **3.0 Participants**

Minimum requirements are established in the RMS for individuals nationwide who perform radon remediation work and wish to participate in EPA's RPP as Mitigation Service Providers. To successfully participate in EPA's RPP, the mitigation contractor shall have completed all training, examination and other program requirements and shall agree to follow the provisions of the RMS.

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## **4.0 Scope**

The requirements addressed in the RMS include the following categories of contractor activity: General Practices, Building Investigation, Worker Health and Safety, Systems Design, Systems Installation, Materials, Monitors and Labeling, Post-Mitigation Testing, and Contracts and Documentation.

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## 5.0 Assumption

Before applying the provisions of the RMS, it is assumed that appropriate radon/radon decay product measurements have been performed within the structure, and that the owner has decided that radon remediation is necessary.

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## 6.0 Implementation

6.1 The RMS includes requirements for installation of radon remediation systems and provides a basis for evaluating the quality of those installations. It may be adopted by state regulatory agencies for state or local radon mitigation contractor licensure programs. It may also be used as a reference during inspection of in-progress or completed radon mitigation work.

6.2 Contractors shall personally conduct follow-up inspection of any radon mitigation systems installed by their firm or by subcontractors to insure conformance with the requirements of the RMS. This requirement shall include the post-mitigation testing prescribed in paragraph 17.0.

6.3 EPA will evaluate reports of non-compliance with the RMS that are referred to the Agency by states and other agencies that monitor radon mitigation services. Based on its evaluation, EPA may initiate established RCP program de-listing procedures against contractors that the Agency or States (with certification programs) find are in violation of the mandatory provisions of the RMS (See paragraph 6.4). In addition, EPA or its agent may conduct inspections of radon mitigation projects. State radon program personnel or their contracted representatives are considered EPA agents for conducting such inspections.

6.4 Those provisions of the RMS that are considered to be mandatory are prefaced by the term "shall." Provisions that are considered good practice but which are not mandatory are prefaced by the terms "should" or "recommended."

6.5 The RMS will be updated as necessary, and in response to technological advances and field experience.

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## 7.0 Limitations

7.1 Although the provisions of the RMS have been carefully reviewed for potential conflicts with other regulatory requirements, adherence to the RMS does not guarantee compliance with the applicable codes or regulations of any other Federal, state, or local agency having jurisdiction.

7.2 Where discrepancies exist between provisions of the RMS and local codes or regulations, local codes shall take precedence. However, where compliance with local codes necessitates a deviation from the RMS, EPA recommends that RPP listed Mitigation Service Providers (mitigation contractors) report the deviation in

writing to the appropriate EPA Regional Office and the appropriate state regulatory official within 30 days. It should be noted that EPA is not requiring the reporting that is recommended in this paragraph. States with radon mitigation contractor certification programs may require that contractors give prior notification of their intent to deviate from the RMS for research or other purposes.

7.3 The RMS is not intended to be used as a design manual, and compliance with its provisions will not guarantee reduction of indoor radon concentrations to any specific level.

7.4 The RMS shall not apply to radon mitigation systems installed prior to its effective date, except when a previously installed system is altered. "Altering" radon mitigation systems does not include activities such as replacing worn out equipment, or providing new filters, while leaving the remainder of the system unchanged. Mitigation systems installed prior to the effective date of the RMS should be in compliance with the requirements in force at that time (i.e. EPA Interim Radon Mitigation Standards, December 15, 1991, as amended by the Addendum on Backdrafting of October 1, 1992). If a radon mitigation system is found that does not comply with current standards, contractors should recommend to clients that the system be upgraded or altered to meet current standards.

7.5 Because of the wide variation in building design, size, operation and use, the RMS does not include detailed guidance on how to select the most appropriate mitigation strategy for a given building. That guidance is provided in the documents referenced in paragraphs 8.1, 8.2, and 8.3.

7.6 The provisions of the RMS are limited to proven technologies and methods. Publication of this standard is not intended, however, to inhibit research and evaluation of other innovative radon mitigation techniques. When such research is conducted, a performance standard shall be applied, i.e., post-mitigation radon levels shall be at or below EPA's action level (currently 4 pCi/L), and the systems design criteria in paragraph 13.0 shall be applied. Contractors who expect to deviate from proven radon mitigation technologies and methods (as defined in the RMS and other EPA references in Section 8.0) for purposes of research on innovative mitigation techniques, shall obtain prior approval from state regulatory offices, document the non-standard techniques, and inform the client of the deviation from standard procedures. In cases where radon mitigation is not regulated by the state, contractors shall obtain prior approval from a Regional EPA office.

7.7 At this time, the RMS does not include standards for installing systems to mitigate radon in water. However, EPA is currently developing a standard that will regulate radon levels in domestic water supplies. Following publication of that standard, the RMS may be revised, as appropriate, to include standards for installation of systems that are effective in reducing radon levels in water.

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## **8.0 Reference Documents**

The following documents are sources of additional radon mitigation information and are recommended reading for contractors participating in EPA's RPP program

as Mitigation Service Providers.

- 8.1 EPA Training Manual, "Reducing Radon In Structures," (Third Edition), January 1993.
- 8.2 "Radon Reduction Techniques for Detached Houses, Technical Guidance (Second Edition)" EPA/625/5-87/019, January 1988.
- 8.3 "Application of Radon Reduction Methods," EPA/625/5-88/024, August 1988.
- 8.4 "Indoor Radon and Radon Decay Product Measurement Device Protocols," EPA 402-R-92-004, July, 1992.
- 8.5 "Protocols for Radon and Radon Decay Product Measurements in Homes," EPA 402-R-92-003, June, 1993.
- 8.6 "A Citizen's Guide To Radon (Second Edition)" EPA 402-K92-001, May 1992.
- 8.7 "Consumer's Guide to Radon Reduction," EPA, 402-K92-003, August, 1992.
- 8.8 "Home Buyer's and Seller's Guide to Radon," EPA 402-R-93-003, March, 1993.
- 8.9 "ASHRAE Standard 62-1989," Appendix B, Positive Combustion Air Supply.
- 8.10 "National Gas Code," Appendix H (p.2223.1-98), 1988, Recommended Procedure for Safety Inspection of an Existing Appliance Installation.
- 8.11 "Chimney Safety Tests User's Manual," Second Edition, January 12, 1988, Scanada Shelter Consortium Inc., for Canada Mortgage and Housing Corp.
- 8.12 OSHA "Safety and Health Regulations for Construction, Ionizing Radiation," 29 CFR 1926.53.
- 8.13 OSHA "Occupational Safety and Health Regulations, Ionizing Radiation," 29 CFR 1910.96.
- 8.14 NIOSH "Guide to Industrial Respiratory Protection," DHHS (NIOSH) Publication No. 87-116, September, 1987.
- 8.15 NCRP "Measurement of Radon and Radon Decay Daughters in Air," NCRP Report No. 97, Nov 1988.
- 8.16 EPA "Handbook, Sub-Slab Depressurization for Low Permeability Fill Material," EPA/625/6-91/029, July 1991.
- 8.17 "Radon Reduction Techniques for Existing Detached Houses, Technical Guidance (Third Edition) for Active Soil Depressurization Systems," EPA/625/R-93-011, October, 1993.

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## **9.0 Description of Terms**

For this document, certain terms are defined in this section. Terms not defined

herein should have their ordinary meaning within the context of their use. Ordinary meaning is as defined in "Webster's Ninth New Collegiate Dictionary."

**9.1 Backdrafting:** A condition where the normal movement of combustion products up a flue, resulting from the buoyant forces on the hot gases, is reversed, so that the combustion products can enter the house. Backdrafting of combustion appliances (such as fireplaces and furnaces) can occur when depressurization in the house overwhelms the buoyant force on the hot gases. Backdrafting can also be caused by high air pressures or blockage at the chimney or flue termination.

**9.2 Backer Rod:** A semi-rigid foam material resembling a rope of various diameters. Used to fill around pipes, etc. to assist in making a sealed penetration. For example, where a pipe is inserted through a concrete slab, a length of backer rod is jammed into the opening around the pipe. Caulking is then applied to the space above the backer rod and between the outside of the pipe and the slab opening. The purpose of the backer rod is to hold the semi-fluid caulk in place until it sets or hardens.

**9.3 Block Wall Depressurization:** A radon mitigation technique that depressurizes the void network within a block wall foundation by drawing air from inside the wall and venting it to the outside.

**9.4 Perimeter Channel Drain:** A means for collecting water in a basement by means of a large gap or channel between the concrete floor and the wall. Collected water may flow to aggregate beneath the slot ("French Drain") or to a sump where it can be drained or pumped away.

**9.5 Certified:** A rating applied by some jurisdictions to individuals or firms that are qualified and authorized to provide radon testing or mitigation services within the area of their jurisdiction.

**9.6 Client:** The person, persons, or company that contracts with a radon mitigation contractor to install a radon reduction system in a building.

**9.7 Combination Foundations:** Buildings constructed with more than one foundation type, e.g., basement/crawlspace or basement/slab-on-grade.

**9.8 Communication Test:** A diagnostic test designed to qualitatively measure the ability of a suction field and air flow to extend through the material beneath a concrete slab floor and thus evaluate the potential effectiveness of a sub-slab depressurization system. This qualitative test is commonly conducted by applying suction on a centrally located hole drilled through the concrete slab and simultaneously observing the movement of smoke downward into small holes drilled in the slab at locations separated from the central suction hole. (See also paragraph 9.16, Pressure Field Extension.)

**9.9 Contractor:** An individual listed in EPA's RPP program, specifically one listed as a "Mitigation Service Provider," or certified by a state which requires adherence to the RMS.

**9.10 Crawlspace Depressurization:** A radon control technique designed to achieve lower air pressure in the crawlspace relative to indoor air pressure by use of a fan-powered vent drawing air from within the crawlspace. (See also paragraph

9.14, Mechanically Ventilated Crawlspace System.)

**9.11 Diagnostic Tests:** Procedures used to identify or characterize conditions within buildings that may contribute to radon entry or elevated radon levels or may provide information regarding the performance of a mitigation system.

**9.12 Drain Tile Loop:** A continuous length of drain tile or perforated pipe extending around all or part of the internal or external perimeter of a basement or crawlspace footing.

**9.13 Mitigation System:** Any system or steps designed to reduce radon concentrations in the indoor air of a building.

**9.14 Mechanically Ventilated Crawlspace System:** A radon control technique designed to increase ventilation within a crawlspace, achieve higher air pressure in the crawlspace relative to air pressure in the soil beneath the crawlspace, or achieve lower air pressure in the crawlspace relative to air pressure in the living spaces, by use of a fan. (See also paragraph 9.10, Crawlspace Depressurization.)

**9.15 pCi/L:** The abbreviation for picocuries per liter which is a unit of measure for the amount of radioactivity in a liter of air. The prefix "pico" means a multiplication factor of 1 trillionth. A Curie is a commonly used measurement of radioactivity.

**9.16 Pressure Field Extension:** The distance that a pressure change is induced in the sub-slab area, measured from a single or multiple suction points. (See also paragraph 9.8, Communication Test.)

**9.17 Radon:** A naturally occurring radioactive element (Rn-222) which exists as a gas and is measured in picocuries per liter (pCi/L).

**9.18 Radon Decay Products:** The four short-lived radioactive elements (Po-218, Pb-214, Bi-214, Po-214) which exist as solids and immediately follow Rn-222 in the decay chain. They are measured in working levels (WL).

**9.19 Re-Entrainment:** The unintended re-entry into a building of radon that is being exhausted from the vent of a radon mitigation system.

**9.20 Soil Gas:** The gas mixture present in soil which may contain radon.

**9.21 Soil-Gas Retarder:** A continuous membrane or other comparable material used to retard the flow of soil gases into a building.

**9.22 Stack Effect:** The overall upward movement of air inside a building that results from heated air rising and escaping through openings in the building envelope, thus causing indoor air pressure in the lower portions of a building to be lower than the pressure in the soil beneath or surrounding the building foundation.

**9.23 Sub-Membrane Depressurization:** A radon control technique designed to achieve lower air pressure in the space under a soilgas retarder membrane laid on the crawl- space floor, relative to air pressure in the crawlspace, by use of a fan-powered vent drawing air from beneath the membrane.

**9.24 Sub-Slab Depressurization (Active):** A radon control technique designed to achieve lower sub-slab air pressure relative to indoor air pressure by use of a

fan-powered vent drawing air from beneath the concrete slab.

**9.25 Sub-Slab Depressurization (Passive):** A radon control technique designed to achieve lower sub-slab air pressure relative to indoor air pressure by use of a vent pipe (without a fan) routed through the conditioned space of a building and connecting the sub-slab area to the outdoor air. This system relies primarily on the convective flow of warmed air upward in the vent to draw air from beneath the concrete slab.

**9.26 Working Level (WL):** A unit of radon decay product exposure rate. Numerically, any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of 130,000 MeV of potential alpha energy. This number was chosen because it is approximately the total alpha energy released from the short-lived decay products in equilibrium with 100 pCi of Rn-222 per liter of air. (See also the referenced document in paragraph 8.15.)

**9.27 Working Level Month (WLM):** A unit of exposure used to express the accumulated human exposure to radon decay products. It is calculated by multiplying the average working level to which a person has been exposed by the number of hours exposed and dividing the product by 170.

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## 10.0 General Practices

The following general practices are required for all contacts between radon mitigation contractors and clients.

10.1 In the initial contact with a client, the contractor shall review any available results from previous radon tests to assist in developing an appropriate mitigation strategy.

10.2 Based on guidance contained in "[A Citizen's Guide to Radon \(Second Edition\)](#)," (paragraph 8.6) or subsequent revisions of that document, the contractor shall refer the client to the discussions of interpreting indoor radon test results and the health risk associated with the radon level found in the building. The "[Consumer's Guide to Radon Reduction](#)," (paragraph 8.7) is an appropriate reference for providing advice on actions to take to reduce indoor radon levels. Similar documents developed by states and mandated for dissemination by state regulations may also be used as references.

10.3 When delays in the installation of a permanent radon control system are unavoidable due to building conditions or construction activities, and a temporary system is installed, the contractor shall inform the client about the temporary nature of the system. A label that is readable from at least three feet shall be placed on the system. The label shall include a statement that the system is temporary and that it will be replaced with a permanent system within 30 days. The label shall also include the date of installation, and the contractor's name, phone number, and RPP Identification Number. (EXCEPTION: The 30 day limit on use of a temporary mitigation system may be extended in cases where a major renovation or change in building use necessitates a delay in installation of a permanent mitigation system that is optimized to the new building configuration or use. The appropriate state or

local building official or radon program official should be notified when this exception is being applied.)

10.4 When the selected mitigation technique requires use of sealants, caulks, or bonding chemicals containing volatile solvents, prior to starting work the contractor shall inform the client of the need to ventilate work areas during and after the use of such materials. Ventilation shall be provided as recommended by the manufacturer of the material.

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## 11.0 Building Investigation

11.1 The contractor shall conduct a thorough visual inspection of the building prior to initiating any radon mitigation work. The inspection is intended to identify any specific building characteristics and configurations (e.g., large cracks in slabs, exposed earth in crawlspaces, open stairways to basements) and operational conditions (e.g., continuously running HVAC systems or operational windows) that may affect the design, installation, and effectiveness of radon mitigation systems. As part of this inspection, clients should be asked to provide any available information on the building (e.g., construction specifications, pictures, drawings, etc.) that might be of value in determining the radon mitigation strategy.

11.2 To facilitate selection of the most effective radon control system and avoid the costs of installing systems that subsequently prove to be ineffective, it is recommended that the contractor conduct diagnostic tests to assist in identifying and verifying suspected radon sources and entry points. Radon grab sampling, continuous radon monitoring, and use of chemical smoke sticks are examples of the type of diagnostic testing commonly used. (See paragraph 11.4).

11.3 It is recommended that during the building investigation, contractors routinely perform diagnostic tests to evaluate the existence of, or the potential for, backdrafting of natural draft combustion appliances. Published procedures for conducting backdrafting tests are covered in the Reference Documents listed in Paragraphs 8.9, 8.10, and 8.11. The following checklist has been extracted from material in these references and may be used to test for existing or potential backdrafting conditions:

1. Close all windows and doors, both external and internal.
2. Open all HVAC supply and return air duct vents/registers.
3. Close fireplace and wood stove dampers.
4. Turn on all exhaust and air distribution fans and combustion appliances EXCEPT the appliance being tested for backdrafting.
5. Wait 5 minutes.
6. Test to determine the indoor-outdoor pressure differential in the room where the appliance being tested is located. If the pressure differential is a negative 5 Pascals or more, assume that a potential for backdrafting exists.
7. To begin a test for actual spillage of flue gases, turn on the appliance being tested. (If the appliance is a forced air furnace, ensure that the blower starts to run before proceeding.)
8. Wait 5 minutes.

9. Using either a smoke tube or a carbon dioxide gas analyzer, check for flue gas spillage near the vent hood.
10. Repeat steps (4) through (9) for each natural draft combustion appliance being tested for backdrafting. Seasonal and extreme weather conditions should be considered when evaluating pressure differentials and the potential for backdrafting.

If spillage is confirmed from any natural draft combustion appliance, clients shall be advised of the backdrafting condition and that active (fan-powered) radon mitigation systems cannot be installed until the condition has been corrected. Contractors should advise the client to contact an HVAC contractor if correcting an existing or potential backdrafting condition is necessary. (See paragraph 17.3 for post-mitigation backdrafting testing.)

11.4 If installation of a sub-slab depressurization system is contemplated and characteristics of the sub-slab material are unknown, a communication test, as defined in paragraph 9.8 is recommended.

11.5 As part of the building investigation, a floor-plan sketch shall be developed (if not already in existence and readily available) that includes illustrations of the building foundation (slab-on-grade, basement or crawlspace area.) The sketch should include the location of load-bearing walls, drain fixtures and HVAC systems. It should be annotated to include suspected or confirmed radon entry points, results of any diagnostic testing, the anticipated layout of any radon mitigation system piping, and the anticipated locations of any vent fan and system warning devices for the envisioned mitigation systems. The sketch shall be finalized during installation and shall be included in the documentation. (See paragraph 18.2 and Appendix A.)

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## **12.0 Worker Health and Safety**

12.1 Contractors shall comply with all OSHA, state and local standards or regulations relating to worker safety and occupational radon exposure. Applicable references in the Code of Federal Regulations and NIOSH publications are listed in paragraphs 8.12, 8.13, and 8.14.

12.2 In addition to the OSHA and NIOSH standards, the following requirements that are specifically or uniquely applicable for the safety and protection of radon mitigation workers shall be met:

12.2.1 The contractor shall advise workers of the hazards of exposure to radon and the need to apply protective measures when working in areas of elevated radon concentrations.

12.2.2 The contractor shall have a worker protection plan on file that is available to all employees and is approved by any state or local regulating agencies that require such a plan. Exception: A worker protection plan is not required for a contractor who is a sole proprietor unless required by state or local regulations.

12.2.3 The contractor shall ensure that appropriate safety equipment such as hard hats, face shields, ear plugs, steel-toe boots and protective gloves are available on

the job site during cutting, drilling, grinding, polishing, demolishing or other activity associated with radon mitigation projects.

12.2.4 All electrical equipment used during radon mitigation projects shall be properly grounded. Circuits used as a power source should be protected by Ground-fault Circuit Interrupters (GFCI).

12.2.5 When work is required at elevations above the ground or floor, the contractor shall ensure that ladders or scaffolding are safely installed and operated.

12.2.6 Work areas shall be ventilated to reduce worker exposure to radon decay products, dust, or other airborne pollutants. In work areas where ventilation is impractical or where ventilation cannot reduce radon levels to less than 0.3 WL (based on a short term diagnostic test, e.g., grab sample), the contractor shall ensure that respiratory protection conforms with the requirements in the NIOSH Guide to Industrial Respiratory Protection. (See paragraph 8.14.) (Note: If unable to make working level measurements, a radon level of 30 pCi/L shall be used.)

12.2.7 Where combustible materials exist in the specific area of the building where radon mitigation work is to be conducted and the contractor is creating any temperatures high enough to induce a flame, the contractor shall ensure that fire extinguishers suitable for type A, B, and C fires are available in the immediate work area.

12.2.8 Pending development of an approved personal radon exposure device and a protocol for its use, contractors shall record employee exposure to radon at each work site, based on:

1. the highest pre-mitigation indoor radon or working level measurement available, and
2. the time employees are exposed (without respirator protection) at that level (See paragraph 12.2.6.)

(Note: This approach is not intended to preclude the alternative use of on-site radon or radon decay product measurements to determine exact exposure.) Consistent with OSHA Permissible Exposure Limits, contractors shall ensure that employees are exposed to no more than 4 working level months (WLM) over a 12 month period. (An equilibrium ratio of 50 percent shall be used to convert radon exposure to WLM.)

12.2.9 In any planned work area where it is suspected that friable asbestos may exist and be disturbed, radon mitigation work shall not be conducted until a determination is made by a properly trained or accredited person that such work will be undertaken in a manner which complies with applicable asbestos regulations.

12.2.10 When mitigation work requires the use of sealants, adhesives, paints, or other substances that may be hazardous to health, contractors shall provide employees with the applicable Material Safety Data Sheets (MSDS) and explain the required safety procedures.

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## **13.0 Systems Design**

13.1 All radon mitigation systems shall be designed and installed as permanent, integral additions to the building, except where a temporary system has been installed in accordance with paragraph 10.3.

13.2 All radon mitigation systems shall be designed to avoid the creation of other health, safety, or environmental hazards to building occupants, such as backdrafting of natural draft combustion appliances.

13.3 All radon mitigation systems shall be designed to maximize radon reduction and in consideration of the need to minimize excess energy usage, to avoid compromising moisture and temperature controls and other comfort features, and to minimize noise.

13.4 All radon mitigation systems and their components shall be designed to comply with the laws, ordinances, codes, and regulations of relevant jurisdictional authorities, including applicable mechanical, electrical, building, plumbing, energy, and fire prevention codes.

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## **14.0 Systems Installation**

### **14.1 General Requirements**

14.1.1 All components of radon mitigation systems installed in compliance with provisions of the RMS shall also be in compliance with the applicable mechanical, electrical, building, plumbing, energy and fire prevention codes, standards, and regulations of the local jurisdiction.

14.1.2 The contractor shall obtain all required licenses and permits, and display them in the work areas as required by local ordinances.

14.1.3 Where portions of structural framing material must be removed to accommodate radon vent pipes, material removed shall be no greater than that permitted for plumbing installations by applicable building or plumbing codes.

14.1.4 Where installation of a radon mitigation system requires pipes or ducts to penetrate a firewall or other fire resistance rated wall or floor, penetrations shall be protected in accordance with applicable building, mechanical, fire, and electrical codes.

14.1.5 When installing radon mitigation systems that use sump pits as the suction point for active soil depressurization, if sump pumps are needed, it is recommended that submersible sump pumps be used. (See paragraphs 14.5.1, 14.7.4, 15.7, and 15.8.)

### **14.2 Radon Vent Pipe Installation Requirements**

14.2.1 All joints and connections in radon mitigation systems using

plastic vent pipes shall be permanently sealed with adhesives as specified by the manufacturer of the pipe material used. (See paragraph 14.3.7 for exception when installing fans, and paragraph 14.2.7 for exception when installing vent pipes in sumps.) Joints or connections in other vent pipe materials shall be made air tight.

14.2.2 Attic and external piping runs in areas subject to subfreezing conditions should be protected to avoid the risk of vent pipe freeze-up.

14.2.3 Radon vent pipes shall be fastened to the structure of the building with hangers, strapping, or other supports that will adequately secure the vent material. Existing plumbing pipes, ducts, or mechanical equipment shall not be used to support or secure a radon vent pipe.

14.2.4 Supports for radon vent pipes shall be installed at least every 6 feet on horizontal runs. Vertical runs shall be secured either above or below the points of penetration through floors, ceilings, and roofs, or at least every 8 feet on runs that do not penetrate floors, ceilings, or roofs.

14.2.5 To prevent blockage of air flow into the bottom of radon vent pipes, these pipes shall be supported or secured in a permanent manner that prevents their downward movement to the bottom of suction pits or sump pits, or into the soil beneath an aggregate layer under a slab.

14.2.6 Radon vent pipes shall be installed in a configuration that ensures that any rain water or condensation within the pipes drains downward into the ground beneath the slab or soil-gas retarder membrane.

14.2.7 Radon vent pipes shall not block access to any areas requiring maintenance or inspection. Radon vents shall not be installed in front of or interfere with any light, opening, door, window or equipment access area required by code. If radon vent pipes are installed in sump pits, the system shall be designed with removable or flexible couplings to facilitate removal of the sump pit cover for sump pump maintenance.

14.2.8 To prevent re-entrainment of radon, the point of discharge from vents of fan-powered soil depressurization and block wall depressurization systems shall meet all of the following requirements: (1) be above the eave of the roof, (2) be ten feet or more above ground level, (3) be ten feet or more from any window, door, or other opening into conditioned spaces of the structure that is less than two feet below the exhaust point, and (4) be ten feet or more from any opening into an adjacent building. The total required distance (ten feet) from the point of discharge to openings in the structure may be measured either directly between the two points or be the sum of measurements made around intervening obstacles. Whenever possible, the exhaust point should be positioned above the highest eave of the

building and as close to the roof ridge line as possible.

14.2.9 When a radon mitigation system is designed to draw soil gas from a perimeter drain tile loop (internal or external) that discharges water through a drain line to daylight or a soakaway, a one-way flow valve, water trap, or other control device should be installed in or on the discharge line to prevent outside air from entering the system while allowing water to flow out of the system.

### **14.3 Radon Vent Fan Installation Requirements**

14.3.1 Vent fans used in radon mitigation systems shall be designed or otherwise sealed to reduce the potential for leakage of soil gas from the fan housing.

14.3.2 Radon vent fans shall be sized to provide the pressure difference and air flow characteristics necessary to achieve the radon reduction goals established for the specific mitigation project. Guidelines for sizing vent fans and piping can be found in the references cited in paragraphs 8.1, 8.16, and 8.17.

14.3.3 Radon vent fans used in active soil depressurization or block wall depressurization systems shall not be installed below ground nor in the conditioned (heated/cooled) space of a building, nor in any basement, crawlspace, or other interior location directly beneath the conditioned spaces of a building. Acceptable locations for radon vent fans include attics not suitable for occupancy (including attics over living spaces and garages), garages that are not beneath conditioned spaces, or on the exterior of the building.

14.3.4 Radon vent fans shall be installed in a configuration that avoids condensation buildup in the fan housing. Whenever possible, fans should be installed in vertical runs of the vent pipe.

14.3.5 Radon vent fans mounted on the exterior of buildings shall be rated for outdoor use or installed in a water tight protective housing.

14.3.6 Radon vent fans shall be mounted and secured in a manner that minimizes transfer of vibration to the structural framing of the building.

14.3.7 To facilitate maintenance and future replacement, radon vent fans shall be installed in the vent pipe using removable couplings or flexible connections that can be tightly secured to both the fan and the vent pipe.

14.3.8 The intakes of fans used in crawlspace pressurization, or in pressurizing the building itself, shall be screened or filtered to prevent ingestion of debris or personal injury. Screens or filters shall be removable to permit cleaning or replacement and building owners shall be informed of the need to periodically replace or clean such screens and filters. This information shall also be included in the documentation. (See paragraph 18.5)

## **14.4 Suction Pit Requirement for Sub-Slab Depressurization (SSD) Systems**

14.4.1 To provide optimum pressure field extension of the subslab communication zone, adequate material shall be excavated from the area immediately below the slab penetration point of SSD system vent pipes.

## **14.5 Sealing Requirements**

14.5.1 Sump pits that permit entry of soil-gas or that would allow conditioned air to be drawn into a sub-slab depressurization system shall be covered and sealed. The covers on sumps that previously provided protection or relief from surface water collection shall be fitted with a water or mechanically trapped drain. Water traps should be fitted with an automatic supply of priming water. (See paragraph 15.7 for details on sump cover and sealing materials.)

14.5.2 Openings around radon vent pipe penetrations of the slab, the foundation walls, or the crawlspace soil-gas retarder membrane shall be cleaned, prepared, and sealed in a permanent, air-tight manner using compatible caulks or other sealant materials. (See paragraph 15.5.) Openings around other utility penetrations of the slab, walls, or soil-gas retarder shall also be sealed.

14.5.3 Where a Block Wall Depressurization (BWD) system is used to mitigate radon, openings in the tops of such walls and all accessible openings or cracks in the interior surfaces of the walls shall be closed and sealed with polyurethane or equivalent caulks, expandable foams, or other fillers and sealants. (See paragraphs 15.5 and 15.6.) Openings or cracks that are determined to be inaccessible or beyond the ability of the contractor to seal shall be disclosed to the client and included in the documentation.

14.5.4 Openings, perimeter channel drains, or cracks that exist where the slab meets the foundation wall (floor-wall joint), shall be sealed with urethane caulk or equivalent material. When the opening or channel is greater than 1/2 inch in width, a foam backer rod or other comparable filler material shall be inserted in the channel before application of the sealant. This sealing technique shall be done in a manner that retains the channel feature as a water control system. Other openings or cracks in slabs or at expansion or control joints should also be sealed. Openings or cracks that are determined to be inaccessible or beyond the ability of the contractor to seal shall be disclosed to the client and included in the documentation.

14.5.5 When installing baseboard-type suction systems, all seams and joints in the baseboard material shall be joined and sealed using materials recommended by the manufacturer of the baseboard system. Baseboards shall be secured to walls and floors with adhesives designed and recommended for such installations. If a baseboard

system is installed on a block wall foundation, the tops of the blockwall shall be closed and sealed as prescribed in paragraph 14.5.3.

14.5.6 Any seams in soil-gas retarder membranes used in crawlspaces for sub-membrane depressurization systems shall be overlapped at least 12 inches and should be sealed. To enhance the effectiveness of sub-membrane depressurization systems, the membrane should also be sealed around interior piers and to the inside of exterior walls.

14.5.7 In combination basement/crawlspace foundations, where the crawlspace has been confirmed as a source of radon entry, access doors and other openings between the basement and the adjacent crawlspace shall be closed and sealed. Access doors required by code shall be fitted with air tight gaskets and a means of positive closure, but shall not be permanently sealed. In cases where both the basement and the adjacent crawlspace areas are being mitigated with active SSD and SMD systems, sealing of the openings between those areas is not required.

14.5.8 When crawlspace depressurization is used for radon mitigation, openings and cracks in floors above the crawl-space which would permit conditioned air to pass out of the living spaces of the building, shall be identified, closed, and sealed. Sealing of openings around hydronic heat or steam pipe penetrations shall be done using non-combustible materials. Openings or cracks that are determined to be inaccessible or beyond the ability of the contractor to seal shall be disclosed to the client and included in the documentation.

## **14.6 Electrical Requirements**

14.6.1 Wiring for all active radon mitigation systems shall conform to provisions of the National Electric Code and any additional local regulations.

14.6.2 Wiring may not be located in or chased through the mitigation installation ducting or any other heating or cooling ductwork.

14.6.3 Any plugged cord used to supply power to a radon vent fan shall be no more than 6 feet in length.

14.6.4 No plugged cord may penetrate a wall or be concealed within a wall.

14.6.5 Radon mitigation fans installed on the exterior of buildings shall be hard-wired into an electrical circuit. Plugged fans shall not be used outdoors.

14.6.6 If the rated electricity requirements of a radon mitigation system fan exceeds 50 percent of the circuit capacity into which it will be connected, or if the total connected load on the circuit (including the radon vent fan) exceeds 80 percent of the circuit's rated capacity, a separate, dedicated circuit shall be installed to power the fan.

14.6.7 An electrical disconnect switch or circuit breaker shall be installed in radon mitigation system fan circuits to permit deactivation of the fan for maintenance or repair by the building owner or servicing contractor (Disconnect switches are not required with plugged fans).

## **14.7 Drain Installation Requirements**

14.7.1 If drains discharge directly into the soil beneath the slab or through solid pipe to a soakaway, the contractor should install a drain that meets the requirements in paragraph 14.5.1.

14.7.2 If condensate drains from air conditioning units terminate beneath the floor slab, the contractor shall install a trap in the drain that provides a minimum 6-inch standing water seal depth, reroute the drain directly into a trapped floor drain, or reconnect the drain to a condensate pump.

14.7.3 Perimeter (channel or French) drains should be sealed with backer rods and urethane or comparable sealants in a manner that will retain the channel feature as a water control system. (See paragraph 14.5.4.)

14.7.4 When a sump pit is the only system in a basement for protection or relief from excess surface water and a cover is installed on the sump for radon control, the cover shall be recessed and fitted with a trapped drain meeting the requirements of paragraph 14.5.1.

## **14.8 HVAC Installation Requirements**

14.8.1 Modifications to an existing HVAC system, which are proposed to mitigate elevated levels of radon, should be reviewed and approved by the original designer of the system (when possible) or by a licensed mechanical contractor.

14.8.2 Foundation vents, installed specifically to reduce indoor radon levels by increasing the natural ventilation of a crawlspace, shall be non-closeable. In areas subject to subfreezing conditions, the existing location of water supply and distribution pipes in the crawlspace, and the need to insulate or apply heat tape to those pipes, should be considered when selecting locations for installing foundation vents.

14.8.3 Heat Recovery Ventilation (HRV) systems shall not be installed in rooms that contain friable asbestos.

14.8.4 In HRV installations, supply and exhaust ports in the interior shall be located a minimum of 12 feet apart. The exterior supply and exhaust ports shall be positioned to avoid blockage by snow or leaves and be a minimum of 10 feet apart.

14.8.5 Contractors installing HRV systems shall verify that the incoming and outgoing airflow is balanced to ensure that the system does not create a negative pressure within the building. Contractors shall inform building owners that periodic filter replacement and inlet

grill cleaning are necessary to maintain a balanced airflow. This information shall also be included in the documentation.

14.8.6 Both internal and external intake and exhaust vents in HRV systems shall be covered with wire mesh or screening to prevent entry of animals or debris or injury to occupants.

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## **15.0 Materials**

15.1 All mitigation system electrical components shall be U.L. listed or of equivalent specifications.

15.2 As a minimum, all plastic vent pipes in mitigation systems shall be made of Schedule 20 PVC, ABS or equivalent piping material. Schedule 40 piping or its equivalent should be used in garages and in other internal and external locations subject to weathering or physical damage.

15.3 Vent pipe fittings in a mitigation system shall be of the same material as the vent pipes. (See paragraph 14.3.7 for exception when installing vent fans, and paragraph 14.2.7 for exception when installing radon vent pipes in sump pit covers.

15.4 Cleaning solvents and adhesives used to join plastic pipes and fittings shall be as recommended by manufacturers for use with the type of pipe material used in the mitigation system.

15.5 When sealing cracks in slabs and other small openings around penetrations of the slab and foundation walls, caulks and sealants designed for such application shall be used. Urethane sealants are recommended because of their durability.

15.6 When sealing holes for plumbing rough-in or other large openings in slabs and foundation walls that are below the ground surface, non-shrink mortar, grouts, expanding foam, or similar materials designed for such application shall be used.

15.7 Sump pit covers shall be made of durable plastic or other rigid material and designed to permit air-tight sealing. To permit easy removal for sump pump servicing, the cover shall be sealed using silicone or other non-permanent type caulking materials or an air-tight gasket.

15.8 Penetrations of sump covers to accommodate electrical wiring, water ejection pipes, or radon vent pipes shall be designed to permit air-tight sealing around penetrations, using caulk or grommets. Sump covers that permit observation of conditions in the sump pit are recommended.

15.9 Plastic sheeting installed in crawlspaces as soil-gas retarders shall be a minimum of 6 mil (3 mil cross-laminated) polyethylene or equivalent flexible material. Heavier gauge sheeting should be used when crawlspaces are used for storage, or frequent entry is required for maintenance of utilities.

15.10 Any wood used in attaching soil-gas retarder membranes to crawlspace walls or piers shall be pressure treated or naturally resistant to decay and termites.

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## 16.0 Monitors and Labeling

16.1 All active soil depressurization and block wall depressurization radon mitigation systems shall include a mechanism to monitor system performance and warn of system failure. The mechanism shall be simple to read or interpret and be located where it is easily seen or heard by building occupants and protected from damage or destruction.

16.2 Electrical radon mitigation system monitors (whether visual or audible) shall be installed on non-switched circuits and be designed to reset automatically when power is restored after service or power supply failure. Battery operated monitoring devices shall not be used unless they are equipped with a low power warning feature.

16.3 Mechanical radon mitigation system monitors, such as manometer type pressure gauges, shall be clearly marked to indicate the range or zone of pressure readings that existed when the system was initially activated.

16.4 A system description label shall be placed on the mitigation system, the electric service entrance panel, or other prominent location. This label shall be legible from a distance of at least three feet and include the following information: "Radon Reduction System," the installer's name, phone number, and RCP Identification Number, the date of installation, and an advisory that the building should be tested for radon at least every two years or as required or recommended by state or local agencies. In addition, all exposed and visible interior radon mitigation system vent pipe sections shall be identified with at least one label on each floor level. The label shall read, "Radon Reduction System."

16.5 The circuit breakers controlling the circuits on which the radon vent fan and system failure warning devices operate shall be labeled "Radon System."

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## 17.0 Post-Mitigation Testing

17.1 After installation of an active radon control system (e.g., SSD), the contractor shall re-examine and verify the integrity of the fan mounting seals and all joints in the interior vent piping.

17.2 After installation of any active radon mitigation system, the contractor shall measure suction or flows in system piping or ducting to assure that the system is operating as designed. (Note: When SSD systems are installed and activated, a test of pressure field extension is a good practice, particularly when there is uncertainty regarding the permeability of materials under all parts of the slab.)

17.3 Immediately after installation and activation of any active (fan-powered) sub-slab depressurization or block wall depressurization system in buildings containing natural draft combustion appliances, the building shall be tested for backdrafting of those appliances. Any backdrafting condition that results from installation of the radon mitigation system shall be corrected before the system is placed in operation. (Procedures and a checklist for conducting backdrafting tests are covered in the reference documents listed in paragraphs 8.9, 8.10, and 8.11,

and in paragraph 11.3.)

17.4 Upon completion of radon mitigation work, a test of mitigation system effectiveness shall be conducted using an EPA RPP Analytical Service Provider listed test device and in accordance with EPA testing protocols or state requirements. This test should be conducted no sooner than 24 hours nor later than 30 days following completion and activation of the mitigation system(s). This test may be conducted by the contractor, by the client, or by a third party testing firm. If this test is conducted by the mitigation contractor, and the test results are accepted by the client as satisfactory evidence of system effectiveness, further postmitigation testing is not required. However, to avoid the appearance of conflict of interest, the contractor shall recommend to the client that a mitigation system effectiveness test be conducted by an independent EPA RPP listed Measurement Service Provider or state certified testing firm or by the client. The contractor should request a copy of the report of any post-mitigation testing conducted by the client or by an independent testing firm.

17.5 To ensure continued effectiveness of the radon mitigation system(s) installed, the contractor shall advise the client to retest the building at least every two years or as required or recommended by state or local authority. Retesting is also recommended if the building undergoes significant alteration.

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## **18.0 Contracts and Documentation**

18.1 EPA recommends that contractors provide the following written information to clients prior to initiation of work:

1. The contractor's EPA RPP Mitigation Service Provider identification number.
2. A statement that describes the planned scope of the work and that includes an estimate of the time needed to complete the work.
3. A statement describing any known hazards associated with chemicals used in or as part of the installation.
4. A statement indicating compliance with and implementation of all EPA standards and those of other agencies having jurisdiction (e.g., code requirements).
5. A statement describing any system maintenance that the building owner would be required to perform.
6. An estimate of the installation cost and annual operating costs of the system.
7. The conditions of any warranty or guarantee.

18.2 EPA recommends that RPP listed mitigation contractors keep records of all radon mitigation work performed and maintain those records for 3 years or for the period of any warranty or guarantee, whichever is longer. These records should include:

1. The Building Investigation Summary and floor plan sketch. (See Appendix A.)
2. Pre- and post-mitigation radon test data.

3. Pre- and post-mitigation diagnostic test data.
4. Copies of contracts and warranties.
5. A narrative or pictorial description of mitigation system(s) installed.

18.2.1 Appendix A contains a suggested standard format for compiling mitigation project records.

18.3 Other records or bookkeeping required by local, state, or Federal statutes and regulations shall be maintained for the period(s) prescribed by those requirements.

18.4 EPA recommends that health and safety records, including worker radon exposure logs, be maintained for a minimum of 20 years.

18.5 Upon completion of the mitigation project, contractors shall provide clients with an information package that includes:

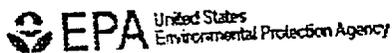
1. Any building permits required by local codes.
2. Copies of the Building Investigation Summary and floor plan sketch. (See Appendix A.)
3. Pre-and post-mitigation radon test data.
4. Copies of contracts and warranties.
5. A description of the mitigation system installed and its basic operating principles.
6. A description of any deviations from the RMS or State requirements.
7. A description of the proper operating procedures of any mechanical or electrical systems installed, including manufacturer's operation and maintenance instructions and warranties.
8. A list of appropriate actions for clients to take if the system failure warning device indicates system degradation or failure.
9. The name, telephone number, and EPA RPP Mitigation Service Provider Identification Number of the contractor, and the phone number of the state radon office.

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Note: Appendix A is available in the hardcopy version which is available from your [state radon contact](#).

Last Modified: April 9, 1998

<http://www.epa.gov/iaq/radon/pubs/mitstds.html>



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Attachment 12-2 11 CFR U.S.C. 101 (2) & (14)

EFFECTIVE DATE  
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TITLE 180 CONTROL OF RADIATION

CHAPTER 12 LICENSING REQUIREMENTS FOR MANAGEMENT OF RADIOACTIVE WASTE

GENERAL PROVISIONS

12-001 SCOPE AND AUTHORITY

12-001.01 180 NAC 12 establishes procedures, criteria, and terms and conditions upon which the Agency issues licenses for the management of wastes received from other persons. Applicability of the requirements in 180 NAC 12 to Agency licenses for waste management facilities in effect on the effective date of this regulation will be determined on a case-by-case basis and implemented through terms and conditions of the license or by orders issued by the Agency. The regulations are authorized by and implement the Nebraska Radiation Control Act, Neb. Stat. Rev. sections 71-3501 to 3519.

12-001.02 180 NAC 12 establishes procedural requirements and performance objectives applicable to any method of waste management. It establishes specific technical requirements for management of radioactive waste which involves disposal above ground of the earth.

12-001.03 The requirements of 180 NAC 12 are in addition to, and not in substitution for requirements in 180 NAC 1, 3, 4, 10, 13, 15, 17 and 18.

12-002 DEFINITIONS: As used in 180 NAC 12.

Active maintenance means any significant activity needed during the period of institutional control to maintain a reasonable assurance that the performance objectives in 180 NAC 12-021 and 12-022 are met. Such active maintenance includes ongoing activities such as the pumping and treatment of water from a disposal unit or one-time measures such as replacement of a disposal unit cover. Active maintenance does not include custodial activities such as repair of fencing, repair or replacement of monitoring equipment, revegetation, minor additions to soil cover, minor repair of disposal unit covers, and general management site upkeep such as mowing grass.

Buffer zone means a portion of the management site that is controlled by the licensee and that lies under the disposal units and between the disposal units and the boundary of the site.

Commencement of construction means any clearing of land, excavation, or other substantial action that would adversely affect the environment of a management facility. The term does not mean disposal site exploration, necessary roads for disposal site exploration, borings to determine foundation conditions, or other preconstruction monitoring or testing to establish background

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information related to the suitability of the management site or the protection of environmental values.

Custodial agency means an agency of the government designated to act on behalf of the government owner of the management site.

Custodial care means the continued observation, monitoring, and care of a management facility for a minimum of one hundred years following transfer of ownership of the management facility from the operator to the Agency.

Disposal means the permanent isolation of radioactive wastes from the biosphere inhabited by man and his food chain by emplacement in a management facility.

Disposal facility means a management facility in which radioactive waste is disposed of in a structure above the earth's surface.

Disposal site means that portion of a disposal facility which is used for disposal of waste. It consists of disposal units and a buffer zone.

Disposal unit means a discrete portion of the management site into which waste is placed for disposal. For surface disposal, the unit is usually a permanent structure above ground.

Engineered barrier means a man-made structure or device that is intended to improve the management facility's ability to meet the performance objectives in 180 NAC 12.

Hydrogeologic unit means any soil or rock unit or zone which by virtue of its porosity or permeability, or lack thereof, has a distinct influence on the storage or movement of groundwater.

Inadvertent intruder means a person who might occupy the management site after closure and engage in normal activities, such as agriculture, dwelling construction, or other pursuits in which an individual might be unknowingly exposed to radiation from the waste.

Institutional control means the institutional control program to physically control access to the disposal site. The institutional control program shall also mean, but not be limited to, custodial care and other requirements as determined by the Agency.

Intruder barrier means a sufficient cover over the waste that inhibits contact with waste and helps to ensure that radiation exposures to an inadvertent intruder will meet the performance objectives set forth in 180 NAC 12 or engineered structures that provide equivalent protection to the inadvertent intruder.

Management facility means the land, buildings, and equipment which is intended to be used for the management of radioactive wastes. A near-surface disposal facility would be a type of management facility.

Monitoring in addition to the definition of monitoring in 180 NAC 1-002. Monitoring means observing and making measurements to provide data to evaluate the performance and characteristics of the management site.

Near-surface disposal facility means a facility built above grade, provided with a protective earthen cover, used for disposal of waste.

Site closure and stabilization means those actions that are taken upon completion of operations that prepare the management site for custodial care and that assure that the management site will remain stable and will not need ongoing active maintenance.

Stability means structural stability.

Surveillance means monitoring and observation of the management site for purposes of vital detection of need for maintenance, custodial care, evidence of intrusion, and compliance with other license and regulatory requirements.

12-003 EXEMPTIONS: 180 NAC 12 does not apply to disposal of byproduct material as defined in 180 NAC 1-002 in quantities greater than 10,000 kilograms containing more than 185 MBq (5 millicuries) of radium-226 or disposal of radioactive material as provided for in 180 NAC 4.

12-004 LICENSE REQUIRED

12-004.01 No person may receive, possess, and dispose of waste received from other persons at a management facility unless authorized by a license issued by the Agency pursuant to 180 NAC 3 and 12.

12-004.02 Each person shall file an application with the Agency pursuant to 180 NAC 3-010 and obtain a license as provided in 180 NAC 12 before commencement of construction of a management facility. Failure to comply with this requirement may be grounds for denial of a license.

12-005 TERM: Licenses shall be issued for a period of thirty (30) years subject to review every five (5) years.

12-006 CONTENT OF APPLICATION: In addition to the requirements set forth in 180 NAC 3-011, an application to receive from others, possess, and dispose of wastes shall consist of general information, specific technical information, institutional information, and financial information as set forth in 180 NAC 12-007 through 12-011.

12-007 GENERAL INFORMATION: The general information shall include each of the following:

12-007.01 Identity of the applicant including:

1. The full name, address, telephone number, and description of the business or occupation of the applicant;
2. If the applicant is a partnership, the name and address of each partner and the principal location where the partnership does business;
3. If the applicant is a corporation or an unincorporated association:
  - a. The state where it is incorporated or organized and the principal location where it does business, and
  - b. The names and addresses of its directors and principal officers; and

4. If the applicant is acting as an agent or representative of another person in filing the application, all information required under 180 NAC 12-007.01 must be supplied with respect to the other person.

12-007.02 Qualifications of the applicant:

1. The organizational structure of the applicant, both offsite and onsite, including a description of lines of authority and assignments of responsibilities, whether in the form of administrative directives, contract provisions, or otherwise;
2. The technical qualifications, including training and experience, of the applicant and members of the applicant's staff to engage in the proposed activities. Minimum training and experience requirements for personnel filling key positions described in 180 NAC 12-007.02, item 1 must be provided, and meet the requirements of 180 NAC 15-032.
3. A description of the applicant's personnel training program; and
4. The plan to maintain an adequate complement of trained personnel to carry out waste receipt, handling, and management operations in a safe manner.

12-007.03 A description of:

1. The location of the proposed management site;
2. The general character of the proposed activities;
3. The types and quantities of waste to be received, possessed, and disposed of;
4. Plans for use of the management facility for purposes other than management of radioactive wastes; and
5. The proposed facilities and equipment.

12-007.04 Proposed schedules for construction, receipt of waste, and first emplacement of waste at the proposed management facility.

12-008 SPECIFIC TECHNICAL INFORMATION: The specific technical information shall include the following information needed for demonstration that the performance objectives and the applicable technical requirements of 180 NAC 12 will be met:

12-008.01 A description of the natural and demographic disposal site characteristics as determined by management site selection and characterization activities. The description shall include geologic, geochemical, geotechnical, hydrologic, ecologic, archaeological, meteorologic, climatologic, and biotic features of the management site and vicinity.

12-008.02 A description of the design features of the management facility and the disposal units. For surface disposal, the description shall include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; management site drainage; management site closure and stabilization; elimination to the extent practicable of long-term management site maintenance; inadvertent intrusion; occupational exposures; management site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.

12-008.03 A description of the principal design criteria and their relationship to the performance objectives.

12-008.04 A description of the design basis natural events or phenomena and their relationship to the principal design criteria.

12-008.05 A description of codes and standards which the applicant has applied to the design and which will apply to construction of the land management facilities.

12-008.06 A description of the construction and operation of the management facility. The description shall include as a minimum the methods of construction of disposal units; waste emplacement; the procedures for and areas of waste segregation; types of intruder barriers; onsite traffic and drainage systems; survey control program; methods and areas of waste storage; and methods to control surface water access to the wastes. The description shall also include a description of the methods to be employed in the handling and management of wastes containing chelating agents or other non-radiological substances that might affect meeting the performance objectives of 180 NAC 12.

12-008.07 A description of the management site closure plan, including those design features which are intended to facilitate management site closure and to eliminate the need for ongoing active maintenance.

12-008.08 An identification of the known natural resources at the management site, whose exploitation could result in inadvertent intrusion into the low-level wastes after removal of active institutional control.

12-008.09 A description of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the management facility.

12-008.10 A description of the quality assurance program, tailored to low level waste disposal, developed and applied by the applicant for the determination of natural disposal site characteristics and for quality assurance during the design, construction, operation, and closure of the management facility and the receipt, handling, and emplacement of waste.

12-008.11 A description of the radiation safety program for control and monitoring of radioactive effluents to ensure compliance with the performance objective in 180 NAC 12-022 and occupational radiation exposure to ensure compliance with the requirements of 180 NAC 4 and to control contamination of personnel, vehicles, equipment, buildings, and the management site. Both routine operations and accidents shall be addressed. The program description must include procedures, instrumentation, facilities, and equipment.

12-008.12 A description of the environmental monitoring program to provide data to evaluate potential health and environmental impacts and the plan for taking corrective measures if migration of radionuclides is indicated.

12-008.13 A description of the administrative procedures that the applicant will apply to control activities at the management facility.

12-008.14 A description of the facility electronic recordkeeping system as required in 180 NAC12-036.

12-009 TECHNICAL ANALYSES: The specific technical information shall also include the following analyses needed to demonstrate that the performance objectives of 180 NAC 12 will be met:

12-009.01 Pathways analyzed in demonstrating protection of the general population from releases of radioactivity shall include air, soil, groundwater, surface water, plant uptake, and exhumation by burrowing animals. The analyses shall clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses shall clearly demonstrate that there is reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in 180 NAC 12-022.

12-009.02 Analyses of the protection of individuals from inadvertent intrusion shall include demonstration that there is reasonable assurance the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided.

12-009.03 Analyses of the protection of individuals during operations shall include assessments of expected exposures due to routine operations and likely accidents during handling, storage, and management of waste. The analyses shall provide reasonable assurance that exposures will be controlled to meet the requirements of 180 NAC 4.

12-009.04 Analyses of the long-term stability of the management site and the need for ongoing active maintenance after closure shall be based upon analyses of active natural processes such as erosion, mass wasting, slope failure, settlement of wastes and backfill, container or building defects, infiltration through covers over management areas, adjacent soils, and surface drainage of the management site. The analyses shall provide reasonable assurance that there will not be a need for ongoing active maintenance of the management site following closure.

12-010 INSTITUTIONAL INFORMATION: The institutional information submitted by the applicant shall include.

12-010.01 A certification by the Federal or State government which owns the management site that the Federal or State government is prepared to accept transfer of the license when the provisions of 180 NAC 12-019 are met and will assume responsibility for custodial care after site closure and post-closure observation and maintenance.

12-010.02 Where the proposed management site is on land not owned by the Federal or a State government, the applicant shall submit evidence that arrangements have been made for assumption of ownership in fee by the Federal or a State agency before the Agency issues a license.

12-011 FINANCIAL INFORMATION: The financial information shall be sufficient to demonstrate that the financial qualifications of the applicant are adequate to carry out the activities for which the license is sought and meet other financial assurance requirements of 180 NAC 12.

12-012 REQUIREMENTS FOR ISSUANCE OF A LICENSE: A license for the receipt, possession, and management of waste containing or contaminated with radioactive material will be issued by the Agency upon finding that:

1. The application is complete.
2. The issuance of the license will not constitute an unreasonable risk to the health and safety of the public;
3. The applicant is qualified by reason of training and experience to carry out the management operations requested in a manner that protects health and minimizes danger to life or property;
4. The applicant's proposed management site, management design, management facility operations, including equipment, facilities, and procedures, management site closure, and post-closure institutional control are adequate to protect the public health and safety in that they provide reasonable assurance that the general population will be protected from releases of radioactivity as specified in the performance objective in 180 NAC 12-022;
5. The applicant's proposed management site, management site design, management facility operations, including equipment, facilities, and procedures, management disposal site closure, and post-closure institutional control are adequate to protect the public health and safety in that they will provide reasonable assurance that individual inadvertent intruders are protected in accordance with the performance objective in 180 NAC 12-023;
6. The applicant's proposed management facility operations, including equipment, facilities, and procedures, are adequate to protect the public health and safety in that they will provide reasonable assurance that the standards for radiation protection set out in 180 NAC 4 will be met;
7. The applicant's proposed management site, management site design, management facility operations, management site closure, and post-closure institutional control are adequate to protect the public health and safety in that they will provide reasonable assurance that long-term stability of the disposed waste and the management site will be achieved and will eliminate to the extent practicable the need for ongoing active maintenance of the management site following closure;
8. The applicant's demonstration provides reasonable assurance that the applicable technical requirements of 180 NAC 12 will be met;
9. The applicant's proposal for institutional control provides reasonable assurance that such control will be provided for the length of time found necessary to ensure the findings in 180 NAC 12-012 items 4 through 7. and that the institutional control meets the requirements of 180 NAC 12-031; and
10. The financial or surety arrangements meet the requirements of 180 NAC 12.

11. The requirements of 10 CFR Chapter I, Part 51, Subpart A, Section 51.20(b) (11) and (12) and Appendix A, attached hereto as Attachment Number 12-1 and incorporated herein by this reference have been met.
12. Any additional information submitted, as requested by the Agency, is adequate.

#### 12-013 CONDITIONS OF LICENSE

12-013.01 A license issued under 180 NAC 12, or any right thereunder, may be transferred, assigned, or in any manner disposed of, either voluntarily or involuntarily, directly or indirectly, through transfer of control of the license to any person, only if the Agency finds, after securing full information, that the transfer is in accordance with Title 180 and the Act and gives its consent in writing in the form of a license amendment.

12-013.02 The licensee shall submit written statements under oath upon request of the Agency, at any time before termination of the license, to enable the Agency to determine whether the license should be modified, suspended, or revoked.

12-013.03 The license will be terminated only on the full implementation of the final closure plan as approved by the Agency, including post-closure observation and maintenance.

12-013.04 The licensee shall be subject to the provisions of the Act now or hereafter in effect, and to all rules, regulations, and orders of the Agency. The terms and conditions of the license are subject to amendment, revision, or modification, by reason of amendments to, or by reason of rules, regulations, and orders issued in accordance with the terms of Title 180 and the Act.

12-013.05 Each person licensed by the Agency pursuant to 180 NAC 12 shall confine possession and use of materials to the locations and purposes authorized in the license.

12-013.06 The licensee shall not dispose of waste until the Agency has inspected the management facility and has found it to be in conformance with the description, design, and construction described in the application for a license.

12-013.07 The Agency may incorporate in any license at the time of issuance, or thereafter, by appropriate rule, regulation or order, additional requirements and conditions with respect to the licensee's receipt, possession, and management of waste as it deems appropriate or necessary in order to:

1. Protect health or to minimize danger to life or property;
2. Require reports and the keeping of records, and to provide for inspections of activities under the license that may be necessary or appropriate to effectuate the purposes of the Act and regulations thereunder.

12-013.08 The authority to dispose of wastes expires on the date stated in the license. Any expiration date on a license applies only to the above ground activities and to the authority to management of waste. Failure to renew the license shall not relieve the licensee of responsibility for implementing site closure, post-closure observation, and transfer of the license to the site owner.

12-013.09 Each licensee shall notify the Agency in writing immediately following the filing of a voluntary or involuntary petition for bankruptcy under any Chapter of Title II (Bankruptcy) of the United States Code by or against:

1. The licensee;
2. An entity (as that term is defined in 11 U.S.C. 101 (14) Attachment Number 12-2 herein) controlling the licensee or listing the license or licensee as property of the estate; or
3. An affiliate (as that term is defined in 11 U.S.C. 101 (2) Attachment Number 12-2 herein) of the licensee.
4. This notification must indicate:
  - a. The bankruptcy court in which the petition for bankruptcy was filed; and
  - b. The date of the filing of the petition.

#### 12-014 CHANGES

12-014.01 Except as provided for in specific license conditions, the licensee shall not make changes in the management facility or procedures described in the license application. The license will include conditions restricting subsequent changes to the facility and procedures authorized which are important to the public health and safety. These license restrictions will fall into three categories of descending importance to public health and safety as follows:

1. Those features and procedures which may not be changed without:
  - a. 60 days prior notice to the Agency;
  - b. 30 days prior notice of opportunity for a prior hearing; and
  - c. Prior Agency approval.
2. Those features and procedures which may not be changed without:
  - a. 60 days prior notice to the Agency; and
  - b. Prior Agency approval; and
3. Those features and procedures which may not be changed without 60 days prior notice to the Agency. Features and procedures falling in 180 NAC 12-014.01, item 3 may not be changed without prior Agency approval if the Agency, after having received the required notice, so orders.

12-014.02 Amendments authorizing site closure, license transfer or license termination shall be included in 180 NAC 12-014.01, item 1 .

#### 12-015 AMENDMENT OF LICENSE

12-015.01 An application for amendment of a license shall be filed in accordance with 180 NAC 3-021.

#### 12-016 APPLICATION FOR RENEWAL OR CLOSURE

12-016.01 An application for renewal or an application for closure under 180 NAC 12-017 must be filed at least 90 days prior to license expiration. Failure to renew the license shall not relieve the licensee of responsibility for implementing site closure, post closure observation, and transfer of the license to the site owner.

12-016.02 Applications for renewal of a license must be filed in accordance with 180 NAC 12-006 through 12-011. Applications for closure must be filed in accordance with 180 NAC 12-017. Information contained in previous applications, statements, or reports filed with the Agency under the license may be incorporated by reference if the references are clear and specific.

12-016.03 In any case in which a licensee has timely filed an application in proper form for renewal of a license, the license does not expire until the Agency has taken final action on the application for renewal.

12-016.04 In determining whether a license will be renewed, the Agency will apply the criteria set forth in 180 NAC 12-012.

#### 12-017 CONTENTS OF APPLICATION FOR SITE CLOSURE AND STABILIZATION

12-017.01 Prior to final closure of the management site, or as otherwise directed by the Agency, the applicant shall submit an application to amend the license for closure. This closure application shall include a final revision and specific details of the management site closure plan included as part of the license application submitted under 180 NAC 12-008.07 that includes each of the following:

1. Any additional geologic, hydrologic, or other data pertinent to the long-term containment of emplaced radioactive wastes obtained during the operational period.
2. The results of tests, experiments, or other analyses relating to closure and sealing, waste migration and interaction with emplacement media, or any other tests, experiments, or analysis pertinent to long-term containment of emplaced waste within the management site.
3. Any proposed revision of plans for:
  - a. Decontamination and/or dismantlement of surface facilities;
  - b. Backfilling of excavated areas; or
  - c. Stabilization of the management site for post-closure care.
4. Any significant new information regarding the environmental impact of closure activities and long-term performance of the management site.

12-017.02 Upon review and consideration of an application to amend the license for closure submitted in accordance with 180 NAC 12-017.01, the Agency shall issue an amendment authorizing closure if there is reasonable assurance that the long-term performance objectives of 180 NAC 12 will be met.

12-018 POST-CLOSURE OBSERVATION AND MAINTENANCE: The licensee shall observe, monitor, and carry out necessary maintenance and repairs at the management site until the site closure is complete and the license is transferred by the Agency in accordance with 180 NAC 12-019. Responsibility for the management site must be maintained by the licensee for 5 years. A shorter or longer time period for post-closure observation and maintenance may be established and approved as part of the site closure plan, based on site-specific conditions.

12-019 TRANSFER OF LICENSE: Following closure and the period of post-closure observation and maintenance, the licensee may apply for an amendment to transfer the license to the management site owner. The license shall be transferred when the Agency finds:

1. That the closure of the management site has been made in conformance with the licensee's management site closure plan, as amended and approved as part of the license;
2. That reasonable assurance has been provided by the licensee that the performance objectives of 180 NAC 12 are met;
3. That any funds for care and records required by 180 NAC 12-036.04 and 12-036.05 have been transferred to the management site owner;
4. That the post-closure monitoring program is operational for implementation by the management site owner; and
5. That the Federal or State agency which will assume responsibility for institutional control of the management site is prepared to assume responsibility and ensure that the institutional requirements found necessary under 180 NAC 12-012 item 9. will be met.

#### 12-020 TERMINATION OF LICENSE

12-020.01 Following any period of institutional control needed to meet the requirements found necessary under 180 NAC 12-012, the licensee may apply for an amendment to terminate the license.

12-020.02 This application will be reviewed in accordance with the provisions of 180 NAC 3-010.

12-020.03 A license shall be terminated only when the Agency finds:

1. That the institutional control requirements found necessary under 180 NAC 12-012.09 have been met;
2. That any additional requirements resulting from new information developed during the institutional control period have been met; and
3. That permanent monuments or markers warning against intrusion have been installed.
4. That any funds for care and records required by 180 NAC 12-036.04 and 12-036.05 have been transferred to the management site owner.

#### PERFORMANCE OBJECTIVES

12-021 GENERAL REQUIREMENT: Management facilities shall be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to individuals are within the requirements established in the performance objectives in 180 NAC 12-022 through 12-025. 180 NAC 12-022 applies only to a near-surface land disposal facility.

12-022 PROTECTION OF THE GENERAL POPULATION FROM RELEASE OF RADIOACTIVITY:

Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals shall not result in an annual dose exceeding an equivalent of 0.25 mSv (25 millirems) to the whole body, 0.75 mSv (75 millirems) to the thyroid, and 0.25 mSv (25 millirems) to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.

12-023 PROTECTION OF INDIVIDUALS FROM INADVERTENT INTRUSION: Design, operation, and closure of the management facility shall ensure protection of any individual inadvertently intruding into the management site and occupying the site or contacting the waste at any time after active institutional controls over the management site are removed.

12-024 PROTECTION OF INDIVIDUALS DURING OPERATIONS: Operations at the management facility shall be conducted in compliance with the standards for radiation protection set out in 180 NAC 4, except for releases of radioactivity in effluents from the management facility, which shall be governed by 180 NAC 12-022. Every reasonable effort should be made to maintain radiation exposures as low as is reasonably achievable.

12-025 STABILITY OF THE MANAGEMENT SITE AFTER CLOSURE: The management facility shall be sited, designed, used, operated, and closed to achieve long-term stability of the management site and to eliminate, to the extent practicable, the need for ongoing active maintenance of the management site following closure so that only surveillance, monitoring, or minor custodial care are required.

TECHNICAL REQUIREMENTS FOR MANAGEMENT FACILITIES

12-026 MANAGEMENT SITE SUITABILITY REQUIREMENTS

12-026.01 Management Site Suitability for Disposal. The primary emphasis in management site suitability is given to isolation of wastes and to management site features that ensure that the long-term performance objectives are met.

1. The management site shall be capable of being characterized, modeled, analyzed and monitored.
2. Within the region where the facility is to be located, a management site should be selected so that projected population growth and future developments are not likely to affect the ability of the management facility to meet the performance objectives of 180 NAC 12.
3. Areas shall be avoided having known natural resources which, if exploited, would result in failure to meet the performance objectives of 180 NAC 12.
4. The management site shall be generally well drained and free of areas of flooding or frequent ponding. Waste management shall not take place in a 100-year flood

plain, meaning that area subject to a one percent or greater chance of flooding in any given year.

5. Upstream drainage areas shall be minimized to decrease the amount of runoff which could erode or inundate waste disposal units.
6. The hydrogeologic unit used for disposal shall not discharge ground water to the surface within the management site.
7. Areas shall be avoided where tectonic processes such as faulting, folding, seismic activity, or vulcanism may occur with such frequency and extent to significantly affect the ability of the management site to meet the performance objectives of 180 NAC 12, or may preclude defensible modeling and prediction of long-term impacts.
8. Areas shall be avoided where surface geologic processes such as mass wasting, erosion, slumping, landsliding, or weathering occur with such frequency and extent to significantly affect the ability of the management site to meet the performance objectives of 180 NAC 12, or may preclude defensible modeling and prediction of long-term impact.
9. The management site must not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives of 180 NAC 12 or significantly mask the environmental monitoring program.

12-026.02 Reserved

12-027 MANAGEMENT SITE DESIGN

12-027.01 Disposal Site Design

1. Site design features shall be directed toward long-term isolation and avoidance of the need for continuing active maintenance after site closure.
2. The management site design and operation shall be compatible with the management site closure and stabilization plan and lead to management site closure that provides reasonable assurance that the performance objectives will be met.
3. The management site shall be designed to complement and improve, where appropriate, the ability of the management site's natural characteristics to assure that the performance objectives will be met.
4. Covers shall be designed to minimize to the extent water infiltration, to direct percolating or surface water away from the disposed waste, and to resist degradation by surface geologic processes and biotic activity.
5. Surface features shall direct surface water drainage away from disposal units at velocities and gradients which will not result in erosion that will require ongoing active maintenance in the future.
6. The management site shall be designed to minimize to the extent practicable the contact of water with waste during storage, the contact of standing water with waste during management and the contact of percolating or standing water with wastes after disposal.

12-027.02 Reserved

12-028 MANAGEMENT FACILITY OPERATION AND MANAGEMENT SITE CLOSURE

12-028.01 Disposal Facility Operation and Management Site Closure

1. Wastes designated as Class A pursuant to Appendix 4-E of 180 NAC 4 shall be segregated from other wastes by placing in disposal units which are sufficiently separated from disposal units for the other waste classes so that any interaction between Class A wastes and other wastes will not result in the failure to meet the performance objectives of 180 NAC 12. This segregation is not necessary for Class A wastes if they meet the stability requirements in Appendix 4-E of 180 NAC 4.
2. Wastes designated as Class C pursuant to Appendix 4-E of 180 NAC 4 shall be disposed of with intruder barriers that are designed to protect against an inadvertent intrusion for at least 500 years.
3. Except as provided in 180 NAC 12-028.01, item 11, only waste classified as Class A, B, C shall be acceptable for disposal. All waste shall be disposed of in accordance with requirements of 180 NAC 12-028.01, item 4 through 10.
4. Wastes shall be emplaced in a manner that maintains the package integrity during emplacement, minimizes the void spaces between packages, and permits the void spaces to be filled.
5. Waste shall be placed and covered in a manner that limits the radiation dose rate at the surface of the cover to levels that at a minimum will permit the licensee to comply with all provisions of 180 NAC 4-014 at the time the license is transferred pursuant to 180 NAC 12-019.
6. The boundaries and locations of each disposal unit shall be accurately located and mapped by means of a land survey. Disposal units shall be marked in such a way that the boundaries of each unit can be easily defined. Three permanent survey marker control points, referenced to United States Geological Survey (USGS) or National Geodetic Survey (NGS) survey control stations, shall be established on the site to facilitate surveys. The USGS or NGS control stations shall provide horizontal and vertical controls as checked against USGS or NGS record files.
7. A buffer zone of land shall be maintained between any waste and the management site boundary and beneath the disposed waste. The buffer zone shall be of adequate dimensions to carry out environmental monitoring activities specified in 180 NAC 12-029.04 and take mitigative measures if needed.
8. Closure and stabilization measures as set forth in the approved site closure plan shall be carried out as each disposal unit is filled.
9. Active waste management operations shall not have an adverse effect on completed closure and stabilization measures.
10. Only wastes containing or contaminated with radioactive material shall be disposed of at the management site.
11. Proposals for management of waste that is not generally acceptable for disposal because the waste form and disposal methods must be different and, in general, more stringent than those specified for Class C waste, may be submitted to the Agency for approval.

12-028.02 Reserved

12-029 ENVIRONMENTAL MONITORING:

12-029.01 At the time a license application is submitted, the applicant shall have conducted a preoperational monitoring program to provide basic environmental data on the management site characteristics. The applicant shall obtain information about the ecology, meteorology, climate, hydrology, geology, geochemistry, and seismology of the management site. For those characteristics that are subject to seasonal variation, data must cover at least a 12-month period.

12-029.02 During the management facility site construction and operation, the licensee shall maintain an environmental monitoring program. Measurements and observations must be made and recorded to provide data to evaluate the potential health and environmental impacts during both the construction and the operation of the facility and to enable the evaluation of long-term effects and the need for mitigative measures. The monitoring system must be capable of providing early warning of releases of waste from the management site before they leave the site boundary.

12-029.03 After the management site is closed, the licensee responsible for post-operational surveillance of the management site shall maintain a monitoring system based on the operating history and the closure and stabilization of the management site. The monitoring system must be capable of providing early warning of releases of waste from the management site before they leave the site boundary.

12-029.04 The licensee shall have plans for taking corrective measures and implementing these plans if the environmental monitoring program detects migration of waste which would indicate that the performance objectives may not be met.

12-030 ALTERNATIVE REQUIREMENTS FOR DESIGN AND OPERATION: The Agency may, upon request or on its own initiative, authorize provisions other than those set forth in 180 NAC 12-027 through 12-029 for the segregation and management of waste and for the design and operation of a management facility on a specific basis, if it finds reasonable assurance of compliance with the performance objectives of 180 NAC 12.

#### 12-031 INSTITUTIONAL REQUIREMENTS

12-031.01 Land Ownership: Disposal of waste received from other persons may be permitted only on land owned in fee by the Federal or a State government.

12-031.02 Institutional Control: The land owner or custodial agency shall conduct an institutional control program to physically control access to the management site following transfer of control of the disposal site from the disposal site operator. The institutional control program shall also include, but not be limited to, conducting an environmental monitoring program at the management site, periodic surveillance, minor custodial care, and other requirements as determined by the Agency; and administration of funds to cover the costs for these activities. The period of institutional controls will be determined by the Agency, but institutional controls may not be relied upon for more than 100 years following transfer of control of the management site to the owner.

EFFECTIVE DATE  
JULY 12, 2001

NEBRASKA HEALTH AND HUMAN SERVICES  
REGULATION AND LICENSURE

180 NAC 12

12-031.03 A map of the type, location and quantity of low-level radioactive waste disposed of at the site shall be filed, within 60 days of transfer of the license to the Agency, with the Register of Deeds of the County where such land is located and with the Agency.

12-032 RESERVED

FINANCIAL ASSURANCES

12-033 APPLICANT QUALIFICATIONS AND ASSURANCES: Each applicant shall show that it either possesses the necessary funds or has reasonable assurance of obtaining the necessary funds, or by a combination of the two, to cover the estimated costs of conducting all licensed activities over the planned operating life of the project, including costs of construction and management.

12-034 FUNDING FOR MANAGEMENT SITE CLOSURE AND STABILIZATION

12-034.01 The applicant shall provide assurances prior to the commencement of operations that sufficient funds will be available to carry out disposal site closure and stabilization, including: (1) Decontamination or dismantlement of management facility structures; and (2) closure and stabilization of the management site so that following transfer of the management site to the site owner, the need for ongoing active maintenance is eliminated to the extent practicable and only minor custodial care, surveillance, and monitoring are required. These assurances shall be based on Agency-approved cost estimates reflecting the Agency-approved plan for management site closure and stabilization. The applicant's cost estimates must take into account total costs that would be incurred if an independent contractor were hired to perform the closure and stabilization work.

12-034.02 In order to avoid unnecessary duplication and expense, the Agency will accept financial sureties that have been consolidated with earmarked financial or surety arrangements established to meet requirements of Federal or other State agencies (and/or local governmental bodies) for such decontamination, closure, and stabilization. The Agency will accept these arrangements only if they are considered adequate to satisfy the requirements of 180 NAC 12-034 and that the portion of the surety which covers the closure of the management site is clearly identified and committed for use in accomplishing these activities.

12-034.03 The licensee's financial or surety arrangement shall be submitted annually for review by the Agency to assure that sufficient funds will be available for completion of the closure plan.

12-034.04 The amount of the licensee's financial or surety arrangement shall change in accordance with changes in the predicted costs of closure and stabilization. Factors affecting closure and stabilization cost estimates include inflation, increases in the amount of distributed land, changes in engineering plans, closure and stabilization that has already been accomplished, and any other conditions affecting costs. The financial or surety arrangement shall be sufficient at all times to cover the costs of closure and stabilization of the disposal units that are expected to be used before the next license renewal.

12-034.05 The financial or surety arrangement shall be written for a specified period of time and shall be automatically renewed unless the person who issues the surety notifies the Agency, the beneficiary (the site owner), and the principal (the licensee) not less than 90 days prior to the renewal date of its intention not to renew. In such a situation, the licensee must submit a replacement surety within 30 days after notification of cancellation. If the licensee fails to provide a replacement surety acceptable to the Agency, the beneficiary may collect on the original surety.

12-034.06 Proof of forfeiture shall not be necessary to collect the surety so that, in the event that the licensee could not provide an acceptable replacement surety within the required time, the surety shall be automatically collected prior to its expiration. The conditions described above shall be clearly stated on any surety instrument.

12-034.07 Financial or surety arrangements generally acceptable to the Agency include surety bonds, cash deposits, certificates of deposit, deposits of government securities, escrow accounts, irrevocable letters or lines of credit, trust funds, and combinations of the above or such other types of arrangements as may be approved by the Agency. Self-insurance, or any arrangement which essentially constitutes self-insurance, will not satisfy the surety requirement for private sector applicants.

12-034.08 The licensee's financial or surety arrangement shall remain in effect until the closure and stabilization program has been completed and approved by the Agency, and the license has been transferred to the site owner.

#### 12-035 FINANCIAL ASSURANCES FOR INSTITUTIONAL CONTROLS

12-035.01 Prior to the issuance of the license, the applicant shall provide for Agency approval, a binding arrangement, between the applicant and the management site owner that ensures that sufficient funds will be available to cover the costs of monitoring and any required maintenance during the institutional control period. The binding arrangement shall be reviewed annually by the Agency to ensure that changes in inflation, technology, and management facility operations are reflected in the arrangements.

12-035.02 Subsequent changes to the binding arrangement specified in 180 NAC 12-035.01 relevant to institutional control shall be submitted to the Agency for prior approval.

#### RECORDS, REPORTS, TESTS, AND INSPECTIONS

#### 12-036 MAINTENANCE OF RECORDS REPORTS AND TRANSFERS

12-036.01 Each licensee shall maintain any records and make any reports in connection with the licensed activities as may be required by the conditions of the license or by the rules, regulations, and orders of the Agency.

12-036.02 Records which are required by these regulations or by license conditions shall be maintained for a period specified by the appropriate regulations or by license condition. If a retention period is not otherwise specified, these records must be maintained and transferred to the officials specified in 180 NAC 12-036.04 as a condition of license termination unless the Agency otherwise authorizes their disposition.

12-036.03 Records which shall be maintained pursuant to 180 NAC 12 may be the original or a reproduced copy or microfilm if this reproduced copy or microfilm is capable of producing copy that is clear and legible at the end of the required retention period.

12-036.04 Notwithstanding 180 NAC 12-036.01 through 12-036.03, copies of records of the location and the quantity of wastes contained in the management site must be transferred upon license termination to the chief executive of the nearest municipality, the chief executive of the county in which the facility is located, the county zoning board or land development and planning agency, the state governor, and other State, local and Federal governmental agencies as designated by the Agency at the time of license termination.

12-036.05 Following receipt and acceptance of a shipment of radioactive waste, the license shall record the date that the shipment is received at the disposal facility, the date of disposal of the waste, a traceable shipment manifest number, a description of any engineered barrier or structural overpack provided for disposal of the waste, the location of disposal and the disposal site, the containment integrity of the waste disposal containers as received, any discrepancies between materials listed on the manifest and those received, the volume of any pallets, bracing, or other shipping or onsite generated materials that are contaminated, and are disposed of as contaminated or suspect materials, and any evidence of leaking or damaged disposal containers or radiation or contamination levels in excess of limits specified in Department of Transportation and Agency regulations. The licensee shall briefly describe any repackaging operations of any of the disposal containers included in the shipment, plus any other information required by the Agency as a license condition. The licensee shall retain these records until the Agency transfers or terminated the license that authorizes the activities described in 180 NAC 12.

12-036.06 Each licensee authorized to dispose of radioactive waste received from other persons shall file a copy of its financial report or a certified financial statement annually with the Agency in order to update the information base for determining financial qualifications.

12-036.07 Each licensee authorized to dispose of waste received from other persons, pursuant to 180 NAC 12, shall submit annual reports to the Agency. Reports shall be submitted by the end of the first calendar quarter of each year for the preceding year.

1. The reports shall include:
  - a. Specification of the quantity of each of the principal contaminants released to unrestricted areas in liquid and in airborne effluents during the preceding year,
  - b. The results of the environmental monitoring program,
  - c. A summary of licensee disposal unit survey and maintenance activities,
  - d. A summary, by waste class, of activities and quantities of radionuclides disposed of,
  - e. Any instances in which observed site characteristics were significantly different from those described in the application for a license; and
  - f. Any other information the Agency may require.

2. If the quantities of radioactive waste released during the reporting period, monitoring results, or maintenance performed are significantly different from those predicted, the report must cover this specifically.

12-036.08 In addition to the other requirements of 180 NAC 12, the licensee shall store, or have stored, manifest and other information pertaining to the receipt and disposal of radioactive waste in an electronic recordkeeping system.

1. The manifest information that must be electronically stored is:
  - a. That information required in 180 NAC 1, Appendix 4-D, with the exception of shipper and carrier telephone numbers and shipper and consignee certifications; and
  - b. That information required in 180 NAC 12-036.05.
2. As specified in facility license conditions, the licensee shall report the stored information, or subsets of this information, on a computer-readable medium.

12-037 TESTS ON MANAGEMENT FACILITIES: Each licensee shall perform, or permit the Agency to perform, any tests the Agency deems appropriate or necessary for the administration of the regulations in 180 NAC 12, including, but not limited to, tests of:

1. Wastes;
2. Facilities used for the receipt, storage, treatment, handling or management of wastes;
3. Radiation detection and monitoring instruments; or
4. Other equipment and devices used in connection with the receipt, possession, handling, treatment, storage, or management of waste.
5. Geohydrologic, hydrologic, soil, or other environmental conditions or parameters.

#### 12-038 AGENCY INSPECTIONS OF MANAGEMENT FACILITIES

12-038.01 Each licensee shall afford to the Agency at all reasonable times opportunity to inspect waste not yet disposed of, and the premises, equipment, operations, and facilities in which wastes are received, possessed, handled, treated, stored, or disposed of.

12-038.02 Each licensee shall make available to the Agency for inspection, upon reasonable notice, records kept by it pursuant to these regulations. Authorized representatives of the Agency may copy and take away copies of, for the Agency's use, any record required to be kept pursuant to Title 180.

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