



American National Standard  
**ANSI/HPS N13.53-2009 (R2016)**

**Control and Release of Technologically Enhanced  
Naturally Occurring Radioactive Material (TENORM)**

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American National Standards Institute, Inc.



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\* The standard is dedicated to the late Floyd Galpin, whose contribution and dedication early in the development efforts of this standard were essential and valued by all.

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<sup>1</sup> Reflects the activities of the working group and not that of the organizations or agencies with which members of the working group are employed.

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American Industrial Hygiene Assoc.

American Iron and Steel Institute

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American Nuclear Insurers

American Nuclear Society

Conference of Radiation Control Program Directors

Council on Ionizing Radiation Msmts & Standards (CIRMS)

Council on Radionuclides and Radiopharmaceuticals, Inc. (CORAR)

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## Contents

|                                                                                                  |    |
|--------------------------------------------------------------------------------------------------|----|
| Foreword                                                                                         | x  |
| 1.0 Purpose and Scope                                                                            | 1  |
| 1.1 Purpose                                                                                      | 1  |
| 1.2 Scope                                                                                        | 1  |
| 1.3 Definitions                                                                                  | 2  |
| 1.4 Exclusions                                                                                   | 5  |
| 2.0 TENORM Exposure and Disposition Criteria                                                     | 7  |
| 2.1 Guiding Radiation Protection Principles                                                      | 7  |
| 2.2 TENORM Criteria and Guidance                                                                 | 8  |
| 2.2.1 Exposure and Dose Criteria                                                                 | 8  |
| 2.2.2 Administrative Surface and Volume Contamination Release Levels                             | 9  |
| 2.2.3 Outdoor Radon                                                                              | 12 |
| 2.2.4 Indoor Radon                                                                               | 12 |
| 2.2.5 Products Manufacturing, Use, and Distribution                                              | 13 |
| 2.2.6 Occupational Radiation Exposures as Non-Radiation Workers                                  | 14 |
| 2.2.7 Records Requirements                                                                       | 15 |
| Table 2-1. Surface and volume contamination administrative release levels                        | 10 |
| <b>Annex A Radionuclide Decay Series</b>                                                         | 16 |
| Table A-1. Uranium decay scheme                                                                  | 16 |
| Table A-2. Actinium decay scheme                                                                 | 17 |
| Table A-3. Thorium decay scheme                                                                  | 18 |
| Table A-4. Potassium decay scheme                                                                | 18 |
| <b>Annex B Basis and Justification for TENORM Criteria</b>                                       | 19 |
| B.1 Introduction                                                                                 | 19 |
| B.2 National Radiation Protection Standards and Guidance                                         | 19 |
| B.2.1 Environmental Protection Agency                                                            | 19 |
| B.2.2 Nuclear Regulatory Commission                                                              | 22 |
| B.2.3 Mine Safety and Health Administration – Department of Labor                                | 23 |
| B.2.4 Department of Energy                                                                       | 24 |
| B.2.5 Department of Transportation                                                               | 24 |
| B.2.6 State Agencies                                                                             | 25 |
| B.2.7 National Bodies                                                                            | 26 |
| B.3 International Radiation Protection Guidance                                                  | 29 |
| B.3.1 International Commission on Radiological Protection                                        | 29 |
| B.3.2 International Atomic Energy Agency                                                         | 30 |
| B.3.3 European Commission – Directorate on the Environment, Nuclear Safety, and Civil Protection | 31 |
| B.3.4 Nuclear Energy Agency – Organization for Economic Cooperation and Development              | 34 |
| B.3.5 Canadian Guidance                                                                          | 34 |

|       |                                                                |    |
|-------|----------------------------------------------------------------|----|
| B.4   | Basis and Justification                                        | 35 |
| B.4.1 | TENORM Radiation Exposure and Dose Criteria                    | 36 |
| B.4.2 | Collective Doses                                               | 37 |
| B.4.3 | ALARA Considerations                                           | 37 |
| B.4.4 | Material and Product Distribution                              | 37 |
| B.4.5 | Occupational Radiation Exposure for Non-Radiation Workers      | 38 |
| B.4.6 | Indoor and Outdoor Radon                                       | 39 |
| B.4.7 | Administrative Volume and Surface Contamination Release Levels | 40 |
| B.4.8 | Records Requirements                                           | 41 |

## **Annex C      Hazard Evaluation and Control Measures** 42

|       |                                                                                 |    |
|-------|---------------------------------------------------------------------------------|----|
| C.1   | Introduction                                                                    | 42 |
| C.2   | Industrial NORM Sector Summaries                                                | 42 |
| C.3   | Past Incidents Involving the Misuse or Improper Disposal of TENORM              | 44 |
| C.4   | Routes of Radiation Exposures                                                   | 45 |
| C.4.1 | Direct Radiation Exposures                                                      | 45 |
| C.4.2 | Airborne Exposures                                                              | 46 |
| C.4.3 | Ground and Surface Water Transport                                              | 46 |
| C.4.4 | Food Chain Transport                                                            | 46 |
| C.4.5 | Radon Infiltration in Structures                                                | 47 |
| C.4.6 | Submersion and Immersion Exposure                                               | 48 |
| C.4.7 | Dermal Exposure                                                                 | 48 |
| C.4.8 | Modeling Uncertainty and Variability                                            | 48 |
| C.5   | Administrative and Process Control Measures                                     | 49 |
|       | Table C-1. Typical ranges of radioactivity levels in selected minerals and rock | 43 |

## **Annex D      Release and Disposal** 50

|       |                                                                 |    |
|-------|-----------------------------------------------------------------|----|
| D.1   | Introduction                                                    | 50 |
| D.2   | Release of Land and Facilities                                  | 50 |
| D.2.1 | Decontamination                                                 | 51 |
| D.2.2 | Unrestricted Release                                            | 51 |
| D.2.3 | Specific End Use                                                | 52 |
| D.2.4 | Transfer to Others                                              | 52 |
| D.2.5 | Scrap Metal Recycling                                           | 52 |
| D.2.6 | Manufacturing                                                   | 53 |
| D.3   | Considerations in Evaluating Disposal Options                   | 53 |
| D.3.1 | Site Selection                                                  | 54 |
| D.3.2 | Site and Waste Characterization                                 | 55 |
| D.4   | Cost–Benefit Analysis                                           | 55 |
| D.5   | Overview of RCRA/CERCLA Process Related to Radioactive Material | 55 |

|                |                                             |    |
|----------------|---------------------------------------------|----|
| <b>Annex E</b> | <b>Normative and Informative References</b> | 59 |
| E.1            | Normative References                        | 59 |
| E.2            | Informative References                      | 60 |

## Foreword

This standard provides general guidance and normative criteria for the control and release of technologically enhanced naturally occurring radioactive material (TENORM). The radioactivity in TENORM is due to radionuclides associated with two radioactive decay series,  $^{238}\text{U}$  and  $^{232}\text{Th}$  and their respective decay products, and  $^{40}\text{K}$ . The standard applies to industries or activities that are not covered by existing federal or state regulations. In addition, the standard may be adopted by American industries and organizations as guidance in foreign countries in which there are no TENORM regulations or guidelines. The activities considered by this standard include mining and beneficiation of ores; processing of ore materials, gangue, and wastes; feedstock used in manufacturing consumer and industrial products; and distribution of products containing TENORM. The standard does not apply to common activities, such as tilling or plowing for agricultural purposes and preparation and grading of sites for construction. This standard is concerned with practices and operations that might concentrate and relocate radioactivity or make radioactivity more accessible such that members of the public may receive doses that would warrant the application of appropriate protective measures and corrective actions. The introduction of TENORM in products with no beneficial attributes is not approved by this standard. Other recommendations suggest that preventive measures, such as engineered safety systems or operational procedures, be implemented to safely manage TENORM in achieving the same objective. Finally, the control of occupational exposures associated with TENORM is covered by the standard, although this aspect may already be addressed through requirements of industrial hygiene standards under current federal and state regulations.

Work on this standard started in late 1993 and the ANSI PIN review and approval were completed in May 1994. The first working draft of the standard was prepared in July 1995. The first working draft of the standard was submitted to the HPSSC in June 1998 and the results of the balloting were issued in November 1998. The second draft of the standard was issued in March 1999 and submitted to the HPSSC in June 1999. The third version of standard was issued in January 2000 following resolution of HPSSC comments. In June 2000, the HPS issued the results of the N13 Committee balloting, with the fourth draft (January 2001) addressing the comments generated by the N13 Committee. As a result, an updated draft (Rev. 5.1, January 2002) was prepared in response to the Working Group's concerns that the revision introduced a number of substantive changes in accommodating the N13 Committee's comments. The April 2002 update addressed editorial changes to Section 2.0; for instance, a table (Table 2-2) was deleted and its criteria were incorporated into the text instead. The final version (May 2005) incorporated comments generated from the second ballot of the N13 Committee. The N13 Committee requested that a few technical clarifications and editorial corrections be incorporated before publication. As incorporated in the 2007 version, the changes did not result in any substantive alterations because the criteria remain the same. The standard was submitted to ANSI for public comment in October 2006. No public comments were submitted to ANSI. In August 2008, the standard was submitted to another N13 Committee ballot. Specific comments generated during this ballot were incorporated in the current version of the standard.

Suggestions addressing the improvement of this standard are welcome. Suggestions should be sent to: Health Physics Society, 1313 Dolley Madison Blvd., Suite 402, McLean, VA 22101.

**Key Words:** Naturally occurring radioactivity, radiation safety, technologically enhanced radioactivity, national standard, administrative release level, NORM, TENORM, recycling, reuse, radiation exposure, and dose criteria.

# Control and Release of Technologically Enhanced Naturally Occurring Radioactive Material (TENORM)

## 1.0 Purpose and Scope

### 1.1 Purpose

This standard specifies dose limits and release criteria for the management of material, products, and waste containing technologically enhanced naturally occurring radioactive material (TENORM), namely uranium and thorium. TENORM is used to differentiate radioactivity present in some materials and processes from NORM contained in nearly all materials of mineral origins. The radioactivity in TENORM is due to a few predominant radionuclides associated with two radioactive decay series, namely uranium-238 ( $^{238}\text{U}$ ) consisting of thorium-234m ( $^{234\text{m}}\text{Th}$ ), protactinium-234m ( $^{234\text{m}}\text{Pa}$ ),  $^{230}\text{Th}$ , radium-226 ( $^{226}\text{Ra}$ ), radon-222 ( $^{222}\text{Rn}$ ), lead-210 ( $^{210}\text{Pb}$ ), and polonium-210 ( $^{210}\text{Po}$ ); and the  $^{232}\text{Th}$  series consisting of  $^{228}\text{Ra}$ ,  $^{228}\text{Th}$ ,  $^{224}\text{Ra}$ , and  $^{220}\text{Rn}$ . In some situations, the actinium decay series, starting with  $^{235}\text{U}$ , may need to be considered as well, especially if  $^{238}\text{U}$  concentrations are elevated even at natural isotopic abundances. The major decay products of  $^{235}\text{U}$  include  $^{231}\text{Th}$ ,  $^{231}\text{Pa}$ , actinium-227 ( $^{227}\text{Ac}$ ),  $^{227}\text{Th}$ ,  $^{223}\text{Ra}$ , and  $^{219}\text{Rn}$ . The isotopic distribution of natural uranium is given as 48.9% for  $^{238}\text{U}$ , 48.9% for  $^{234}\text{U}$ , and 2.2% for  $^{235}\text{U}$ , in terms of activity. Potassium-40 ( $^{40}\text{K}$ ) is also included because in some instances it may be isotopically enriched. Annex A presents the radioactive decay schemes for the uranium and thorium series and potassium.

In defining the objective of this standard, it should be recognized that the demarcation between NORM and TENORM is not always well delineated; often, an industry using or receiving materials may not be capable of distinguishing materials that are TENORM, or even materials that may be subject to existing federal or state regulations. Given that it is not possible to catalog *a priori* all situations involving the use of TENORM, the standard provides a common theme and information with which to recognize practices that may result in unnecessary radiation exposures to workers and the public and possibly have an impact on the environment. In considering a specific practice,

the information provided in this standard should be used to seek technical and regulatory advice from qualified regulatory agencies or experts in the appropriate disciplines. In this context, the standard recommends that industries routinely monitor rule-making activities as emerging issues involving TENORM are addressed by federal or state agencies. Finally, the standard may be adopted by industries and organizations as guidance in foreign countries where there are no TENORM regulations or guidelines.

The criteria are contained in Section 2.0, and Annex B presents the basis for the recommended criteria. Also, the standard offers further guidance to facilitate its implementation. Annex C presents background information for recognizing and evaluating practices that may have potential impacts on the public, workers, and the environment. Annex D describes various options for managing TENORM and also includes supporting technical information. The guidance presented in Annexes C and D is informative and not part of the requirements or criteria presented in Section 2.0. Annex E presents normative and informative references cited throughout the standard.

### 1.2 Scope

The standard applies to practices that use, process, recycle or reuse, and distribute TENORM, including the generation and disposal of wastes that may result in making radioactivity more accessible to humans or the environment. Among others, practices of specific concern to this standard include home building using materials obtained from mining and mineral extraction spoils, overburden, and wastes or building homes on sites containing extraction spoils, overburden, aggregates, and wastes from mineral mining and oil and gas extraction. The quarrying of gravel and sand and their use as aggregates in construction material, such as cement, are excluded from this standard, but other materials with known elevated levels of NORM, such as some minerals, aggregates used in building construction, mining overburden and spoils, and sands, are covered by this standard.

The standard applies to consumer and industrial products that are known to contain TENORM. The intentional introduction of TENORM into products or materials with no benefit to their

properties or functions is not approved by this standard. Regarding recycling, the standard does not approve practices whose only purpose is to dilute TENORM in a manner that constitutes disposal or processes leading to that intent.

This standard does not apply to NORM present in natural soils, rocks, and materials involving human activities that are generally regarded as common practices. Among others, such practices include materials used in scientific and research studies; engineering studies and applications; soil and geological samples used in site or material characterizations, research, and engineering studies; farming, including tilling and plowing; site grading; grave digging; and trenching or similar types of excavation or earth work.

The cultivation, distribution, and consumption of agricultural crops and foodstuffs that are known to contain NORM are not covered by this standard because such practices do not involve technological enhancement by definition. However, this exclusion does not apply to foodstuffs grown in TENORM whether as a product, waste, aggregate, or mixed with soils.

In the absence of regulatory requirements or guidance, the standard does not apply to industrial settings or activities involving the use of materials or products containing TENORM as long as such materials and products are used in their intended form and function and workers are provided a standard of care under Occupational Safety and Health Administration (OSHA) or Mine Safety and Health Administration (MSHA) regulations or other applicable regulatory provisions. This exclusion applies insofar as it shall be demonstrated that such practices and the associated standard of care for worker safety rendered under OSHA or MSHA regulations would result in a level of protection that is equivalent to this standard.

In considering the voluntary implementation of a TENORM management program, an acceptable approach may involve identifying relevant protective requirements for regulated materials (e.g., uranium and thorium under the Atomic Energy Act (AEA)), since radiation exposures and doses associated with TENORM are the same as those arising from other types of radioactive materials. Accordingly, it follows that radiation protection principles promulgated by

existing federal or state regulatory programs for radioactive materials of other origins may be applied to TENORM as templates in developing safety programs, operating plans, and procedures for specific practices. Finally, other options, as possible long-term alternatives, may be to consider the use of materials with lower levels of TENORM or research leading to the use of substitute materials that are essentially free of NORM or have NORM at levels not likely to result in doses in excess of the provisions of this standard.

This standard may provide suitable guidance to federal or state agencies overseeing remediation projects where TENORM is the contaminant of concern, depending on the ownership and regulatory status of the property. For example, a federal or state agency might find the provisions of this standard protective and adopt it by reference. Other federal agencies, such as the U.S. Department of Energy (DOE) and the U.S. Nuclear Regulatory Commission (NRC), oversee other radiation cleanups involving TENORM or contaminants similar to TENORM (e.g., regulated source material). Accordingly, this standard offers relevant guidance over a broad range of practices and remediation projects involving TENORM.

Finally, the standard does not address issues associated with the linear, no threshold radiation dose response hypothesis; they are being addressed by radiation standard-setting organizations and regulatory agencies. However, its use is acknowledged because it represents a prudent approach in protecting workers and the public health until more definitive scientific information becomes available and an alternative hypothesis is proposed and adopted by regulatory agencies.

### 1.3 Definitions

The following definitions are provided for the purpose of facilitating the interpretation and implementation of the standard.

**Administrative release:** The act of removing items or material from administrative controls with no further radiological restrictions on their use or disposition. This definition is used to differentiate it from “clearance” or “unrestricted release,” which relates to the release of material or items that are under the jurisdiction of a

regulatory authority or regulatory controls for licensed radioactive materials.

**ALARA:** As Low As is Reasonably Achievable. In radiation protection philosophy, ALARA means making every reasonable effort to maintain exposures to radiation as far below dose limits as is practical consistent with the purpose of the practice, taking into account the state of technology, the economics of improvements in relation to the technology, the economics of improvements in relation to benefits to public health and safety, and other societal and socioeconomic considerations (see Radiation protection philosophy).

**Background radiation:** The radiation associated with the presence of naturally occurring radioactivity present in the environment (e.g., soil, water, air, vegetation, and foodstuffs), cosmogenic radionuclides, and radioactivity from weapons fallout. Background radioactivity includes radionuclides from the  $^{238}\text{U}$ ,  $^{235}\text{U}$ , and  $^{232}\text{Th}$  decay series,  $^{40}\text{K}$  and  $^{87}\text{Rb}$ , those due to weapons fallout, and cosmogenic radionuclides. Weapons fallout includes the ubiquitous distribution of  $^3\text{H}$ ,  $^{90}\text{Sr}$ ,  $^{137}\text{Cs}$ ,  $^{241}\text{Am}$ , and  $^{239/240/241}\text{Pu}$ . Cosmogenic radionuclides, produced by the interaction of cosmic radiation with atoms present in the atmosphere, include  $^3\text{H}$ ,  $^{14}\text{C}$ ,  $^7\text{Be}$ , and  $^{22}\text{Na}$ . As a component of ambient background, cosmic radiation includes primarily high-energy muons and electrons produced by the interactions of charged particles (mainly protons) with the Earth's atmosphere. Naturally occurring radioactive material that has been technologically enhanced is not considered background for the purpose of this standard.

**Decay series:** The decay of a radionuclide (parent) by spontaneous transformation, producing decay products. With time, parent and decay products, depending on their half-lives and decay rates, may establish an equilibrium in which the activity levels of the parent and decay products are the same. The rate of decay is specific to each radionuclide and expressed as radioactivity in terms of Becquerel (Bq) (and its multiples) corresponding to the number of transformation per second.

**Environment:** The total terrestrial, atmospheric, and aquatic environments, including flora and fauna, where radioactive material may be introduced and expose individuals and populations.

**Equilibrium for radon decay products:** A condition in which the radioactivity of each short-lived decay product is equal (in equilibrium) to that of the parent, radon.

**Exempted materials, products, and practices:** See Exclusion 1.4.2.

**Intervention:** An activity or action taken to 1) prevent or decrease radiation exposures and doses to individuals or the public and 2) minimize or mitigate the impact on the environment from sources of radioactivity and radiation that are not part of a managed practice, that occurred before the implementation of controls sufficient to limit exposures and doses to the public, or that resulted from an emergency situation.

**Licensed material:** Any radioactive material or product received, possessed, used, transferred, or disposed of under a general or specific license granted or issued by a responsible regulatory agency (i.e., with legislative authority).

**May:** The term “may” is used to identify elements or actions that are optional, not mandatory, but are permissible or useful in interpreting and implementing the requirements of this standard.

**Naturally occurring and Accelerator-produced Radioactive Material (NARM):** The term includes naturally occurring radioactivity and radioactive materials excluded by the Atomic Energy Act, as defined by the Act and regulated by federal and state agencies.

**Naturally Occurring Radioactive Material (NORM):** Any of the primordial radionuclides or radioactivity present in soils, rocks, and materials undisturbed as a result of human activities. (see Background radiation).

**Occupational dose:** Any dose received by a worker or critical population group from exposure to TENORM in occupational settings. Occupational dose includes exposures and doses associated with the manufacturing, disposal, and distribution of materials and products containing TENORM. Occupational dose does not include occupational exposures and doses received as a “radiation worker” associated with the use or possession of

material and equipment regulated or licensed by a federal or state agency (see Public dose).

**Practice:** An activity that can result in radiation exposures and doses to workers or members of the public from TENORM, including any associated sources of radiation used in the normal course of a process, usage, beneficiation, manufacturing, storage, distribution, recycling, or disposal. Practice excludes events that can be classified as emergencies or incidents (see Intervention).

**Process knowledge:** A collection of facts, information, and data characterizing or describing past or current processes or practices. When invoked, process knowledge shall be documented, as appropriate, with supporting technical information, including plans, procedures, specifications, assumptions, algorithms, definitions, expert testimony, etc. As a substitute, professional judgment shall only be used in situations in which information or data are not reasonably available by collection, survey, literature search, or experimentation.

**Products:** Something made, manufactured, refined, beneficiated, or processed as raw or finished material and feedstock for use by other industries or in consumer or industrial products. Products include items, materials, devices, and equipment.

**Public dose:** Any dose received by a member of the public or critical population group from exposure to TENORM in non-occupational settings. Public dose does not include doses received from background radiation, medical procedures and administration, or voluntary participation in medical research programs (see Occupational dose).

**Radiation:** Alpha particles, beta particles, gamma rays, x-rays, and other particles capable of causing ionizations. This definition does not include non-ionizing radiation, such as micro- and radio waves or infrared and ultraviolet radiation.

**Radiation protection philosophy:** A concept that espouses radiation protection principles emphasizing the justification of a practice involving the use of radioactive materials on the basis that the expected benefits to society exceed the overall societal costs, and limitation of individual risks by maintaining doses below

limits established for radiation protection (see ALARA).

**Recycling or reuse:** Any process by which material, products, or feedstock are used or reused, as is, for any purpose; contaminated scrap metals that may be recycled for their metallic properties; and equipment salvaged and returned intact for use in their originally intended purpose (form and function).

**Shall:** The term “shall” is used to identify elements or actions that are mandatory for the full implementation of the standard.

**Should:** The term “should” is used to identify elements or actions that are considered guidance but are not mandatory. If the guidance is not followed, technical equivalency in the outcome should be demonstrated when using alternate methods.

**Sum-of-the-ratios:** A method used to determine when two or more radionuclides present in a mixture meet the criteria. Mathematically, it is a unitless expression, defined as:

$$\sum_{i=1}^n C_i \div CL_i \leq 1$$

where  $C_i$  is the concentration of radionuclide,  $i$ , on or in a material of interest;  $CL_i$  is the criteria limit for radionuclide,  $i$ , on or in a material of interest; and  $n$  is the total number of radionuclides present in the mixture determined using appropriate radio-analytical procedures or process knowledge.

**Surface contamination:** The presence of radioactive contamination on or near the surface of an item or material. If the radioactivity is present in inaccessible areas or on internal surfaces and at depths well beyond the surface, the contamination shall be considered as volumetric contamination. Surface contamination is expressed in terms of radioactivity levels per unit area, including  $\text{Bq cm}^{-2}$ ,  $\text{Bq 100 cm}^{-2}$ , or  $\text{dpm 100 cm}^{-2}$ .

**Survey:** A systematic evaluation and documentation of the radiological characteristics of areas, items, or materials using calibrated instrumentation or laboratory radio-analytical techniques that meet data quality objectives established for the survey. Data quality

objectives define the appropriate type of data, specify tolerance levels for decision errors, and establish the quality and quantity of data needed to support the decision process when evaluating results.

**Technologically Enhanced Naturally Occurring Radioactive Material (TENORM):**

Naturally occurring radioactive material disturbed or altered from natural settings or present in a technologically enhanced state due to past or present human activities and practices, which may result in a relative increase in radionuclide concentrations, radiation exposures and risks to the public, and threat to the accessible environment above background radiation levels. "Technologically enhanced" means that the radiological, physical, and chemical properties of the radioactive material have been altered such that there exists a potential for:

- (a) redistribution and contamination of environmental media (soil, water, air, and biota),
- (b) increased environmental mobility in soils and surface and ground water,
- (c) incorporation of elevated levels of radioactivity or increased accessibility in products and construction material, or
- (d) improper disposal or use of disposal methods that may result in unnecessary or elevated exposures to individuals and populations via the accessible environment.

In comparing background radioactivity or radiation levels with TENORM, the definition does not provide a point of reference, such as a level equivalent to a multiple of background, because this may lead to situations in which a material not considered TENORM in a high background area could become TENORM when relocated to a lower background area.

TENORM does not include radiation emanating from or radioactivity present in ores, rocks, soils, and materials containing uranium and thorium subject to regulations under the Atomic Energy Act, as amended.

**Total Effective Dose Equivalent (TEDE):** The sum of the effective dose equivalent (due to external radiation) and the committed effective dose equivalent (from internal exposure via inhalation, ingestion, and skin breaks or

absorption) from exposures during a single year. The deep dose equivalent to the whole body may be used as the effective dose equivalent for external radiation exposures.

**Volume contamination:** The presence of radioactive contamination residing in or throughout the volume or matrix of an item or material. Volume contamination is usually expressed in terms of radioactivity levels per unit mass, including Bq g<sup>-1</sup>, Bq kg<sup>-1</sup>, dpm kg<sup>-1</sup>, dpm g<sup>-1</sup>, Bq cm<sup>-3</sup>, or dpm cm<sup>-3</sup>.

**Working Level (WL):** That amount of potential alpha energy in one cubic meter of air that will result in the emission of  $2.08 \times 10^{-5}$  joules (J) of energy, or alternatively  $1.3 \times 10^{-5}$  MeV, in one liter of air.

**Working Level Month (WLM):** A cumulative exposure, equivalent to the exposure of one working level for a working month (170 hours), corresponding to  $2.08 \times 10^{-5} \text{ J m}^{-3} \times 170 \text{ h} = 3.5 \times 10^{-3} \text{ J h m}^{-3}$ , or alternatively  $1.3 \times 10^{-5} \text{ MeV L}^{-1} \times 170 \text{ h} = 2.2 \times 10^{-7} \text{ MeV h L}^{-1}$ . Cumulative exposure is expressed as:

$$\text{WLM} = \sum_{i=1}^n (\text{WL})_i t_i \div 170$$

where  $(\text{WL})_i$  is the average concentration of radon short-lived decay products during exposure time interval,  $i$ , and  $t_i$  is the total duration of the exposure, expressed in hours.

## 1.4 Exclusions

The following exclusions are given for the purpose of further defining the scope of the standard and facilitating its interpretation and implementation.

- 1.4.1 Naturally occurring radioactive material (NORM) as any of the primordial radionuclides or radioactivity present in soils, rocks, and materials involving practices and human activities that are generally regarded as common practice. Among others, such practices include materials used in scientific research, engineering studies and applications, farming, tilling, plowing, site grading, grave digging, trenching, or similar types of excavation or earth work. This

- exclusion does *not* apply to materials or practices making radioactivity more accessible to humans or the environment, thereby resulting in material that should be considered TENORM. Among others, such practices include home building using materials obtained from mining and mineral extraction spoils, overburden, and wastes; or building homes on sites containing extraction spoils, overburden, and wastes from mineral mining or oil and gas extraction.
- 1.4.2 Materials, products, and practices for which an exemption from regulatory requirements has been provided by a regulatory agency with legislative authority, and materials and equipment that have been decontaminated to release criteria defined by a regulatory agency with legislative authority. Uranium and thorium covered by exemptions from NRC or state regulations are still considered to be subject to regulations under the Atomic Energy Act and thus are not NORM or TENORM.
- 1.4.3 Source, byproduct, or special nuclear material as defined by the Atomic Energy Act of 1954, as amended.
- 1.4.4 Distribution and consumption of foodstuffs known to contain NORM when cultivated under normal agricultural practices, including the use of man-made fertilizers, and processed such that naturally occurring radionuclide concentrations and isotopic ratios have not been increased or altered through human intervention. This exclusion does not apply to foodstuffs grown in TENORM whether as a product, waste, or mixed with soils (see Exclusion 1.4.10).
- 1.4.5 Consumer products or industrial materials used in their intended form and function according to a standard of care under Occupational Safety and Health Administration (OSHA) or Mine Safety and Health Administration (MSHA) regulations, manufacturer's instructions, and other applicable regulatory provisions. This exclusion applies insofar as there has not been overriding product- or material-specific guidance or regulations. Moreover, this exclusion applies insofar as it shall be demonstrated that such practices and the associated standard of care in worker safety rendered under OSHA or MSHA regulations would result in a level of protection that is equivalent to this standard.
- 1.4.6 Potassium, potassium compounds, and products containing potassium, provided that naturally occurring potassium isotopic ratios are maintained (i.e., the potassium has not been isotopically enriched in  $^{40}\text{K}$ ).
- 1.4.7 The possession, storage, and distribution of fuels, such as coal and coal byproducts (e.g., gas), natural gas and natural gas byproducts, and crude oil and crude oil products. This exclusion addresses itself only to fuel products before combustion and does not include production waste and residues contained in processing systems, storage tanks, and distribution pipelines that may contain TENORM. Wastes and residues generated during and after combustion may be excluded if it is demonstrated that such wastes and residues have TENORM at levels resulting in exposures and doses that are in conformance with this standard.
- 1.4.8 Possession, custom blending, distribution, and use of fertilizer feedstock and products for agricultural applications, animal feed products, and soil amendments, including phosphate and potash fertilizers.
- 1.4.9 The manufacture of fertilizers and fertilizer-based products whenever regulated by federal or state regulatory agencies with legislative authority.
- 1.4.10 Distribution of material containing TENORM for use in agricultural applications or research and development as covered by exemptions issued by the U.S. Environmental Protection Agency (EPA) (National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations, 40 CFR Part 61, as amended) and equivalent state

regulations.

- 1.4.11 Radioactivity and radionuclides covered by the U.S. Environmental Protection Agency under NESHAP regulations (40 CFR Part 61, as amended). However, these specific regulations do not exempt the presence of the same radionuclides in other types of TENORM materials.
- 1.4.12 Use of mineral admixture in concrete, as defined and authorized by the U.S. Environmental Protection Agency (Office of Solid Waste and Emergency Response) regulations and directives or equivalent state requirements.
- 1.4.13 Sites and facilities previously contaminated with TENORM that have been remediated under the provisions of the U.S. Environmental Protection Agency regulations and directives or appropriate state requirements. This provision includes all related restrictions defining the types and amounts of material allowed to remain at the site, surficial extent of the site or facility, and assignment of specific institutional controls.
- 1.4.14 Sites where the U.S. Environmental Protection Agency and states have assumed authority under the Superfund or the Comprehensive Environmental Response, Compensation, and Liability Act and Clean Air Act (CERCLA). Current U.S. Environmental Protection Agency and state regulatory requirements and guidance shall be reviewed and their applicability evaluated in the context of site-specific conditions.

## 2.0 TENORM Exposure and Disposition Criteria

This section presents dose limits for members of the public and workers involving the manufacturing, use, and distribution of products, items, materials, and devices containing technologically enhanced naturally occurring radioactive material (TENORM). The section provides release criteria for materials containing TENORM. Annex C provides supplemental

information on the application of administrative measures and engineered controls to minimize radiation exposure to workers and members of the public. Annex D describes various management and disposal options for TENORM. The voluntary implementation of such measures is expected to avoid the possibility of leaving contaminated materials or sites as future legacies, thereby eliminating the need for corrective interventions.

A review of federal and state regulations shall be conducted to determine whether the manufacturing, use, and distribution of products, items, materials, or devices shall be conducted under a general or specific license commensurate with the amounts or concentrations of TENORM. This determination should be based on documented process knowledge. If such activities fall under the oversight of federal or state regulations, the standard of practice described in this document shall not apply.

### 2.1 Guiding Radiation Protection Principles

Radiation exposures and doses associated with the presence of TENORM are the same as those arising from other types of radioactive materials governed by existing federal and state regulatory programs. It follows that radiation protection principles recommended for radioactive materials of other origins should be applied to TENORM. In their recommendations, regulatory agencies and organizations chartered to develop radiation protection regulations or guidance have advocated three basic principles in controlling radiation exposures and doses:

1. justification of a practice involving the use of radioactive materials on the basis that the expected benefits to society exceed the overall societal costs,
2. optimization of radiation protection where doses are kept as low as is reasonably achievable (ALARA), taking into account economic and social factors, and
3. limitation of individual risks by maintaining doses below limits established for radiation protection.

The standard adopts these principles and provides supplemental guidance for their implementation. Also, the standard advocates that during intervention higher doses may be

permitted in the short term in order to mitigate long-term radiation exposures and impacts on the accessible environment. The selection of any specific mitigative measure should be determined on the basis of an ALARA evaluation by comparing the resulting reduction in doses against costs and other detrimental or societal impacts to potential receptors and the environment. However, cost alone shall not be the only factor used in selecting and implementing such measures.

## 2.2 TENORM Criteria and Guidance

The following defines TENORM criteria and guidance for their implementation. In implementation, the radiation protection principles of Section 2.1 for limiting radiation exposures and keeping doses ALARA shall be considered in the context of the practice or application of interest. It should be noted that some site remediations may be under CERCLA authority and, consequently, the criteria that follow would not apply.

### 2.2.1 Exposure and Dose Criteria

- a. The dose criteria shall apply to individual members of the public exposed to TENORM sources of radioactivity and radiation. Dose limits shall be expressed as total effective dose equivalent (TEDE). The criteria are:
  - (i) an annual dose limit of 1 mSv (100 mrem), above background, from all pathways and sources of radioactivity (except radon and its short-lived decay products) and practices associated with site and facility operations, including effluent discharges into the environment.
  - (ii) specific dose constraints for each practice and source of radioactivity, if established by an agency with legislative authority, shall be considered to ensure that dose limits are not exceeded when all individual dose contributions are added in determining the total dose.
  - (iii) an annual dose limit of 0.25 mSv (25 mrem), above background, from all appropriate pathways associated with

the presence of residual sources of radioactivity (except radon and its short-lived decay products) from land and facilities that have been remediated and released for any use with no further radiological restrictions.

- (iv) dose limits for internal and external exposures exclude doses from radon gases ( $^{219}\text{Rn}$ ,  $^{220}\text{Rn}$ ,  $^{222}\text{Rn}$ ) and its short-lived decay products. Exposures and doses due to long-lived radon gas particulate decay products shall be included in the dose limit of Section 2.2.1.a(i). Sections 2.2.3 and 2.2.4 present criteria for exposure to indoor and outdoor radon gas, respectively, including short-lived particulate decay products from radon gas.
- (v) the Maximum Contaminant Levels (MCLs) for site and facility effluent discharges that may have an impact on current or potential sources of ground water using the National Primary Drinking Water regulations, as amended, for the presence of  $^{226}\text{Ra}$  and  $^{228}\text{Ra}$  (combined), uranium, and gross alpha particle radioactivity (excluding radon and uranium). In the context of ALARA, ground-water protection should emphasize prevention over the remediation of contaminated aquifers.
- b. For interventions, the dose limits noted above shall not apply in the short term to the general public because higher doses may be permitted in order to mitigate long-term radiation exposures to the public and impacts on the environment. Interventions that result in doses to workers involved in intervention activities above limits for members of the public shall be subject to regulatory controls under state or federal regulations.
- c. Doses shall be determined using best estimates evaluated over the expected duration of the radiological hazards for radionuclides characterized by slow migration rates in ground water (about 1,000 years). Doses shall be determined using risk assessment methods recognized by agencies with legislative

authority or standard-setting organizations. Alternatively, conformance with the standard may be demonstrated by environmental measurements or results of site characterization studies, when feasible, using process knowledge.

- d. If institutional controls are used to meet the dose criteria, a risk assessment analysis shall be performed to determine whether there is reasonable assurance that such controls will remain effective over the expected duration of the radiological hazards. The application of institutional controls should consider cost-benefits and societal impacts to receptors and the environment. However, cost alone shall not be the only factor used in defining and implementing institutional controls.
- e. If institutional controls are used to meet dose criteria, the documentation of such controls shall be permanently recorded such that knowledge of the controls is maintained for reference by future site owners and/or occupants, workers, and the public. Institutional controls include deed covenants, constraints on the extraction of natural resources, and zoning laws, among others, that restrict the use of the site to applications intended to minimize radiation exposures to members of the public. Institutional controls shall require that the owner/operator or an independent third party carry out periodic monitoring and maintenance of the site and facilities to restrict the movement of radioactivity into the accessible environment.

### 2.2.2 Administrative Surface and Volume Contamination Release Levels

- a. Limited quantities of material containing TENORM at concentrations not exceeding the administrative release levels of Table 2-1 shall be exempted from this standard, given that the subsequent provisions of this section are met. "Limited quantities" means amounts on the order of one metric ton, but not exceeding a few metric tons. By definition, "administrative release" is used to differentiate it from "clearance"

or "unrestricted release," which relates to the removal of materials that are under the jurisdiction of a regulatory authority involving the use of licensed radioactive materials. This provision shall not exempt the applicability of federal, state, and local regulations governing the presence of any toxic or hazardous materials in TENORM.

- b. Significant quantities of material containing TENORM at concentrations not exceeding the administrative release levels of Table 2-1 shall be permanently disposed of 1) in disposal facilities authorized to accept materials at TENORM concentrations within the limits of Table 2-1; 2) in disposal facilities that have specific waste acceptance criteria for TENORM and concentration limits other than those in Table 2-1; or 3) in disposal facilities under case-specific approvals for the materials of interest. "Significant quantities" means amounts on the order of several or more metric tons. The management of TENORM shall comply with state or federal requirements addressing the presence of non-radioactive hazardous materials, with the most protective requirement governing the final disposition.

Significant quantities of material containing TENORM at concentrations exceeding the administrative release levels of Table 2-1 shall be permanently disposed of 1) in disposal facilities authorized to accept materials at TENORM concentrations above the limits given in Table 2-1 or 2) in disposal facilities that have specific waste acceptance criteria for TENORM and concentration limits other than those in Table 2-1. "Significant quantities" means amounts on the order of several or more metric tons. The management of TENORM shall comply with state or federal requirements addressing the presence of non-radioactive hazardous materials, with the most protective requirement governing the final disposition.

**Table 2-1.** Surface and volume contamination administrative release levels.<sup>a</sup>

| Radionuclide groups                                                                                                                                                                                      | Volume release level <sup>b</sup>                      | Surface release level <sup>b</sup>                              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|-----------------------------------------------------------------|
| Group 1<br>Radium and thorium, and associated decay products:<br><sup>210</sup> Po, <sup>210</sup> Pb, <sup>226</sup> Ra, <sup>228</sup> Ra, <sup>228</sup> Th, <sup>230</sup> Th, and <sup>232</sup> Th | 0.1 Bq g <sup>-1</sup><br>or<br>3 pCi g <sup>-1</sup>  | 0.1 Bq cm <sup>-2</sup><br>or<br>600 dpm 100 cm <sup>-2</sup>   |
| Group 2<br>Natural U: <sup>238</sup> U, <sup>235</sup> U, and <sup>234</sup> U                                                                                                                           | 1.0 Bq g <sup>-1</sup><br>or<br>30 pCi g <sup>-1</sup> | 1.0 Bq cm <sup>-2</sup><br>or<br>6,000 dpm 100 cm <sup>-2</sup> |
| Group 3<br><sup>40</sup> K <sup>c</sup>                                                                                                                                                                  | 30 Bq g <sup>-1</sup><br>or<br>800 pCi g <sup>-1</sup> | 0.6 Bq cm <sup>-2</sup><br>or<br>3,600 dpm 100 cm <sup>-2</sup> |

<sup>a</sup>Endorsed by reference to ANSI/HPS N13.12-1999, Surface and Volume Radioactivity Standards for Unconditional Clearance, August 31, 1999. In application, ANSI/HPS N13.12-1999 assumes unity for a mass-to-surface ratio.

<sup>b</sup>The release level limits are exclusive of background. In demonstrating conformance, the evaluation shall consider the applicability of each note listed below:

1. For natural uranium, the isotopic distribution is given as 48.9% for <sup>238</sup>U, 48.9% for <sup>234</sup>U, and 2.2% for <sup>235</sup>U, by activity.

2. When two or more radionuclides are present from dissimilar decay series (e.g., <sup>210</sup>Po and <sup>228</sup>Th), the sum-of-the-fractions shall be used in determining if the release limit is met. It is defined as:

$$\sum_{i=1}^n C_i \div CL_i \leq 1$$

where  $C_i$  is the concentration of radionuclide  $i$ , on or in a material of interest;  $CL_i$  is the criteria limit for radionuclide  $i$ , on or in material of interest; and  $n$  is the total number of radionuclides present in the mixture determined using appropriate radio-analytical procedures or process knowledge.

3. The sum-of-the-fractions method need not be applied when radionuclides present are part of a decay series and its decay products are in secular equilibrium based on process knowledge or radiochemical analysis. If sufficient time has elapsed since the parent and decay products were separated, secular equilibrium may be assumed taking into account their radioactive half-lives.

4. For radionuclides that are known or assumed to be present in the mixture, but are not detectable by conventional or portable survey equipment used to measure the presence of those that are reliably detectable, the sum-of-the-fractions expression may be modified as follows to account for the radioactivity associated with undetectable radionuclides:

$$\sum_{i=1}^n \frac{C_i}{CL_i} \div D_{f,i} \leq 1$$

where  $D_{f,i}$  is the detectable fraction of radionuclide  $i$  in the mixture, and by definition  $D_{f,i} \neq 0$ , and the other terms are as previously defined. The detectable fraction represents the actual fraction of radionuclides that are measured by the chosen survey method. The presence and fraction of detectable radionuclides, for the given type of radiation survey instrumentation being used, shall be determined by appropriate radio-analytical procedures or process knowledge.

For materials containing single or mixtures of radionuclides that are not detectable (i.e.,  $D_{f,i} = 0$ ) by the chosen survey instrumentation or method, the above modification does not apply and their presence and concentrations shall be determined using appropriate laboratory radio-analytical procedures. More specific guidance on implementation can be found in MARSSIM [Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), EPA 402-R-97-016, Rev. 1]. MARSSIM, Section 4.3.2 and Appendix I.11, presents the methodology in considering the presence of multiple radionuclides and use of surrogate ratios for radionuclides that are not detectable or readily measurable.

5. For implementation purposes, additional guidance may be obtained from the following documents: Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NUREG-1575); Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP) (EPA 402-B-04-001A); Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME), (EPA 402-R-09-001, Suppl.1); Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions (NUREG-1507); A Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys (NUREG-1505, Rev.1); and recognized dose assessment codes: Development of Probabilistic RESRAD 6.3 and RESRAD-BUILD 3.3, and NUREG/CR-6697; Residual Radioactive Contamination from Decommissioning - User's Manual DandD, Ver. 2.1 (NUREG/CR-5512, Vol. 2); and MicroShield® (Ver. 7.0).

<sup>c</sup>For  $^{40}\text{K}$ , the volume release level is based on its specific activity of  $834 \text{ pCi g}^{-1}$  and rounded off to  $800 \text{ pCi g}^{-1}$ , assuming an elemental abundance of 0.0118%. The surface release level for  $^{40}\text{K}$  was derived using the NRC's "DandD" code and bench-marking the result to N13.12-1999. Levels assume an annual dose (TEDE) of less than or equal to 1.0 mrem, see ANSI/HPS N13.12-1999.

- d. The volume release levels shall not apply to disposal methods or applications that may result in exposures to the public (i.e., release of soils or land for agricultural purposes, land treatment application, and use as aggregates in construction material or backfill under buildings). This restriction should ensure that the management of TENORM under these situations is evaluated instead under the dose criteria (Section 2.2.1.a) in recognition of environmental conditions on a site-specific basis rather than using a generically defined volume release level.
- e. The volume release levels shall not be construed as provisions for the disposal of higher-activity waste by mixing and dilution with clean material.
- f. Items known to contain activity levels in excess of the surface release levels of Table 2-1 shall not be intentionally coated, plated, or covered as a means to reduce actual or apparent surface activity levels.
- g. Items characterized by inaccessible areas shall be dismantled and surveyed or treated as volumetrically contaminated with the appropriate release level applied accordingly.
- h. The volume release levels shall not apply to liquid waste, sludge, and other residues mixed in liquids for the express purpose of dilution and/or discharge into surface water bodies and streams, for underground injection in deep or shallow wells, and land treatment applications. The discharge of liquid effluents containing TENORM in surface water bodies or ground water is covered by the criteria of Section 2.2.1.a. The spreading of sludge on lands or injection of sludge in deep wells shall be evaluated against state or federal regulations because these requirements address the presence of non-radioactive contaminants (e.g., metals and organic and inorganic compounds).

### 2.2.3 Outdoor Radon

- a. Radon ( $^{222}\text{Rn}$ ) and its short-lived decay products released to outdoor environments shall be controlled to a radon exhalation rate or release rate corresponding to:
  - (i) an annual average concentration of less than or equal to  $20 \text{ Bq m}^{-3}$  ( $0.50 \text{ pCi L}^{-1}$ ), above background, at downwind locations of property or site boundaries, or
  - (ii) an equivalent radon gas limit based on working level (WL) concentration for its short-lived decay products using relevant guidelines from the U.S. Environmental Protection Agency (EPA).
- b. When two or more radon isotopes are present in the mixture, the sum-of-the-fractions method shall be used in determining conformance with the annual average concentration limit. Other radon isotopes may include  $^{219}\text{Rn}$  and  $^{220}\text{Rn}$ . Where  $^{219}\text{Rn}$  or  $^{220}\text{Rn}$  are the gases of concern, an alternate radon concentration limit shall be calculated based on a radon gas or WL concentration, dose limit, or risks comparable to that of  $^{222}\text{Rn}$  using U.S. Environmental Protection Agency guidelines (EPA).
- c. Conformance may be demonstrated by atmospheric dispersion modeling and downwind sectors concentration averaging, or environmental measurements when feasible.
- d. If institutional or engineered controls are used to meet criterion 2.2.3.a, the analysis shall indicate that there is reasonable assurance that the controls will remain effective over the expected duration of the radiological hazards.
- e. The application of institutional and engineered controls should consider cost-benefits and societal impacts to receptors and the environment. This consideration should be based on documented process knowledge. However, cost alone shall not be the

only factor used in defining and implementing such controls.

### 2.2.4 Indoor Radon

- a. The presence of indoor radon ( $^{222}\text{Rn}$ ) and its short-lived decay products in buildings and structures shall be limited in areas that are occupied or occupiable to:
  - (i) an annual average concentration of less than  $150 \text{ Bq m}^{-3}$  ( $4 \text{ pCi L}^{-1}$ ),
  - (ii) an equivalent radon gas limit based on working level (WL) concentration for short-lived decay products using relevant guidelines from the U.S. Environmental Protection Agency (EPA), or
  - (iii) a radon gas or WL concentration for short-lived decay products established for workers under a standard of care defined by the Occupational Safety and Health Administration (OSHA) or Mine Safety and Health Administration (MSHA).
- b. When two or more radon isotopes are present in the mixture, the sum-of-the-fractions method shall be used in determining conformance with the annual average concentration limit. Where  $^{219}\text{Rn}$  or  $^{220}\text{Rn}$  are the gases of concern, an alternate radon concentration limit shall be calculated based on a radon gas or WL concentration, dose limit, or risks comparable to that of  $^{222}\text{Rn}$  using U.S. Environmental Protection Agency (EPA) guidelines.
- c. The derivation of an alternate radon gas limit or WL concentration shall take into consideration specific building characteristics, such as ventilation rates, equilibrium of decay products, and occupancy times.
- d. In the context of the standard, "occupied" or "occupiable" means casual or routine occupancy of areas within a structure where radon may exist at elevated levels. For residential structures, indoor areas may include basements, rooms built directly on the ground, and rooms or areas with exposed soils, rocks, and materials

containing TENORM. For commercial structures, indoor areas may include offices, workshops, warehouses, etc., and areas with exposed soils, rocks, and materials containing TENORM. Such situations should require further evaluations in planning and implementing specific monitoring methods or when considering mitigative measures.

- e. Conformance with this criterion should be demonstrated by using long-term monitoring methods for radon gas or decay products using radon measurement proficiency programs approved by a state agency with legislative authority or the U.S. Environmental Protection Agency (EPA). "Long-term" refers to measurement periods that adequately represent the seasonal and yearly variability of indoor radon levels.
- f. In mitigating ambient radon gas or short-lived decay products concentrations, mitigation techniques and building design features should be applied using U.S. Environmental Protection Agency (EPA) guidelines addressing mitigation practices and building construction standards.
- g. The conduct of radon gas or radon decay products measurements or installation of radon mitigation systems shall be performed by qualified organizations or individuals listed in state agencies' (or the U.S. Environmental Protection Agency (EPA)) radon measurement proficiency programs.

## 2.2.5 Products Manufacturing, Use, and Distribution

- a. A review of federal and state regulations shall be conducted to determine whether the manufacturing, distribution of items, materials, devices, or equipment (i.e., products) shall be conducted under a general or specific license commensurate with resulting doses and amounts or concentration of TENORM. This determination should be based on documented process knowledge. If such activities fall under the oversight of federal or state regulations,

the standard of practice described in this document shall not apply.

- b. The intentional introduction of TENORM into products with no beneficial attributes is not approved by this standard. The presence of TENORM in products shall be controlled such that doses received by individual users during incidental or routine usage shall not exceed:
  - (i) an annual dose limit of 0.25 mSv (25 mrem), above background and ALARA, from all pathways associated with the presence of radioactivity (except radon and its short-lived decay products). The dose limit is expressed as total effective dose equivalent (TEDE) from internal and external exposures.
  - (ii) specific dose constraints, if established by an agency with legislative authority, shall be considered to ensure that the dose limit is not exceeded when dose contributions from multiple products are added in determining the total dose.
  - (iii) an annual average radon ( $^{222}\text{Rn}$ ) concentration of  $150 \text{ Bq m}^{-3}$  ( $4 \text{ pCi L}^{-1}$ ), an equivalent radon gas limit based on working level (WL) concentration using relevant guidelines from the U.S. Environmental Protection Agency (EPA), or a radon gas or WL concentration defined by the Occupational Safety and Health Administration (OSHA) and Mine Safety and Health Administration (MSHA).
- c. When two or more radon isotopes are present in the mixture, the sum-of-the-fractions method shall be used in determining conformance with the annual average concentration limit. Other radon isotopes may include  $^{219}\text{Rn}$  and  $^{220}\text{Rn}$ . Where  $^{219}\text{Rn}$  or  $^{220}\text{Rn}$  are the gases of concern, an alternate radon concentration limit shall be calculated based on a radon gas or WL concentration, dose limit, or risks comparable to that of  $^{222}\text{Rn}$  using U.S. Environmental Protection Agency (EPA) guidelines.
- d. The derivation of alternate radon gas or

WL concentration shall consider specific building characteristics, such as ventilation rates, inherent radon emanation rates of products, equilibrium of short-lived decay products, manufacturing practices, and occupancy times.

- e. In assessing doses, the analysis should consider representative scenarios and assumptions regarding appropriate exposure pathways and frequency of exposures to users or critical population groups. The analysis shall assess product features that may result in higher doses, should they be compromised during handling and use. Manufacturers or suppliers shall include information with products providing guidance for their proper use, handling, storage, and disposal. This information may be included in Material Safety Data Sheets (MSDS), safety instructions, user's manuals, etc.

## 2.2.6 Occupational Radiation Exposures As Non-Radiation Workers

- a. A review of federal and state regulations shall be conducted to determine whether the manufacturing and distribution of items, materials, devices, and equipment (i.e., products) shall be conducted under a general or specific license commensurate with resulting doses and amounts or concentration of TENORM. This determination should be based on documented process knowledge. If such activities fall under the oversight of federal or state regulations, the standard of practice described in this document shall not apply.
- b. Occupational doses received during manufacturing, handling, use, storage, transportation, and distribution of products containing TENORM shall be controlled under normally encountered conditions such that the following limits shall not be exceeded:
  - (i) annual dose limit of 1.0 mSv (100 mrem), above background and including ALARA, from all pathways associated

with the presence of radioactivity (except radon and its short-lived decay products). The dose limit is expressed as total effective dose equivalent (TEDE) from internal and external exposures.

- (ii) annual average radon ( $^{222}\text{Rn}$ ) concentration of  $150 \text{ Bq m}^{-3}$  ( $4 \text{ pCi L}^{-1}$ ), an equivalent radon gas limit based on working level (WL) concentration using relevant guidelines from the U.S. Environmental Protection Agency (EPA), or a radon gas or WL concentration defined by the Occupational Safety and Health Administration (OSHA) and Mine Safety and Health Administration (MSHA).
- c. The derivation of alternate radon gas or WL concentration shall consider specific building characteristics, such as ventilation rates, inherent radon emanation rates of products, equilibrium of radon decay products, manufacturing practices, and occupancy times.
- d. When two or more radon isotopes are present in the mixture, the sum-of-the-fractions method shall be used in determining conformance with the annual average concentration limit. Other radon isotopes may include  $^{219}\text{Rn}$  and  $^{220}\text{Rn}$ . Where  $^{219}\text{Rn}$  or  $^{220}\text{Rn}$  are the gases of concern, an alternate radon concentration limit shall be calculated based on a radon gas or WL concentration, dose limit, or risks comparable to that of  $^{222}\text{Rn}$  using U.S. Environmental Protection Agency guidelines (EPA).
- e. Work conditions likely to result in doses or exposure to radon in excess of the above limits under routine conditions shall warrant the implementation of a formal occupational radiation protection and monitoring program and use of appropriate engineered controls and administrative safety measures. A radiological assessment shall confirm whether (a) doses from external and internal exposures are above these limits in light of working conditions and types of TENORM-bearing materials being used or (b) the practice is subject to regulatory oversight under

appropriate state or federal regulations with occupational dose limits established for "radiation workers," including those addressing health and safety program managed in compliance with OSHA or MSHA requirements.

### 2.2.7 Records Requirements

- a. The record-keeping system of ANSI/HPS N13.6-1999 and NCRP Report No. 114 shall be used in documenting radiological protection activities, including policies and procedures, radiation safety and ALARA analyses, personnel radiation exposures, radiation monitoring and surveys, radio-bioassays (as needed), effluent discharges, waste disposals, material storage and inventories, instrument calibration and maintenance, inspections and audits, personnel training, and record retention.
- b. The record-keeping requirements of ANSI/HPS N13.12-1999 shall be used in documenting material and items released and/or disposed of under the provisions of Section 2.2 of this standard. The requirements include descriptions of items or materials, survey results, disposition of materials or items, and supporting documentation, such as procedures, instrument calibration records, and personnel qualifications and training.
- c. The transfer or shipment of materials and items to third parties shall be documented using documents commonly used in general commerce, such as a shipment manifest, bill of lading or freight, or an equivalent type of contractual documentation.