



American National Standard

ANSI/HPS N13.12-2013

**Surface and Volume Radioactivity
Standards for Clearance**

Approved: May 6, 2013

American National Standards Institute, Inc.



Published by

Health Physics Society
1313 Dolley Madison Blvd.
Suite 402
McLean, VA 22101

Copyright © 2013 by the Health Physics Society.
All rights reserved.

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without prior written permission of the publisher.

Printed in the United States of America

ANSI/HPS N13.12-2013

1313 Dolley Madison Blvd.
Suite 402
McLean, VA 22101
703/441-5500
www.hpsociety.org

This standard was developed under the authority of the Health Physics Society Accredited Standards Committee (ASC) N13, Radiation Protection. The Working Group responsible for this standard had the following members:

William E. Kennedy, Jr., Chairperson
Dade Moeller & Associates, Inc.

Ricky A. Bowser
Duke Energy Carolinas, LLC

Wayne M. Glines
Dade Moeller & Associates, Inc.
(formerly with the U.S. Department of Energy, Richland Operations Office)

Debra McBaugh
Dade Moeller & Associates, Inc.
(formerly with the Washington State Department of Health, Radiation Protection)

Robert A. Meck
Science and Technology Systems, LLC
(U.S. Nuclear Regulatory Commission, retired)

Phillip D. Newkirk
U.S. Environmental Protection Agency, retired

Andrew Wallo III
U.S. Department of Energy

Robert C. Woodard
EnergySolutions

The Working Group chairperson would like to recognize the Working Group members and consultants responsible for the development of the August 1999 version of this standard, whose contributions laid the groundwork for this revision:

Working Group Members

David E. Bernhardt
Rogers & Associates Engineering Corp.

Arthur E. Desrosiers
Bartlett Services, Inc.

Stephen W. Duce
International Technology Corporation

Wayne C. Gaul
Chem-Nuclear Systems

Tracy A. Ikenberry
Dade Moeller & Associates, Inc.

Alfred N. Johnson
Scientific Ecology Group, Inc.

Robert A. Meck
U.S. Nuclear Regulatory Commission

Francis R. O'Donnell
Oak Ridge National Laboratory

Jack M. Selby
M.H. Chew and Associates, Inc.

Fredrick P. Straccia
Radiation Safety & Control Services, Inc.

Alden N. Tschaeche
Nuclear Standards Unlimited

Robert C. Woodard
Canberra Industries

Consultants

Shin-Yew Chen
Argonne National Laboratory

Hong-Nian Jow
Sandia National Labs

Kenneth L. Swinth
Health Physics Consultant

Toshihide Ushino
Southern California Edison

Andrew Wallo III
U.S. Department of Energy

Oversight for development of this standard was provided by the N13 Administrative Committee, which had the following members:

Chair:	Tracy A. Ikenberry
Vice-Chair:	Michelle L. Johnson
Secretary/Standards Coordinator:	Nancy Johnson
Medical and Operational Health Physics Section Manager:	Glenn Sturchio
Environmental Section Manager:	J. Matthew Barnett
External Dosimetry Section Manager:	Charles A. (Gus) Potter
Instrumentation Section Manager:	Michelle Johnson (acting)
Internal Dosimetry Section Manager:	Elizabeth (Liz) M. Brackett

This standard was consensus-balloted and approved by members of the ANSI/HPS N13 Committee on December 21, 2012. At the time of balloting, the Committee had the following membership:

Chairperson	Tracy A. Ikenberry
Vice Chairperson	Michelle L. Johnson
American Association of Physicians in Medicine (AAPM)	Robert A. Phillips
American College of Occupational and Environmental Medicine	Lynne Fairbent (alt.)*
American Industrial Hygiene Association (AIHA)	Bryce Breitenstein
American Iron and Steel Institute	Ray Johnson
American Mining Congress	Anthony La Mastra
American Nuclear Insurers	Scott C. Munson
American Nuclear Society (ANS)	Bob Oliveira
Conference of Radiation Control Program Directors (CRCPD)	Ali Simpkins
Council on Ionizing Radiation Measurements and Standards (CIRMS)	Earl Fordham
Council on Radionuclides and Radiopharmaceuticals, Inc. (CORAR)	Chris Soares
Health Physics Society (HPS)	Leonard Smith
Institute of Electrical and Electronic Engineers (IEEE)	Sandy Perle
Institute of Nuclear Materials Management	Wayne Glines (alt.)
National Council on Radiation Protection and Measurements (NCRP)	Mike Unterweger
National Registry of Radiation Protection Technologists (NRRPT)	Harrison (Skip) Kerschner
Nuclear Energy Institute (NEI)	James Cassata
U.S. Department of Commerce	Dwaine Brown
U.S. Department of Energy	Ralph L. Andersen
U.S. Department of Defense	Thomas J. McGiff
U.S. Department of Homeland Security	Janna Shupe (alt.)
U.S. Environmental Protection Agency	Joel Rabovsky
U.S. Nuclear Regulatory Commission	Peter O'Connell (alt.)
U.S. Navy	Tim Mikulski
Individual members	John Cuellar (alt.)
	Don Potter
	Mike Boyd
	Donald A. Cool
	Luis A. Benevides
	Eric Darois
	Joseph P. Ring
	L. Max Scott
	Toshihide Ushino

*Alternate.

Contents

Foreward	viii
1.0 Purpose and Scope	1
1.1 Purpose.....	1
1.2 Scope	1
2.0 Definitions	1
3.0 Dose Criteria and Derived Screening Levels	3
3.1 Primary Dose Criterion.....	3
3.2 Derived Screening Levels	4
3.3 Screening Level Discussion	6
4.0 Implementation	7
4.1 Process Knowledge	7
4.2 Volume and Surface Measurements.....	8
4.3 Concentration Averaging	8
4.4 Summing Radionuclide Fractions	9
4.5 Removable Radioactivity Levels	11
4.6 Measuring Radionuclides Above Background.....	11
4.7 Instrument Selection	11
4.8 Radiological Measurements.....	11
4.9 Statistically Based Representative Measurements	14
4.10 Implementation Approach: MARSAME	14
 Annex A: IAEA Clearance Recommendations and Harmonization with This Standard	18
 Annex B: As Low As Reasonably Achievable Considerations	36
 Annex C: Comparisons with Other Guidance	39
 Annex D: References for the Annexes	44

Foreword

(This foreword is not part of American National Standard ANSI/HPS N13.12-2013.)

The need for comprehensive clearance¹ criteria for items, equipment, and facilities with surface or volume radioactive materials has been recognized for several decades. Initial attempts to develop this standard began in 1964 and were limited in scope to the consideration of radioactive materials on surfaces. Volume radioactivity, including radioactive materials dispersed throughout the material, materials activated by neutrons, and radioactive materials in soils were all beyond the scope of the initial efforts.

In 1999, the final version of this standard was formally issued. It provided both the primary dose² standard for clearance and derived screening levels for surface and volume sources of radioactivity, based on the primary dose standard. However, the 1999 version of this standard was not fully adopted by U.S. federal or state agencies because, although judgment and consensus were used in its development, the technical basis was not deemed robust enough (because the technical basis used information from the reported literature instead of conducting internally consistent scenario and pathway analysis) to warrant broad application.

During the 1980s and 1990s, exposure pathway assessment was used to support the development of new regulations or standards. Of particular note have been the efforts of the U.S. Nuclear Regulatory Commission (USNRC) to develop revised decommissioning regulations, guidance from the National Council on Radiation Protection and Measurements (NCRP) on the development and application of screening models, and the International Atomic Energy Agency (IAEA) efforts to develop clearance (formerly exemption) criteria. The intent of these efforts was to link secondary (derived) criteria with a primary dose (or risk) criterion.

Since 1999, federal and state agencies have developed proposals related to clearance. In an April 26, 2010, *Federal Register* notice the USNRC reported the status of their efforts. "The staff provided a draft proposed rule package on Controlling the Disposition of Solid Materials to the Commission on March 31, 2005, which the Commission disapproved. The Commission's decision was based on the fact that the Agency is currently faced with several high priority and complex tasks, that the current approach to review specific cases on an individual basis is fully protective of public health and safety, and that the immediate need for this rule has changed due to the shift in timing for reactor decommissioning. The Commission has deferred action on this rulemaking." The schedule for the notice of proposed rulemaking is to be determined.

Internationally, the IAEA published Safety Guide No. RS-G-1.7, "Application of the Concepts of Exclusion, Exemption and Clearance," along with Safety Report Series No. 44, "Derivation of Activity Concentration Values for Exclusion, Exemption and Clearance" (IAEA 2004, 2005). These two reports provide definitive

¹**Clearance** is the removal of items or materials that contain or *may* contain residual levels of radioactive materials within authorized practices from further radiological control. Clearance is distinct from authorized radioactive discharges. Clearance implies that the subject materials or objects were under regulatory control—exclusion and exemption do not. **Exclusion** is the designation by a regulatory authority that the magnitude or likelihood of an exposure is essentially unamenable to control through requirements of standards and such exposures are typically outside the scope of requirements or standards (e.g., exposure from ⁴⁰K in the body, from cosmic radiation at the surface of the earth, and from unmodified concentrations of radionuclides in most raw materials). **Exemption** is the designation by a regulatory authority that specified uses of radioactive materials or sources of radiation are not subject to regulatory control because the radiation risks to individuals and the collective radiological impact are sufficiently low. [Sources: Principles for the Exemption of Radiation Sources and Practices from Regulatory Control; Safety Series No. 89; 1988; and International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, 1996; International Atomic Energy Agency, Vienna.]

²Where radiation dose in this context is the total effective dose. Radiation dose, in general, is the energy deposited per unit mass. The SI unit for total effective dose is joule per kilogram, given the special name sievert (Sv). The conventional unit for total effective dose in the United States is the rem, which equals 0.01 joule per kilogram.

international recommendations for clearance of items or materials that contain levels of radioactive materials within authorized practices from further radiological control.

In response to the IAEA recommendations, the U.S. federal agencies concerned with controlling radiation exposures requested that the writing group for this standard be reformed to determine whether it would be possible to harmonize, or bring into accord, the 1999 version of this standard and the IAEA recommendations. The writing group was reformed in 2005, and this revised standard is a result of the harmonization effort. It is noted that this standard focuses only on clearance, and not on exemption and exclusion, as included in the IAEA recommendations. It is also noted that the IAEA recommendations are based on modeling that uses the dosimetric recommendations of the International Commission on Radiological Protection (ICRP) found in their publication 60 (ICRP 1991). The writing group considered using the dosimetric recommendations from the newer ICRP Publication 103 (ICRP 2007) but concluded that, lacking scenario-specific dose conversion factors, it was not possible at this time.

The purpose and scope of this standard are provided in Section 1.0 and basic definitions are provided in Section 2.0. Section 3.0 contains the basic dose criterion (in terms of the primary dose standard for clearance) and the derived screening levels (in terms of the activity per unit surface area or mass). Section 4.0 provides information useful in the implementation of this standard and covers a wide variety of topics including the role of process knowledge, instrument selection, surface versus volume measurements, summing radionuclide fractions, concentration averaging, removable radioactivity levels, radiological measurements, representative sampling and testing, and quantitative versus qualitative measurement techniques. Section 5.0 provides a discussion of records, and Section 6.0 provides the references cited in this standard. A more complete discussion of the details and technical basis for the harmonization of the previous version of this standard with the IAEA recommendations for clearance are found in Annex A. Annex B contains a discussion of as low as reasonably achievable (ALARA) considerations for clearance. A comparison of the derived screening levels with other guidance is provided in Annex C. Annex D contains informative references supporting the information in Annexes A, B, and C.

Suggestions for improvement of this standard are welcome. Send suggestions to the Health Physics Society, 1313 Dolley Madison Blvd., Suite 402, McLean, VA 22101.

Surface and Volume Radioactivity Standards for Clearance

1.0 Purpose and Scope

1.1 Purpose

This standard is intended to provide guidance for protecting human health from radiation exposure by specifying a primary radiation dose criterion and derived screening levels for the clearance of items or materials that could contain radioactive materials, in a manner consistent with the recommendations of the International Atomic Energy Agency (IAEA) on clearance.

1.2 Scope

This standard applies to the clearance of items and materials from areas controlled to protect individuals from exposure to radiation or radioactive material during or after operations. This standard establishes a primary radiation dose criterion and derived screening levels for surface and volume radioactivity for groups of radionuclides.

The following are not included in the scope of this standard:

1. naturally occurring radioactive materials (NORM) in bulk;
2. radioactive materials in or on persons, including ^{40}K in the body;
3. release of a licensed or regulated site or facility;
4. radioactive materials on or in foodstuffs;
5. release of land or soil intended for agricultural purposes;
6. clearance issues related to national defense or security;
7. process gases and liquids, including those discharged in accordance with federal or state license requirements;
8. radioactive material in transport in accordance with Department of Transportation, U.S. Nuclear Regulatory Commission (USNRC), or U.S. Department of Energy (DOE) regulations; and
9. radioactive materials at concentrations or quantities governed by regulations or exemption or exclusion.

This clearance standard is not intended as a substitute for radiological criteria for decommissioning or for intervention criteria during cleanup projects. This standard provides screening levels, which are protective of the public health, for the clearance of items or materials.

2.0 Definitions

The following basic definitions are provided to aid in the understanding and interpretation of this standard.

ALARA: The acronym means As Low As is Reasonably Achievable. ALARA is not a standard of care; it is the process through which the Optimization Principle of the radiation protection philosophy is addressed. ALARA means making every reasonable effort to maintain exposures to radiation as far below dose limits as is practical and consistent with the authorized 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 worker and public health and safety, and other societal and socioeconomic considerations.

Background: Background radiation includes both natural and anthropogenic sources. Natural background radiation sources include primordial radionuclides (i.e., radionuclides belonging to the three radioactive decay series headed by ^{238}U , ^{235}U , ^{232}Th), ^{40}K , and ^{87}Rb cosmogenic radionuclides (i.e., radionuclides produced by interactions of cosmic nucleons with target atoms in the atmosphere or in the earth including ^{14}C , ^3H , ^7Be , and ^{22}Na), and cosmic radiation (i.e., radiation from the secondary particles, mostly high-energy muons and electrons, produced by interactions of charged particles, primarily protons, from extraterrestrial sources with the Earth's atmosphere). Anthropogenic background radiation and radioactive material in the environment includes human-made or human-induced sources such as nuclear fallout from previous weapons testing or significant accidents with major geographic impacts and industrial releases such as emissions from coal-fired combustion that are dispersed to the

environment. Naturally occurring radioactive material in bulk that has been technologically enhanced is not considered background for purposes of this standard.

Clearance: The removal of items or materials that contain or *may* contain residual levels of radioactive materials within authorized practices from further radiological control for radiation protection purposes.

Committed Effective Dose: The dosimetric quantity formed by multiplying the time integral of the equivalent dose rate in a tissue or organ following an intake by the appropriate tissue weighting factor and then summing the resultant products, as defined by the International Commission on Radiological Protection (ICRP 1991).

Critical Group: A group of individuals in the population expected to receive the highest dose.

Decay Series: The decay of a radionuclide (parent) producing a decay product (progeny) that itself is radioactive and subsequently undergoes radioactive decay, producing its own decay product. This process *may* be repeated several times with each succeeding radioactive decay product undergoing radioactive decay until a stable (i.e., nonradioactive) decay product is produced. The entire sequence from the original parent radionuclide through all of the succeeding decay products to the final stable decay product is a decay series.

DQO: The acronym means Data Quality Objectives, which are an established set of qualitative and quantitative criteria, including acceptable tolerance levels, to specify the quality and quantity of data necessary to support a given decision (e.g., conformance with acceptable clearance screening levels).

Effective Dose: Formed by weighting the equivalent dose in a tissue or organ by the tissue weighting factor, w_T , and summing over the tissues or organs, as defined by the International Commission on Radiological Protection (ICRP 1991). The equivalent dose to the whole body at a depth of 1.0 cm *may* be used as the effective dose for external exposures.

Equivalent Dose: The product of the absorbed dose in a tissue or organ and the radiation weighting factor, w_R , as defined by the International Commission on Radiological Protection (ICRP 1991).

Exclusion: The designation by a regulatory authority that the magnitude or likelihood of an exposure is essentially unamenable to control through requirements of standards and such exposures are outside the scope of standards (e.g., exposure from ^{40}K in the body, from cosmic radiation at the surface of the earth, and from unmodified concentrations of radionuclides in most raw materials).

Exemption: The designation by a regulatory authority that specified uses of radioactive materials or sources of radiation are not subject to regulatory control because the radiation risks to individuals and the collective radiological impact are sufficiently low.

Ionizing Radiation: Includes alpha particles, beta particles, gamma rays, x-rays, and other particles capable of causing ionization of target materials.

May: The term *may* is used in this standard to identify elements of optional guidance potentially useful in interpreting and implementing the requirements of this standard.

MQO: The acronym means Measurement Quality Objectives, which are an established set of performance criteria for a given measurement method necessary to meet the established DQOs for a given clearance action.

Process Knowledge: A collection of facts, information, and data characterizing or describing past or current processes or practices.

Screening Level: Activity concentrations (for either surface or volume radioactivity) that are designed to determine compliance with the primary dose criterion through comparison with radiation survey results.

Shall: The word *shall* is used to identify mandatory elements of this standard needed for full implementation of the standard.

Should: The word *should* is used to identify elements of guidance in this standard. If the guidance is not followed, technical equivalency in outcome must be demonstrated in alternative manners.

Site: A licensed or regulated location that includes one or more (1) facilities designated for the use of radioactive materials or radiation generating devices or (2) radiologically controlled or restricted areas.

Surface Radioactivity: Radioactivity residing on or near the surface of items or materials that can be adequately quantified in units of activity per unit area. When an item or material (including structural components and shielding at nuclear reactors) has been exposed to neutron irradiation, or when an item or material could have cracks or interior surfaces allowing the distribution of radioactivity within the interior matrix, it is conservatively considered to be a volume source of radioactivity.

Survey: A systematic evaluation and documentation of radiological measurements with a correctly calibrated and operated instrument or instruments that meet the detection levels required by the objective of the evaluation.

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 that could 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. 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 could 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 (ANSI/HPS N13.53-2009).

Total Effective Dose (TED): The sum of the effective dose (for external exposures) and the committed effective dose (for internal exposures) from exposures during a single year.

Volume (or Volumetric) Radioactivity: Radioactive material residing in or throughout the volume of items or materials. Volume radioactivity can result from activation (e.g., through neutron irradiation) or from the penetration or absorption of radioactive materials into porous materials, cracks, or on interior surfaces within the interior matrix of items or materials. A common example is wood that has absorbed fluids containing radioactive materials.

3.0 Dose Criteria and Derived Screening Levels

The following section defines the primary (dose) and secondary screening (derived) criteria that comprise this standard.

3.1 Primary Dose Criterion

The primary criterion of this standard is to provide for public health and safety to an average member of a critical group such that the dose *shall* be limited to 10 $\mu\text{Sv/y}$ (1.0 mrem/y) TED for clearance of materials from regulatory control. When justified on a case-by-case basis, clearance *may* be permitted at higher dose levels when it can be reasonably assured that exposures to multiple sources (including those that are beyond the scope of this standard) will be maintained ALARA below established public dose limits (e.g., 1 mSv/y [100 mrem/y]) TED. Justification and application of a higher dose standard for clearance is beyond the scope of this standard.

3.2 Derived Screening Levels

Table 1 provides screening levels, above background, for the clearance of items or materials that contain surface radioactivity or items or materials that contain volume radioactivity. The screening levels *shall* apply, irrespective of future use or application of the item or material after clearance, given the exclusions noted in Section 1.2. A generic consideration of the ALARA process has been applied in the development of the derived screening levels. Based on a detailed ALARA evaluation, it *shall* be permissible to derive less-restrictive screening levels on a case-by-case basis using the primary dose criterion.

The screening levels for TENORM are equivalent to the surface and volume administrative release levels provided in Table 2-1 of ANSI/HPS N13.53-2009.

A discussion of how the screening levels in Table 1 were derived is found in Annex A. As shown in Table 1, the radionuclides have been divided into five groups based on similarity of screening levels, ranging from 0.1 to 1,000 Bq/cm² or Bq/g, depending on the group considered. Surface radioactivity screening levels, in units of Bq/cm² (or in conventional units of disintegrations per

minute per 100 cm²) were derived using a surface-to-mass conversion factor (i.e., cm²/g) of 1. This approach was verified by comparing the scenario results for surface radioactivity only against the scenario results for volume sources for representative radionuclides. For materials where this ratio is significantly different, the surface radioactivity screening levels *shall* be adjusted accordingly, as discussed in Annex A. Note that within a specific radiation protection program, the surface screening *may* be modified based on ALARA considerations or based on operational requirements to limit the amount of surface radioactivity encountered (i.e., radioactivity control requirements).

Annex B contains a discussion of ALARA considerations for clearance. Annex C contains comparisons of the screening levels with previous guidance provided by the U.S. Atomic Energy Commission (AEC) in Regulatory Guide 1.86 (USAEC 1974), and clearance levels published by the IAEA in Safety Series No. RS-G-1.7, "Application of the Concepts of Exclusion, Exemption and Clearance" (IAEA 2004) based on pathway analyses described in a companion report, Safety Report Series No. 44, "Derivation of Activity Concentration Values for Exclusion, Exemption and Clearance" (IAEA 2005).

Table 1. Screening levels for clearance^a

Radionuclide groups ^b	SI units	Conventional units	
	Surface (Bq/cm ²) Volume (Bq/g)	Surface (dpm/100 cm ²)	Volume (pCi/g)
Group 1 High-energy gamma, radium, thorium, transuranics, and mobile beta-gamma emitters: ²² Na, ⁴⁶ Sc, ⁵⁴ Mn, ⁵⁶ Co, ⁶⁰ Co, ⁶⁵ Zn, ⁹⁴ Nb, ¹⁰⁶ Ru, ^{110m} Ag, ¹²⁵ Sb, ¹²⁹ I, ¹³⁴ Cs, ¹³⁷ Cs, ¹⁵² Eu, ¹⁵⁴ Eu, ¹⁸² Ta, ²⁰⁷ Pb, ²¹⁰ Po, ²¹⁰ Pb, ²²⁶ Ra, ²²⁸ Ra, ²²⁸ Th, ²²⁹ Th, ²³⁰ Th, ²³² Th, ²³² U, ²³⁸ Pu, ²³⁹ Pu, ²⁴⁰ Pu, ²⁴² Pu, ²⁴⁴ Pu, ²⁴¹ Am, ²⁴³ Am, ²⁴⁵ Cm, ²⁴⁶ Cm, ²⁴⁷ Cm, ²⁴⁸ Cm, ²⁴⁹ Cf, ²⁵¹ Cf, ²⁵⁴ Es, and associated decay chains ^d , and others ^b	0.1	600	3
Group 2 Uranium and selected beta-gamma emitters: ¹⁴ C, ³⁶ Cl, ⁵⁹ Fe, ⁵⁷ Co, ⁵⁸ Co, ⁷⁵ Se, ⁸⁵ Sr, ⁹⁰ Sr, ⁹⁵ Zr, ⁹⁹ Tc, ¹⁰⁵ Ag, ¹⁰⁹ Cd, ¹¹³ Sn, ¹²⁴ Sb, ^{123m} Te, ¹³⁹ Ce, ¹⁴⁰ Ba, ¹⁵⁵ Eu, ¹⁶⁰ Tb, ¹⁸¹ Hf, ¹⁸⁵ Os, ¹⁹⁰ Ir, ¹⁹² Ir, ²⁰⁴ Tl, ²⁰⁶ Bi, ²³³ U, ²³⁴ U, ²³⁵ U, ²³⁸ U, natural uranium ^e , ²³⁷ Np, ²³⁶ Pu, ²⁴³ Cm, ²⁴⁴ Cm, ²⁴⁸ Cf, ²⁵⁰ Cf, ²⁵² Cf, ²⁵⁴ Cf, and associated decay chains ^d , and others ^b	1	6,000	30
Group 3 General beta-gamma emitters: ⁷ Be, ⁷⁴ As, ^{93m} Nb, ⁹³ Mo, ⁹³ Zr, ⁹⁷ Tc, ¹⁰³ Ru, ^{114m} In, ¹²⁵ Sn, ^{127m} Te, ^{129m} Te, ¹³¹ I, ¹³¹ Ba, ¹⁴⁴ Ce, ¹⁵³ Gd, ¹⁸¹ W, ²⁰³ Hg, ²⁰² Tl, ²²⁵ Ra, ²³⁰ Pa, ²³³ Pa, ²³⁶ U, ²⁴¹ Pu, ²⁴² Cm, and others ^b	10	60,000	300
Group 4 Low-energy beta-gamma emitters: ³ H, ³⁵ S, ⁴⁵ Ca, ⁵¹ Cr, ⁵³ Mn, ⁵⁹ Ni, ⁶³ Ni, ⁸⁶ Rb, ⁹¹ Y, ^{97m} Tc, ^{115m} Cd, ^{115m} In, ¹²⁵ I, ¹³⁵ Cs, ¹⁴¹ Ce, ¹⁴⁷ Nd, ¹⁷⁰ Tm, ¹⁹¹ Os, ²³⁷ Pu, ²⁴⁹ Bk, ²⁵³ Cf, and others ^b	100	600,000	3,000
Group 5 Low-energy beta emitters: ⁵⁵ Fe, ⁷³ As, ⁸⁹ Sr, ^{125m} Te, ¹⁴⁷ Pm, ¹⁵¹ Sm, ¹⁷¹ Tm, ¹⁸⁵ W, and others ^b	100 (surface) ^f 1,000 (volume)	600,000 ^f	30,000

^aThe screening levels for clearance have been rounded to one significant figure and are assigned to both surface and volume radioactivity (assuming an average surface to mass ratio of 1:1, as discussed in Annex A), unless otherwise noted. Note: regulatory authorities *may* increase all volume and surface screening levels by one order of magnitude when clearing bulk quantities of less than 1 metric ton or 1 m².

^bTo determine the specific group for radionuclides not shown, a comparison of the screening factors, by exposure scenario, listed in Tables B. 1, C. 1, and D. 1 of NCRP Report No. 1231 (NCRP 1996) for the radionuclides in question and the radionuclides in the general groups above *should* be performed and a determination of the proper group made, as described in Annex A.

^cBecause of potential ground-water concerns, the volume or surface radioactivity values for ¹²⁹I *should* be lowered by one order of magnitude when disposal to landfills or direct disposal to soil is anticipated.

^dFor decay chains, the screening levels represent the total activity (i.e., the activity of the parent plus the activity of all progeny) present.

^eThe natural uranium screening levels for clearance *shall* be lowered from Group 2 to Group 1 if decay-chain progeny are present (i.e., uranium ore versus process or separated uranium, for example, in the form of yellowcake). The natural uranium activity equals the activity from uranium isotopes (48.9% from ²³⁸U, plus 48.9% from ²³⁴U, plus 2.2% from ²³⁵U). This approach is consistent with summing radionuclide fractions discussed in Section 4.4.

^fFor radioactivity control considerations, surface radioactivity screening levels for Group 5 radionuclides are controlled to the Group 4 surface radioactivity screening levels.

3.3 Screening Level Discussion

The radionuclide groupings for the screening levels for clearance shown in Table 1 were determined based on the potential of the radionuclides in the group to deliver similar radiation doses for the pathways and scenarios evaluated by the IAEA (2004, 2005). The titles of Groups 1 through 5 were developed as a shorthand notation, which *may* not describe the radiations emitted by all of the radionuclides assigned to a particular group. For example, Group 2, uranium and selected beta gamma emitters, also contains selected transuranic radionuclides that are alpha emitters. However, all of the radionuclides in Group 2 have a similar potential to deliver 10 μ Sv (1 mrem) TED per year for the scenarios and pathways identified, independent of the type of radiation emitted.

As noted in footnote a to Table 1, the surface screening levels were derived based on a surface-to-mass ratio of 1 to 1 (cm^2/g). The surface screening levels *should* be reduced proportionally for items or materials where this ratio is greater than 1 to 1 (for items such as thin sheet metal), and increased proportionally when the ratio is less than one (for items such as heavy metal components). A discussion of surface to mass ratios is included in Annex A. Footnote a to Table 1 also provides guidance for establishing volume screening levels when small quantities are encountered, indicating that regulatory authorities *may*, with appropriate justification and scenario documentation, increase the volume screening levels by one order of magnitude when quantities are less than 1 metric ton. This statement is in recognition of the reduced ability of small quantities of cleared material to deliver radiation doses to individuals and is consistent with the guidance provided by the IAEA (2004, 2005).

As stated in Footnote b to Table 1, to determine the specific group for radionuclides not shown, a comparison of the screening factors, by exposure scenario, listed in Tables B.1, C.1, and D.1 of NCRP Report No. 1231 (NCRP 1996) for radionuclides in question and the radionuclides in the general groups *should*

be performed and a determination of the proper group made, as described in Annex A. It is recognized that the selection of reference radionuclides in the groups shown in Table 1 could influence the outcome of this process. For this reason, at most three radionuclides from the relevant groups from Table 1 for comparison *shall* be selected that (1) have similar half-lives, (2) have similar chemical properties (i.e., are from the same elemental groups on the periodic table), and (3) represent similar types of radiation. As also discussed in Annex A, the IAEA guidance (2004) incorporated derived levels for exemption and exclusion, when appropriate, in addition to clearance. This means that IAEA includes values for numerous short-lived radionuclides assuming exposure to a continuously replenishing source (such as an effluent stream from an operating facility), rather than clearance where the radioactivity associated with cleared items or materials would rapidly decrease with time. Values from the IAEA that were derived for exemption and exclusion are not included in this standard because the focus is on clearance; thus, direct use of the IAEA clearance levels *should* be done with caution. As a practical matter, *should* short-lived radionuclides be encountered, the items or material could be stored for radioactive decay prior to clearance.

As noted in footnote c to Table 1, the IAEA lowered the clearance level for ^{129}I by one order of magnitude because of its potential environmental mobility through the ground-water pathway. This is a concern when disposal of bulk materials to soil is encountered. For this reason, the surface and volume screening levels for clearance of ^{129}I -bearing items or materials *should* be lowered by one order of magnitude when bulk disposal to landfills or direct disposal to soil is anticipated. It is also noted that release of land or soil intended for agriculture is beyond the scope of this standard because this situation is associated with release of land following decommissioning or license termination activities.

Footnote d to Table 1 indicates that the screening levels for clearance for decay chains represent the total activity of the

parent plus all of the progeny present. The screening level could appropriately be derived using the sum of fractions methods outlined in Section 4.4.

For Footnote e to Table 1, because natural uranium and other radionuclides of natural origin are ubiquitous in the environment with varying concentrations, the IAEA concluded that the resulting exposures from the same radionuclides that are present from practices are often unamenable to control through the requirements of their Basic Safety Standards (IAEA 2004). The IAEA activity concentrations for clearance were determined on the basis of consideration of the worldwide distribution of activity concentrations for these radionuclides, not a dose criterion of 10 $\mu\text{Sv/y}$ (1.0 mrem/y) TED with activity concentrations derived through a scenario analysis. However, several naturally occurring radionuclides are individually included in licensed or controlled sources and screening levels for clearance are needed. The clearance screening levels for radionuclides of natural origin would be consistent with those derived for artificial (human-made) radionuclides. For this reason, individual naturally occurring radionuclides are included based on N13.12-1999 (in Group 1) and uranium radionuclides that have been separated from their decay chain progeny (in Group 2). As a result, footnote e to Table 1 indicates that the screening levels for clearance are for the uranium radionuclides only, that is, assuming that the uranium had been processed to remove non-uranium progeny. When those progeny are present in equilibrium with the uranium decay-chain parents, the screening levels *shall* be lowered by one order of magnitude to reflect the screening level that would be derived using the sum of fractions methods outlined in Section 4.4. This approach is consistent with a companion ANSI/HPS standard (N13.53-2009) and takes into consideration cases in which individual naturally occurring radionuclide decay-chain members could be in licensed or controlled materials, independent of the entire decay chain. This general guidance is applicable when decay progeny are in a more restrictive clearance screening group than the parent and is consistent with the summing radionuclide

fractions information presented in Section 4.4.

Finally, the derived surface radioactivity screening levels for Group 5 radionuclides was inconsistent with the principles of radioactivity control for operating facilities. Therefore, the surface radioactivity screening level for Group 5 radionuclides were lowered to the Group 4 surface radioactivity screening level.

4.0 Implementation

Measurement of radioactivity and the quantity of radioactive material on or in items or materials suitable for clearance *shall* be performed to verify conformance with the screening levels established in Section 3.0 of this standard. Radiological measurements performed for the purpose of clearance *shall* include direct field surveys of the item or material, laboratory analysis of representative samples of the item or material, or a combination of both, with measurement results characterizing radioactivity levels from accessible surface areas and internal volumes.

4.1 Process Knowledge

When invoked, process knowledge *shall* be documented, as is appropriate, with supporting technical information, including plans, procedures, specifications, assumptions, algorithms, definitions, expert testimony, and historical measurements. It is recognized that some degree of professional judgment is used in all situations; however, it is often most relevant to situations in which information or data are not reasonably available by collection, survey, literature search, or experimentation. Radiological measurements performed for the purpose of clearance *shall* take into consideration the following:

- a) all relevant operational history of the items or materials to identify the known or potentially present radionuclides and associated activity levels;
- b) the potential radionuclide distribution (on the surface of the item or material and/or within the volume of the item or material);

- c) the size, geometry, composition, and physical properties of the item or material;
- d) any associated radionuclides that result from radioactive decay and progeny in-growth; and
- e) the use of surrogate radionuclides in interpreting the activity of hard-to-detect radionuclides when their respective relationships are well established.

4.2 Volume and Surface Measurements

Volume measurements for clearance *shall* be used when volume radioactivity in items or materials is known or potentially present. The number and location of samples taken and analyzed *shall* be sufficient to provide reasonable confidence that they are representative for the item or material being cleared (see Section 4.9).

Volume measurements for clearance *may* be used in lieu of surface levels provided that:

- a) the size or shape of the item or material makes it unreasonable to perform radiological surveys representative of the radioactivity on all of the surfaces of the item or material;
- b) the item or material can be representatively sampled for laboratory analysis; and
- c) it can be demonstrated that the use of volume measurements for clearance is as protective as using surface measurements (e.g., the volume sampling is not used to dilute excessive surface activity to meet the clearance screening levels).

Surface screening levels *shall* be used when the size or shape of the item or material reasonably allows direct radiological surveys for surface radioactivity.

Items or materials known to have activity levels that are in excess of the clearance screening levels *should* not be:

- a) intentionally blended with lower activity material for the purpose of meeting this standard; or

- b) intentionally coated, plated, encased, or covered to reduce the apparent surface or volume radioactivity.

4.3 Concentration Averaging

Averaging is inherent to the radiological measurement process for determining both surface activity and volume activity concentrations. When performing radiological measurements of items or materials for clearance, a determination of the average radionuclide concentrations *should* be performed such that:

- a) Multiple surface measurements are averaged over an established item or material surface area not to exceed 1 m^2 , or an area already specified in applicable regulations, or an area determined by the DQO/MQO process. For items or materials with a surface area less than the established surface area for averaging measurements, an average over the entire surface *shall* be derived for each item or material. The intent is that there must be a reasonable expectation that average concentration of radioactive material is less than the applicable surface screening level over (1) the established surface area for averaging measurements for items or materials or (2) the total surface area of each item or material when that area is less than the applicable surface screening level. This does not necessarily require physical measurement of each item or material over every specified area for averaging (see Sections 4.8, 4.9, and 4.10).
- b) Multiple volume measurements are averaged over an established total volume or mass not to exceed 1 m^3 or a mass of 1 metric ton, or the volume or mass specified in applicable regulations, or the mass or volume determined by the DQO/MQO process (which could be larger than 1 m^3 or a mass of 1 metric ton). For items or materials with mass less than the established total volume or mass for averaging measurements, an average over the entire mass *shall* be derived for each item or material. The intent is that there must be reasonable confidence that the volume concentration of radionuclides in any established