PNNL-13484

Pacific Northwest National Laboratory
Operated by Battelle for the
U.S. Department of Energy

Uses of ANSI/HPS N13.12-1999 "Surface and Volume Radioactivity Standards for Clearance" and Comparison with Existing Standards

P.S. Stansbury
D.J. Strom

April 2001

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO1830

PNNL-13484

Uses of ANSI/HPS N13.12-1999, "Surface and Volume Radioactivity Standards for Clearance" and Comparison with Existing Standards

P.S. Stansbury
D.J. Strom

April 2001

PNNL Project No. 14647
DOE Project No. 01-ES-592

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Risk Analysis and Health Protection
Pacific Northwest National Laboratory
Richland, Washington 99352

Disclaimer

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Executive Summary

In August 1999, the American National Standards Institute (ANSI) approved a standard for clearance of materials contaminated with residual levels of radioactivity. "Clearance," as used in the standard, means the movement of material from the control of a regulatory agency to a use or disposition that has no further regulatory controls of any kind. The standard gives derived screening levels (*DSL*s) in Bq/g and Bq/cm^2 for 50 radionuclides. Items or materials with residual surface and volume radioactivity levels below the *DSL*s can be cleared, that is, managed, without regard to their residual radioactivity.

Since federal agencies are to use voluntary industry standards developed by the private sector whenever possible, the standard should play an important role in the U.S. Department of Energy's (DOE's) regulatory process. The thrust of this report is to explain the standard, make observations on its usefulness to DOE, and explore uses of the standard within DOE facilities beyond the clearance of radioactive materials.

The standard identifies a primary dose criterion of 10 μSv/y (1 mrem/y) total effective dose equivalent (TEDE) above background. Using this criterion, the standard assigns 50 radionuclides to one of four groups, 0.1, 1, 10, or 100 Bq/g and Bq/cm^2 for volume and surface *DSL*s, respectively. The grouping is done on the basis of conservative, but not worst-case, scenarios and with consideration of detectability and the "as low as reasonably achievable" (ALARA) principle. The *DSL*s are also presented in the traditional units of pCi/g and dpm/100 cm^2, rounded off to one significant figure.

It would be reasonable, prudent, and cost-effective for DOE to replace the values currently in Appendix D of 10 CFR 835, "Occupational Radiation Protection," and in Figure IV-1 in DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, with the *DSL*s in ANSI/HPS N13.12-1999. This action would ensure consistency between the operational and environmental radiation protection programs operated throughout DOE.

The standard identifies a primary dose criterion of 10 μSv/y (1 mrem/y) TEDE above background. This value is not an absolute limit. The standard permits clearance of materials at a higher levels, justified on a case-by-case basis, when it can be ensured that exposures to multiple sources will be maintained ALARA and will provide an adequate margin of safety below the public does limit of 1 mSv/y (100 mrem/y) TEDE.

The DOE sets the same primary dose limit of 1 mSv/y (100 mrem/y) for a member of the general public in many of its regulations. Thus, in using the *DSL*s in the standard for clearance or the other potential uses, DOE would have the flexibility to choose a different dose criterion, providing it could show that such level was consistent with the ALARA principle and would not lead to combined doses from multiple sources in excess of the DOE public dose limit. For example, a dose criterion of 250 μSv/y (25 mrem/y) would lead to a 25-Bq/g group containing all of the radionuclides in the 1-Bq/g group in the standard.

Potential benefits from using the ANSI N13.12-1999 standard in occupational radiation protection include:

- use of a single surface contamination limit rather than separate limits for removable and total contamination as done today - The *DSL*s are less restrictive than the current total contamination limits, for all nuclides of significance to DOE operations and cleanup. They are much less restrictive than the current removable contamination limits.

- “down-posting” of some current High Contamination Areas and “de-posting” of some current Contamination Areas, reducing the footprint of areas that must be managed as Controlled Areas - Using the *DSL*s in place of current values would have a remarkably beneficial impact on research laboratories where common biomedical tracers are used.

- “field counting” of transuranic and ^{90}Sr smear samples, expediting operational decisions based on survey results, thus saving time and money - In addition, “field counting” of smear samples would reduce the workload of counting laboratories

Potential benefits from using the ANSI N13.12-1999 standard in environmental radiation protection include:

- using the standard as a basis for defining “solid effluents,” integrating the clearance process into the menu of options that the DOE has for managing its environmental cleanup and research missions - For two waste streams, metals and hazardous waste contaminated with radionuclides, DOE’s current policy is based on “detectability” as the primary criterion. Using the risk-based consensus standard ANSI N13.12 could give the DOE a credible and valid basis for changing its current policy on these two important waste streams.

- releasing, for ordinary disposal, materials with trace amounts of contamination throughout their volume - ANSI N13.12-1999 provides a technical basis for treating materials with trace amounts of radioactive contamination throughout their volume as ordinary waste. Such a practice would help in the disposal of slightly contaminated soils and rubble from cleanup operations. It would also do much to make DOE national laboratories using tracer radionuclides for biomedical research more productive and cost-competitive.

Acknowledgments

The authors gratefully acknowledge the help of William E. Kennedy, Jr., chairman and long-time member of the working group that prepared the ANSI/HPS N13.12-1999 standard. We believe his sharing of the history and philosophy behind the standard led us to a more cogent report. We also acknowledge the foresight of Jerome B. Martin, who identified the need for this report and initiated the project to prepare it, and the thoughtful review by Dr. Joel L. Rabovsky of the Office of Worker Protection Policy, whose comments increased the usefulness of the document to DOE and its contractors. The authors also acknowledge the help of James R. Weber, technical editor, in improving this document as we finalized it and Rose M. Watt, document designer, in preparing the final document.

Contents

Executive Summary iii

Acknowledgments v

1 Introduction 1

2 Synopsis of the ANSI/HPS N13.12-1999 Standard in the Context of Related Documents 2
  2.1 Purpose and Scope 2
  2.2 Definitions 2
  2.3 Dose Criteria and Derived Screening Levels 4
  2.4 Implementation 5
  2.5 Records 5
  2.6 References 6

3 Examination of the Derived Screening Levels for Radionuclides 7

4 Potential Uses of the ANSI Clearance Standard 14
  4.1 Derived Screening Levels Scalable to Other Dose Criteria 14
  4.2 Direct Use in the Recycling and Disposal of Radioactively Contaminated Materials or Wastes at Cleanup Sites 15
  4.3 Disposal of Biomedical and Similar Research Laboratory Wastes 15
  4.4 Use of the ANSI Screening Levels for Designating Contamination Areas 16
  4.5 Decreasing the Number and Frequency of Measurements of Surface Contamination in Workplace Environments 18
  4.6 Reduce or Eliminate the Need to Count Smears in a Counting Laboratory 18

5 ANSI Standard as a Technical Basis for “Solid Effluents” 19

6 Conclusions and Recommendations 20
  6.1 Conclusions and Recommendations Relevant to Both Occupational and Environmental Radiation Protection 20
  6.2 Conclusions and Recommendations Relevant to Occupational Radiation Protection 21
  6.3 Conclusions and Recommendations Relevant to Environmental Radiation Protection 21

7 References 22

Figures

1 Entry to, Exit from, and Bypass of Regulation of Sources of Radiation Exposure 2
2 Comparison of 0.1 Bq/g or Bq/cm^2 Group – Shaded area is IAEA-recommended range and slim black line is Regulatory Guide 1.86 value. 8
3 Comparison of 1 Bq/g or Bq/cm^2 Group – Shaded area is IAEA-recommended range and slim black line is Regulatory Guide 1.86 value. 8
4 Comparison of 10 Bq/g or Bq/cm^2 Group – Shaded area is IAEA-recommended range and slim black line is Regulatory Guide 1.86 value. 9
5 Comparison of 100 Bq/g or Bq/cm^2 Group – Shaded area is IAEA-recommended range and slim black line is Regulatory Guide 1.86 value. 9
6 Distribution of Ratios of ANSI Screening Levels to 10 CFR 835 Appendix D Total Surface Contamination Limits 10
7 Ratio of ANSI Screening Levels to 10 CFR 835 Removable Contamination Limits 11
8 Ratio of ANSI Screening Level to DAC for 10 and 100 Groups 12
9 Ratio of ANSI Screening Level to DAC for 0.1 and 1 Groups 12

1 Introduction

In August 1999, the American National Standards Institute (ANSI) approved ANSI/HPS N13.12-1999*, Surface and Volume Radioactivity Standards for Clearance* (ANSI 1999; referred to here as "ANSI N13.12" or "the standard"). Publishing this standard culminated an effort begun in 1964.

The stated purpose of the standard is

> to provide guidance for protecting the public and the environment from radiation exposure by specifying a primary radiation dose criterion and derived screening levels for the clearance of items that could contain radioactive material.

The standard is a voluntary consensus standard developed by the ANSI-Accredited HPS N13 Committee. ANSI has designated the Health Physics Society (HPS) as the secretariat for this standards committee. At the time the standard was approved, the committee consisted of representatives of 22 organizations and 7 individual members. The organizations represented included:

- seven government agencies, including the U.S. Department of Energy (DOE) and the U.S. Nuclear Regulatory Commission (NRC)
- two labor organizations
- the American Chemical Society, the American Industrial Hygiene Association, the Health Physics Society, the American College of Occupational and Environmental Medicine, other professional societies, and
- groups representing the mining, manufacturing, electronics, and nuclear industries.

The objectives of this report are a) to identify potential uses for the standard above and beyond those in the standard itself and b) to make recommendations concerning these potential uses. To achieve this objective, this report

- provides a synopsis of the standard in the context of other guidance on release of contaminated items and materials
- discusses *clearance* of sources from regulation
- compares and contrasts the standard's screening values for over 50 radionuclides with those of other guidance and standards
- presents various uses of the standard DOE may wish to consider above and beyond the use implied by the standard's title, and
- provides conclusions and recommendations based on the findings of the report.

2 Synopsis of the ANSI/HPS N13.12-1999 Standard in the Context of Related Documents

The standard consists of 8 pages of text plus 47 pages of appendices that include 3 pages of normative references and 8 pages of informative references as well as some 14 pages of tables. The standard itself consists of 6 sections: purpose and scope, definitions, dose criteria and derived screening levels, implementation, records, and cited references. Each of these sections is discussed below, with explanatory background from other documents to cover gaps and implicit knowledge in the standard.

2.1 Purpose and Scope

The scope of the standard excludes naturally occurring radioactive material, radioactive material on or in foodstuffs, process gasses and liquids (effluents, presumably), release of land or soil intended for agricultural purposes, and release of licensed or regulated sites or facilities for unrestricted use.

2.2 Definitions

This section of the standard defines concepts needed to understand the scope of the standard, some of which do not appear in the standard. To understand *clearance*, one must consider entry of radioactive materials into the regulatory arena, exit of radioactive materials from the regulatory arena, and bypass of the regulatory arena (Figure 1).

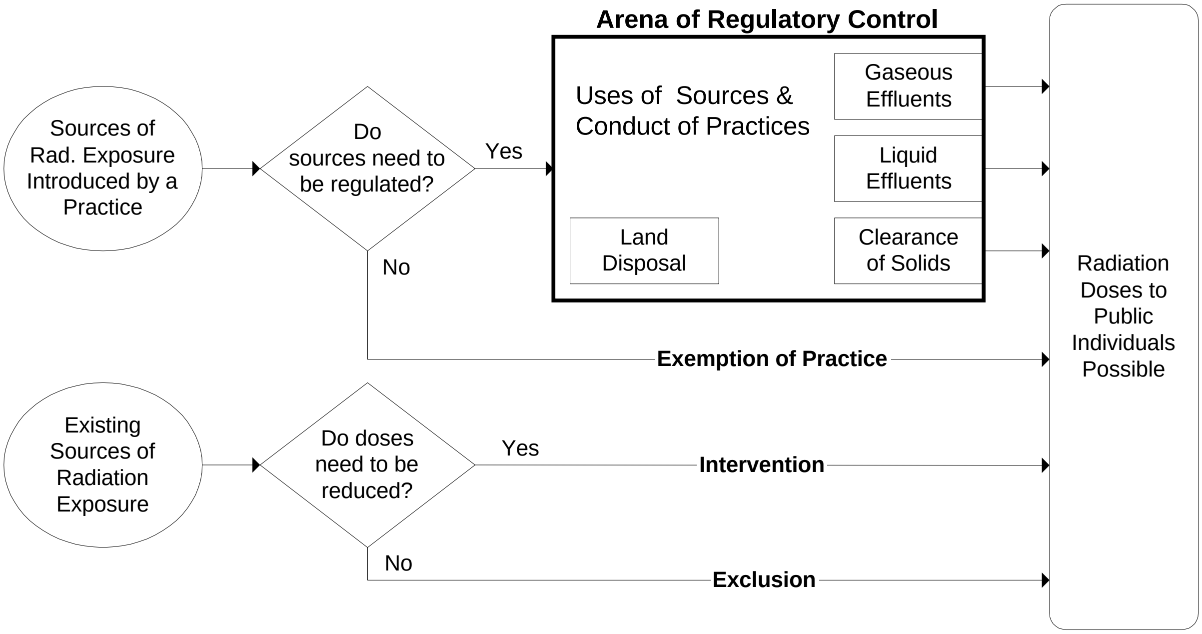

Figure 1. Entry to, Exit from, and Bypass of Regulation of Sources of Radiation Exposure

Terms such as "exemption" and "exclusion," used in Figure 1 and discussed below, have very specific connotations in the context of the ANSI Standard. Such terms may have different meanings when used in 10 CFR 820 "Procedural Rules for DOE Nuclear Activities," in 10 CFR 835, "Occupational Radiation Protection," and in other regulations. "Background radiation" as used in the standard has a meaning slightly different from the definition in 10 CFR 835.

Clearance is defined in the standard as "the removal of items or materials that contain residual levels of radioactive materials within authorized practices from any further [regulatory] control of any kind."

Although not defined in the standard, it is important to understand the notion of a *practice* as introduced by the International Commission on Radiological Protection (ICRP) and subsequently modified. According to the International Atomic Energy Agency (IAEA), a *practice* is

> any human activity that introduces additional sources of exposure or exposure pathways or extends exposure to additional people or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed (IAEA 1996b).

Examples of practices include production of electricity with nuclear energy, medical diagnosis using x rays, and use of radionuclide sources in smoke detectors.

Exclusion is defined in the standard as "the designation by a regulatory authority that the magnitude or likelihood of an exposure is essentially unamenable to control...." The examples given are cosmic radiation at the earth's surface, exposure from ^{40}K in the body, and natural radionuclides in 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."

One can think of the collection of all U.S. laws and regulations as an "arena of regulatory control," represented by the black rectangle in Figure 1. Thus, *excluded exposures* are those exposures that are never in the regulatory sphere, such as cosmic ray exposure to people on the surface.

Exempted practices are those that could be regulated, but the regulatory authorities choose not to do so, such as not controlling the uranium in dental porcelain after dentures are manufactured.

Cleared materials are those that move from being regulated to being unregulated. An example is NRC licensees disposing of radionuclides in the sanitary sewer as permitted under 10 CFR 20.

Background is defined in the standard as "natural radiation or radioactive material in the environment," but not including "naturally occurring radioactive material that has been technologically enhanced."

2.3 Dose Criteria and Derived Screening Levels

The standard's primary dose criterion is 10 µSv/y (1 mrem/y) total effective dose equivalent (TEDE) above background. Annex A to the standard, an "informative" section, reviews U.S. regulations and international guidance and discusses the rationale for the primary dose criterion. The strongest points in favor of this dose level are that 1) it is in the range of 10 to 100 µSv/y (1 to 10 mrem/y) given by the IAEA as a "level of trivial effective dose equivalent" (IAEA 1988) and 2) it is the same as the National Council on Radiological Protection and Measurements (NCRP) value for a "negligible individual dose" (NCRP 1993). A major disadvantage for the 10 µSv/y (1 mrem/y) level is detectability. For some radionuclides, the surface and volume concentrations that correspond to the dose level are not measurable with field instruments.

The standard does state that it is allowable for higher TEDEs to be used in the clearance of materials from regulatory control, justified on a case-by-case basis, when it can be ensured that exposures to multiple sources (including those that are beyond the scope of this standard)

- will be maintained as low as reasonably achievable (ALARA) and
- will provide an adequate margin of safety below the public dose limit of 1 mSv/y (100 mrem/y) TEDE.

Derived screening levels (*DSL*s) are surface or volume concentrations that correspond to the primary dose criterion, linked to it by considering one or more exposure models. Annex B (also "Informative") describes the models considered in deriving the screening levels. For both the surface and volume cases, three pathways were considered: exposure to sources of penetrating radiation external to the body, inhalation of radioactive materials, and ingestion of the radioactive materials. The standard notes that in deriving worst-case scenarios, other exposure pathways could be significant. However, it was judged that such scenarios are not needed to "provide reasonable assurance that the primary dose criterion will be met" and are not part of the modeling for the standard.

For establishing the derived screening level with respect to volume contamination, the working group for the standard developed a building remodeling scenario for 50 radionuclides in a manner consistent with IAEA studies in this area (IAEA 1987). The group also reviewed the results of previous studies and modeling. In particular, a screening model developed by the NCRP, two previous studies done for DOE, one for the U.S. Environmental Protection Agency (EPA), and one for the NRC, were examined for volume concentration limits.

For surface contamination levels, the group developed a model similar to that developed by the IAEA in 1987 and found a published study that had surface contamination limits for the reuse of tools and equipment.

In calculating the effective dose equivalent via inhalation and ingestion, the group assumed that all surface contamination was removable. Thus, there is no need for separate "removable" and "fixed plus removable" *DSL*s in the standard.

For each radionuclide, the working group examined the range of results of modeling and used "professional judgment" to assign each into one of four groups. The groups used were 0.1, 1, 10, and

100 Bq/g or Bq/cm^2, that is, using the same numerical value for both the surface and volume screening levels when expressed in these units. If screening levels for the low-energy beta-emitters had been based on dose alone, there would need to be a group with a much larger screening level. However, the working group judged that contamination control considerations justified including these radionuclides in the 100 Bq/g or Bq/cm^2 group.

Further, the working group considered detectability of the screening levels and concluded that "with a careful selection of alpha and gamma spectrometry instruments, it should be possible to attain minimum detectable activity lower than the screening level for most groups of radionuclides identified in this standard." This conclusion is based on calculations of a 10-minute gamma spectrometry count of a liter of water with a high-purity germanium (HPGe) detector, a 1,000-minute count for alpha spectroscopy, a 10-minute count for liquid scintillation of a smear, and a 1-minute count of smear for gammas with an HPGe detector. The HPGe detector modeled has 60% efficiency for ^{60}Co relative to a 3×3 in. NaI(Tl) detector.

The working group then converted the surface and volume screening levels in Bq/cm^2 and Bq/g to dpm/100 cm^2 and pCi/g, respectively. Unfortunately, the standard rounds the values for traditional units, so that values in the old units would read "3" when the un-rounded value is 2.7027. Thus, ANSI/HPS N13.12 does not specify unique values for surface and volume contamination.

2.4 Implementation

In this section, the standard gives guidance on issues related to measurements needed to demonstrate compliance with the standard:

- the importance of using process knowledge in planning for the measurements
- criteria for use in the selection of instruments and methods to perform the measurements
- the use of volumetric measurements in lieu of surface measurements
- criteria for averaging surface or volume measurements
- a sum of fractions method when more than one radionuclide or chain of radionuclides is present - Progeny with a half-life that is short compared to the parent do not need to be considered in the sum of fractions. For decay chains, the screening levels are for the total activity present.
- considerations for ensuring that sampling is representative when 100% sampling is unreasonable
- considerations for using scanning measurements as opposed to direct measurements.

2.5 Records

This short section gives the requirements for records above and beyond those in ANSI N13.6-1989, *Practice for Occupational Radiation Exposure Records Systems* (ANSI 1989):

- description of the items surveyed

- survey results, date, and identity of the person who performed the survey, and

- archived procedures or other records that specify pertinent details about how the measurements were made, such as personnel training, operating instructions, and calibration details.

2.6 References

There is a short list of references cited in the standard itself. In addition, there is a complete Annex C that is an extensive list of "normative and informative" references for Annexes A and B. The normative references are those actually cited in one of the annexes. The informative references are a bibliography of material related to contamination and related subjects.

3 Examination of the Derived Screening Levels for Radionuclides

The screening levels for the 50 radionuclides listed in the standard can be viewed in several different ways. Figures 2 through 5 show levels from other sources for groups of radionuclides corresponding to the standard's screening levels of 0.1, 1, 10, and 100 Bq/g or Bq/cm^2, respectively. In each figure, the heavy black line shows the standard's level for each group for comparison with the range of clearance levels given by the IAEA (1996a) and the values given in Regulatory Guide 1.86 (USAEC 1974). The order of the radionuclides in each graph was chosen to correspond with the lower end of the IAEA range to minimize the "sawtooth" appearance.

The 0.1-Bq/g or Bq/cm^2 group (Figure 2) includes the alpha-emitting nuclides except the uranium isotopes. The ANSI screening levels are generally at the low end of the IAEA-recommended range but above the Regulatory Guide 1.86 values.

The 1-Bq/g or Bq/cm^2 group (Figure 3) includes the natural isotopes of uranium and, generally, radionuclides that emit energetic betas or gammas. For most of the nuclides in this group, the ANSI screening levels are in line with the Regulatory Guide 1.86 values and at the high end of the IAEA range.

For the 10- Bq/g or Bq/cm^2 group (Figure 4), all screening levels are at least a factor 10 larger than the Regulatory Guide 1.86 values and are in or below the IAEA range. Note that the ANSI standard level is 600 times greater than the Regulatory Guide 1.86 level for ^{241}Pu and ^{129}I. Plutonium-241 emits a weak beta (21 keV) and its 14.4-y half-life allows for significant decay over the 50-y period for which the committed effective dose equivalent is calculated. Although it has a long half-life (16 million years), ^{129}I emits a beta of modest energy (150 keV).

The 100-Bq/g or Bq/cm^2 group shows the greatest difference between the ANSI screening levels and the Regulatory Guide 1.86 values. All of the ANSI values are two orders of magnitude less restrictive. Over half of the ANSI screening levels lie outside the IAEA range.

Another way of looking at the ANSI screening levels is to compare them with the values in Appendix D of 10 CFR 835 (Figures 6 and 7). Figure 6 is a histogram of the distribution of ratios of screening levels in the standard to total surface contamination values in Appendix D of 10 CFR 835. Figure 7 shows the ratios themselves in bar graph format. DOE facilities use Appendix D to identify and post Contamination and High Contamination Areas.

The Appendix D values are the same as those in Regulatory Guide 1.86 with one exception: The Appendix D "total contamination" limit for the group that contains the transuranic radionuclides and other radionuclides is 0.0833 Bq/cm^2 (500 dpm/cm^2), five times the value for the corresponding group in Regulatory Guide 1.86. Therefore, the ANSI screening level of 0.1 Bq/cm^2 is almost no change.

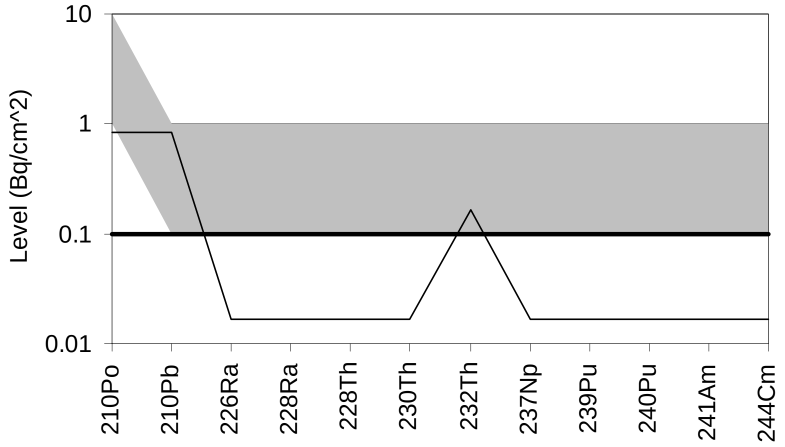

Figure 2. Comparison of 0.1 Bq/g or Bq/cm^2 Group – Shaded area is IAEA-recommended range and slim black line is Regulatory Guide 1.86 value.

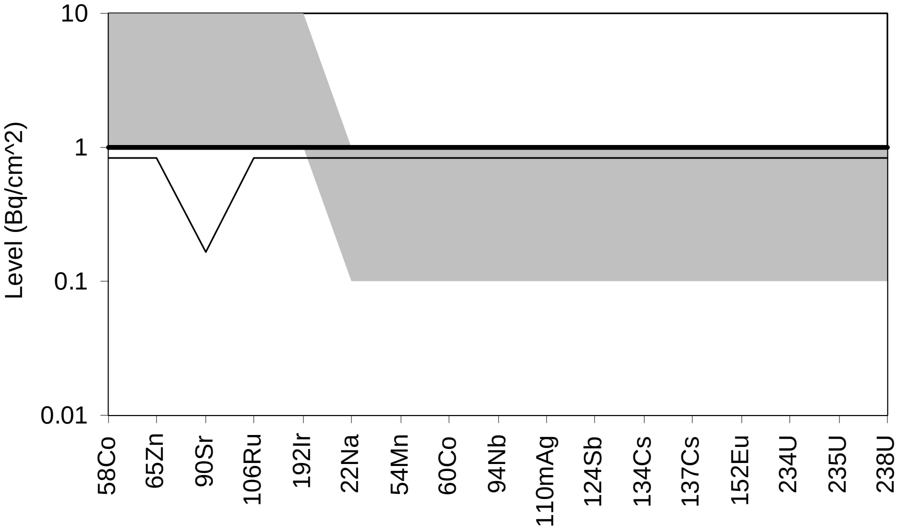

Figure 3. Comparison of 1 Bq/g or Bq/cm^2 Group – Shaded area is IAEA-recommended range and slim black line is Regulatory Guide 1.86 value.

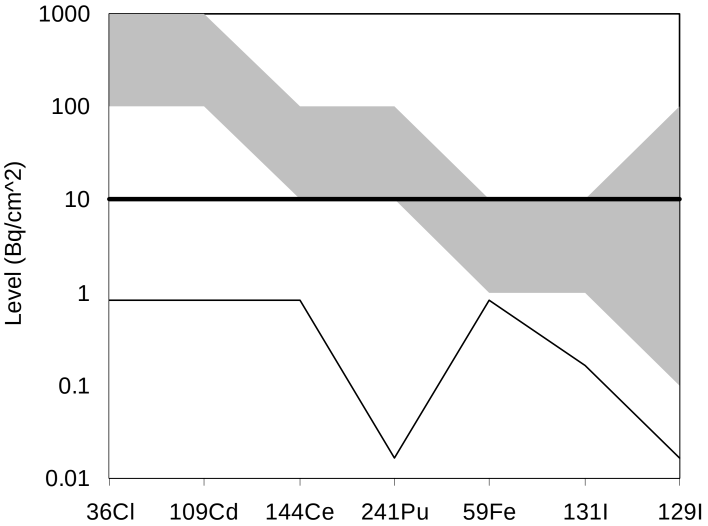

Figure 4. Comparison of 10 Bq/g or Bq/cm^2 Group – Shaded area is IAEA-recommended range and slim black line is Regulatory Guide 1.86 value.

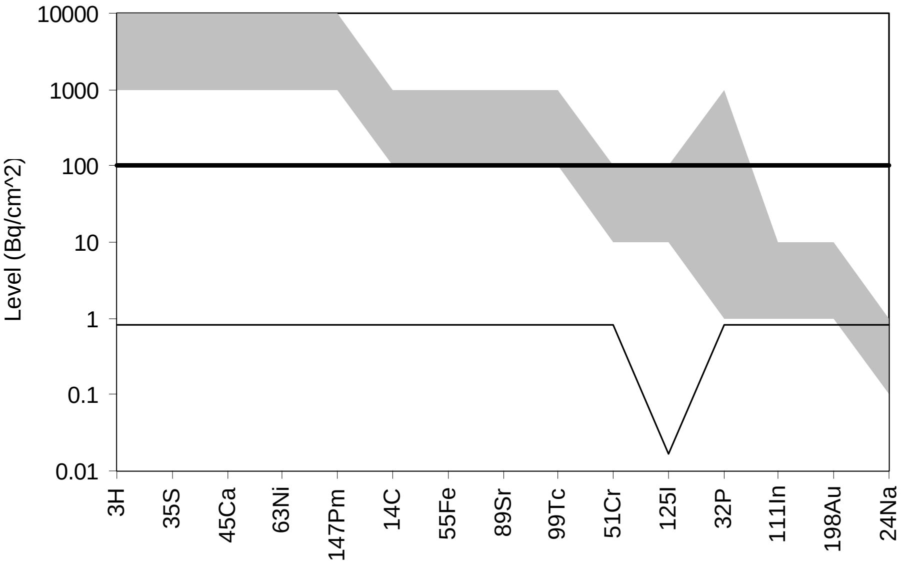

Figure 5. Comparison of 100 Bq/g or Bq/cm^2 Group – Shaded area is IAEA-recommended range and slim black line is Regulatory Guide 1.86 value.

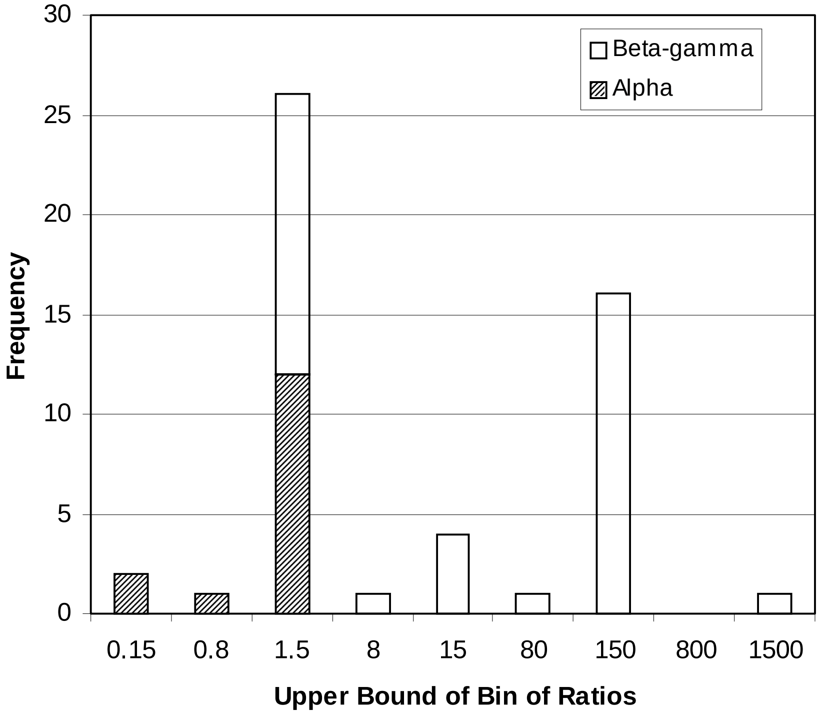

Figure 6. Distribution of Ratios of ANSI Screening Levels to 10 CFR 835, Appendix D, Total Surface Contamination Limits

Some DOE sites could, or do, use a labor-saving alternative to smearing items and workplace surfaces to measure removable contamination. The alternative is to measure all contamination with a 100-cm^2 probe and then compare the results with the removable contamination value. Such a practice would work well at sites with little contamination and would save the labor of collecting the smear sample, taking it to a counting laboratory, and delaying completion of the survey form until the lab results are returned. For a site using or considering this practice, the ANSI screening levels would be significantly less restrictive, as shown in Figures 6 and 7.

Figures 8 and 9 show the ratio of the ANSI screening level to the most restrictive derived air concentration (*DAC*) for the radionuclides. The purpose of these plots is to examine the uniformity of the balancing of hazard and control, within and among the ANSI radionuclide groups. The ratio has units of meters, but there is no physical significance to this fact of dimensional analysis.

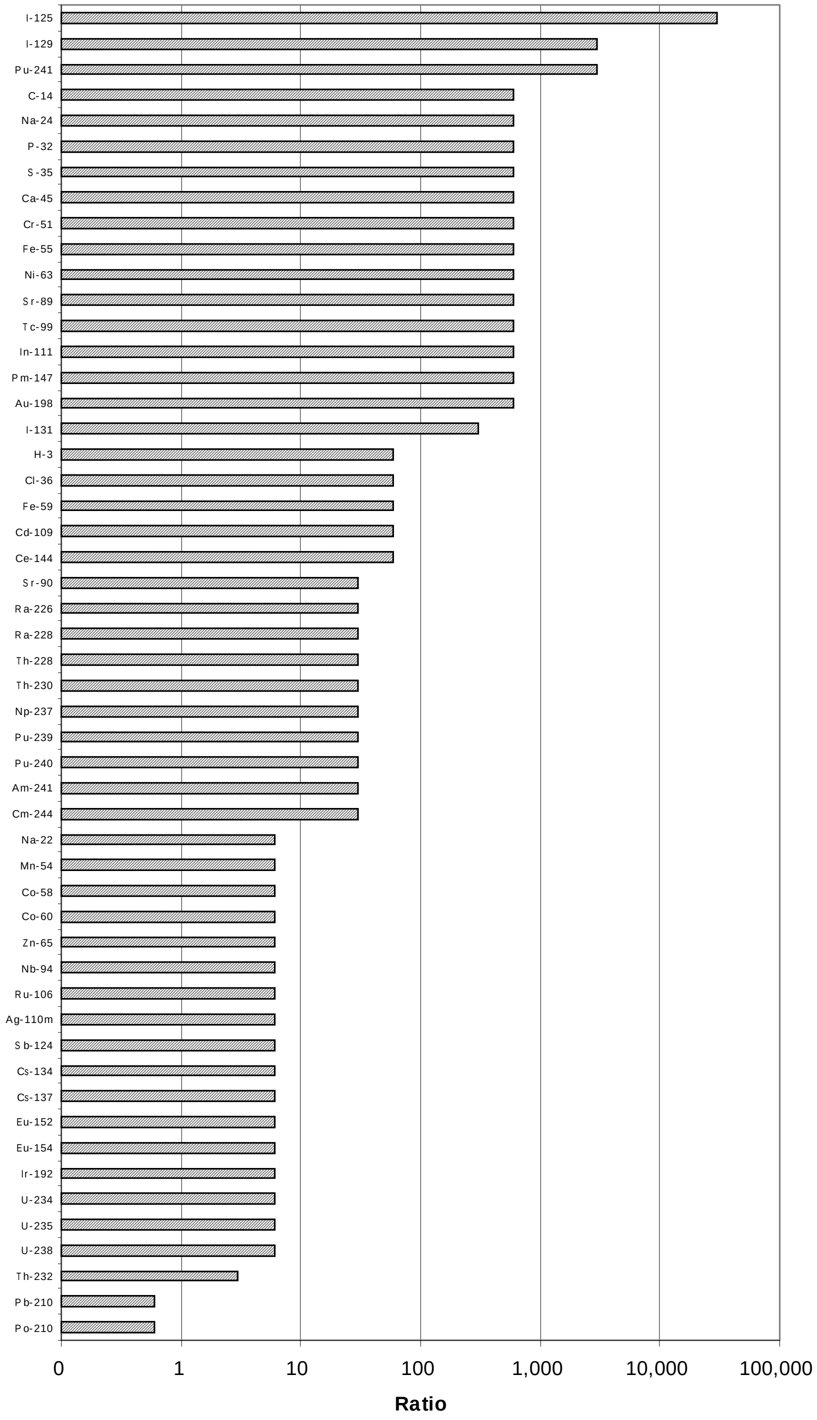

Figure 7. Ratio of ANSI Screening Levels to 10 CFR 835 Removable Contamination Limits

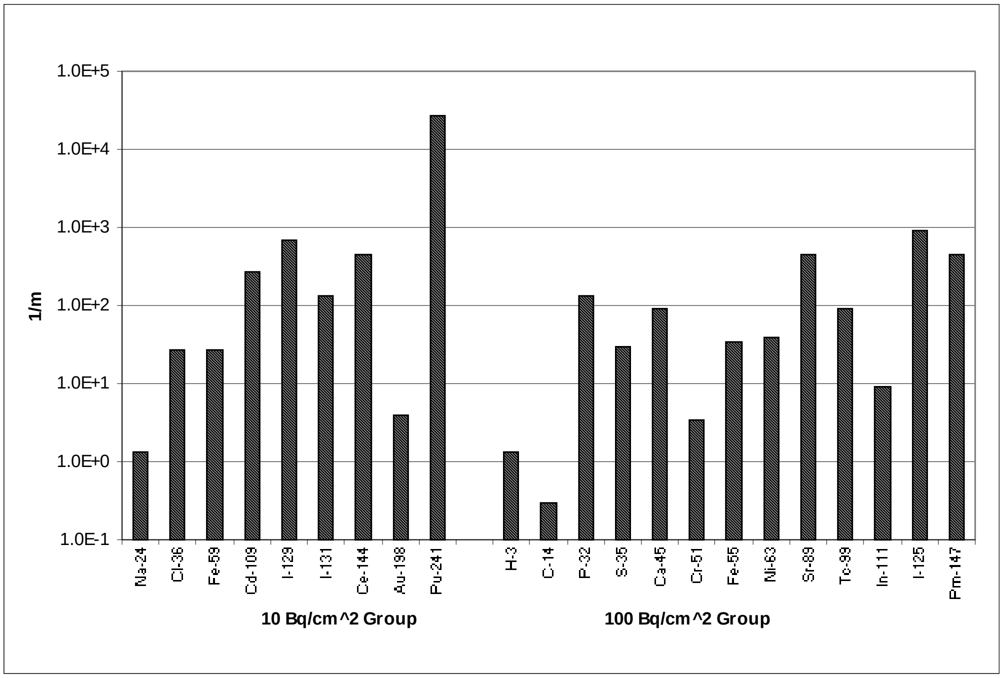

Figure 8. Ratio of ANSI Screening Level to DAC for 10 and 100 Bq/cm^2 Groups

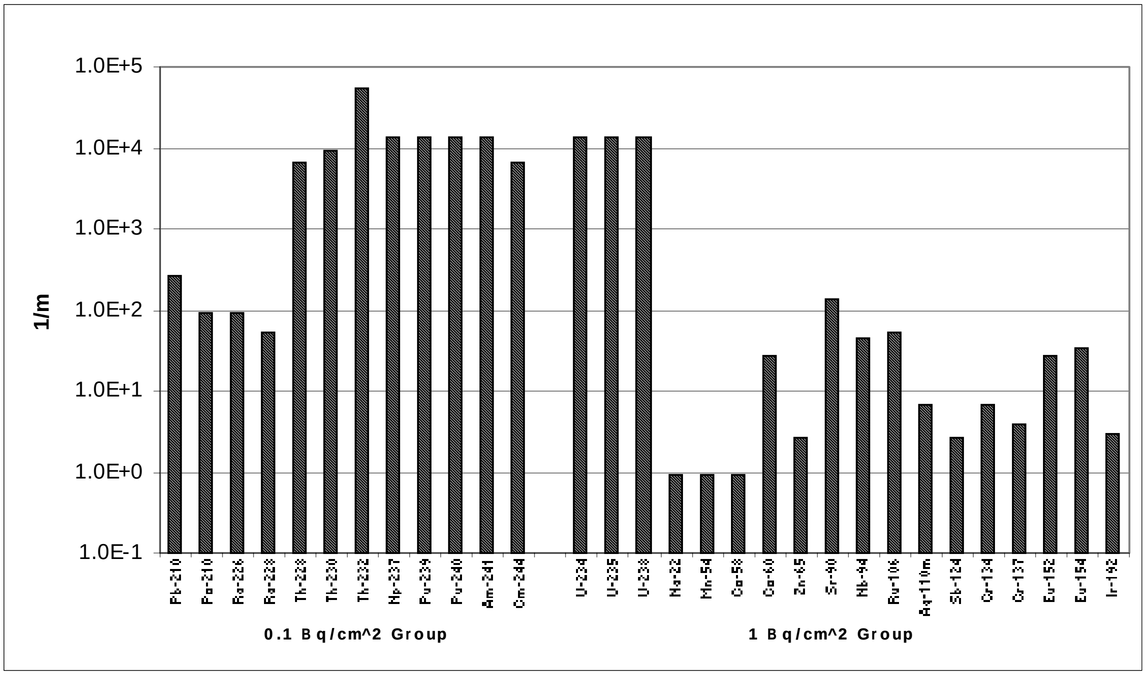

Figure 9. Ratio of ANSI Screening Level to DAC for 0.1 and 1 Bq/cm^2 Groups

The ANSI screening level, *S*, is inversely proportional to the amount of control recommended for the radionuclide:

$$S \propto \frac{1}{amount\,of\ control} \tag{1}$$

The *DAC* is inversely proportional to the intake hazard of a radionuclide, to a first approximation:

$$DAC \propto \frac{1}{hazard} \tag{2}$$

The ratio of *S* to *DAC* is, therefore, one representation of the ratio of hazard to the amount of control recommended implicitly for the radionuclide:

$$\frac{S}{DAC} \propto \frac{hazard}{amount\,of\ control} \tag{3}$$

The hazard-to-control ratios, *S/DAC*, for all of the radionuclides to the right of uranium in Figure 9 and in most of Figure 8 tend to be lower than the ratios for the thorium, uranium, and transuranium radionuclides. This pattern suggests that the control needs, implied by the value of the screening levels, are greater for the thorium, uranium, and transuranium radionuclides than if based solely on the hazard implied by the *DAC*. With the exception of ^{3}H and ^{14}C, small *S/DAC* ratios are characteristic of hard gamma-emitting radionuclides, for which contamination levels are limited by external irradiation levels. Also, the figures show three orders of magnitude of spread in *S/DAC* among the radionuclides in the groups above the 0.1-Bq group. An alternative interpretation to the hazard-to-control ratios in Figures 8 and 9 is that the ratios are correct for uranium, thorium, and the transuranic radionuclides, but the other radionuclides are “under-controlled.”

4 Potential Uses of the ANSI Clearance Standard

There are several potential uses for ANSI/HPS N13.12-1999. The DOE may wish to consider

- direct use of standard values in disposal and recycling of radioactively contaminated materials or wastes at cleanup sites
- application of standard values to biomedical and similar research laboratory wastes
- use of standard values for posting and controlling contamination areas
- application of standard values to decrease the number and frequency of measurements of surface contamination in workplace environments
- use of standard values to reduce or eliminate the need to count smears in a counting laboratory.

Requirements for the first two potential uses are codified in DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE 1993). Requirements for the last three potential uses are found in 10 CFR 835, "Occupational Radiation Protection." As the potential uses of HPS/ANSI N13.12-1999 are discussed below, modifications of, or actions under, the appropriate set of requirements are discussed.

4.1 Derived Screening Levels Scalable to Other Dose Criteria

The standard identifies a primary dose criterion of 10 μSv/y (1 mrem/y) TEDE above background. This value is not an absolute limit. The standard permits clearance of materials at higher levels, justified on a case-by-case basis, when it can be ensured that exposures to multiple sources will be maintained ALARA and will provide an adequate margin of safety below the public dose limit of 1 mSv/y (100 mrem/y) TEDE.

In Order 5400.5, DOE, sets the same primary dose limit, that is, 1 mSv/y (100 mrem/y), for a member of the general public. Chapter IV of the Order provides for guidelines for concentrations of radioactivity in soil and surface contamination based on existing radiation protection standards or on the primary dose limit. The same dose limit, 1 mSv/y (100 mrem/y), is used in 10 CFR 835 as the limit for members of the general public entering a controlled area, the dose limit for minors, and the threshold requiring appropriate personnel dosimetry for general workers. Thus, in using the *DSL*s in the standard for clearance or the other potential uses, DOE would have the flexibility to choose a different dose criterion, providing it could show that such level was consistent with the ALARA principle and would not lead to combined doses from multiple sources in excess of the applicable DOE dose limit. For example, a dose criterion of 250 μSv/y (25 mrem/y) would lead to a 25-Bq/g group containing all of the radionuclides in the 1-Bq/g group in the standard.

DOE Order 5400.5 also allows establishing authorized limits and supplemental limits under the primary dose limit. Authorized limits are developed by project offices in the field and are based on health, safety, practical, programmatic, and socioeconomic considerations. Authorized limits are approved by the appropriate Headquarters Program Office. DOE field offices may establish supplemental limits when “the established limits do not provide adequate protection or *are unnecessarily restrictive and costly*” (emphasis added).

In considering the use of the *DSL*s at the recommended or alternatively chosen dose level, the exact nature of the standard’s dose criterion is important. The standard establishes the dose criterion for an average member of a critical group. Thus, a dose to a single individual (real or hypothetical) approaching or even exceeding the dose criterion is not necessarily a violation of the standard.

4.2 Direct Use in the Recycling and Disposal of Radioactively Contaminated Materials or Wastes at Cleanup Sites

The values of the *DSL*s could be incorporated into DOE Order 5400.5, replacing the values in Chapter IV, notably the Surface Contamination Guidelines in Figure IV-1, and expanding their use to apply to volume contamination as well. DOE issued significant interim guidance in 1995, expanding the isotopes addressed in Figure IV-1 (DOE 1995). Alternatively, the standard could be used as the basis for justifying and establishing authorized limits or supplemental limits. Since the occupancy and renovation scenarios used to establish the *DSL*s are consistent with the Order 5400.5 expectations of “worst case plausible use” scenarios, use of the *DSL*s should require no additional formal documentation establishing their technical basis. Annexes A and B to the standard are robust and self-explanatory.

Use of the standard’s *DSL*s associated with the 10 µSv/y (1 mrem/y) dose criterion will have only modest benefit in cleaning up former production sites. For cleanup, the uranium isotopes, the transuranic radionuclides, and ^{90}Sr and ^{137}Cs are important. As Figures 2 and 3 show, the *DSL*s are only six times less restrictive for plutonium, the other transuranic radionuclides, and ^{90}Sr. The *DSL*s for ^{137}Cs and the uranium isotopes are almost unchanged. However, use of the standard would provide risk-based volume contamination standards. Furthermore, if a higher dose criterion, such as 100 µSv/y (10 mrem/y) or 250 µSv/y (25 mrem/y), were used, the benefits of using the standard could be substantial.

DOE has adopted a policy on acceptable levels of radionuclides in hazardous waste and is considering establishing a policy on acceptable levels of contamination on metals released from DOE facilities for recycle at commercial facilities. In neither of these cases are release levels based on DOE Order 5400.5, Figure IV-1 values. Rather, “detectability” is the primary criterion. Thus, replacing the current Order 5400.5, Figure IV-1 values with ANSI N13.12 values will have little impact on items judged by the different criterion of “detectability.” However, the risk-based consensus standard ANSI N13.12 could give DOE a credible and valid basis for changing its current policy on these two important waste streams.

4.3 Disposal of Biomedical and Similar Research Laboratory Wastes

Much of the work done at DOE national laboratories involves tracer radionuclides that are used for in vitro experiments and measurements. These radionuclides include ^{3}H, ^{14}C, ^{32}P, ^{35}S, and others. The ANSI screening level for ^{3}H is 60 times less restrictive than the Appendix D value, and for the other three radionuclides and many of the other tracers, a factor of 120 less restrictive. Also, the ANSI standard gives volumetric contamination limits; DOE Order 5400.5 does not. Gels, used filters, paper and other laboratory wastes often have contamination that is not strictly surface contamination. Because some of the contamination is within the volume of the waste, it would be difficult to defend the use of the current DOE Order 5400.5 surface contamination values for waste that is known to have contamination below the surface. However, use of the ANSI screening levels could be easily defended. Thus, DOE and its contractors could use the ANSI screening levels to dispose of much of their biomedical and similar low-activity waste in ordinary landfills. The cost savings are not estimated in this report but would be considerable.

Given the general public's concern about radioactive wastes, even those with very low concentrations of radionuclides, it is not likely that DOE could unilaterally adopt the ANSI/HPS N13.12-1999 screening levels and start sending much of its biomedical research wastes to public sanitary landfills. Nonetheless, the recently adopted ANSI standard should be a good basis for beginning discussions with EPA and NRC about changing the regulations for all generators of radioactive waste with low concentrations of radionuclides.

ANSI N13.12, an industry standard, should play an important role in the regulatory process. In fact, the White House Office of Management and Budget (OMB) issued on February 10, 1998, a revision to Circular No. A-119, *Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities*. The revision is the result of the National Technology Transfer Act of 1995 (Public Law 104-113), signed by the President in March 1996. The OMB directive and the law require federal agencies to use voluntary industry standards developed by the private sector whenever possible. The purpose of this requirement is to eliminate excessive costs to the government incurred in developing its own standards. This government-wide directive should help the EPA, NRC, and DOE cooperate to adopt the ANSI N13.12 methodology and values.

4.4 Use of the ANSI Screening Levels for Designating Contamination Areas

The final review draft of ANSI/HPS N13.12-1999 indicated that the standard could apply "to areas within facilities during operation". This draft language was intended to cover the situation at operating DOE facilities where the historic surface contamination values found in Regulatory Guide 1.86, as adopted in 10 CFR Part 835, Appendix D, were used to make decisions about designating and posting radiological control areas.(a) The writing group fully intended that the surface contamination screening levels in ANSI/HPS N13.12-1999 could be used for this purpose. However, during the final review by the HPS N13 Committee, the representative of the NRC took exception to this language because the ANSI/HPS N13.12-1999 values and methodology were not sufficiently consistent with the NRC's screening levels for license termination. The NRC criterion is 250 µSv/y (25 mrem/y), 25 times greater than the ANSI N13.12 level.

In light of the NRC concerns, the writing group chose to eliminate the language that referred to operational facilities. Two changes were made to the draft standard: 1) modifying the scope statement to

---

(a) Areas where radioactive contamination is 1 to 100 times the values in 10 CFR 835, Appendix D, are designated "Contamination Areas," while those exceeding Appendix D values by more than a factor of 100 are designated "High Contamination Areas." Such areas are posted with appropriate warning signs. If and when contamination levels are reduced, the warning signs are changed or removed. The removal of the designation and warning signs is commonly called "de-posting" or "de-regulating," while changing from High Contamination to Contamination Area is commonly called "down-posting."

read, “This standard applies to the clearance of materials and equipment from controlled areas during operations” (deleting the phrases “and areas within facilities” and including “decontamination activities”), and 2) deleting the sentence, “However, this standard could be incorporated into a decommissioning plan to provide criteria for clearance of materials during the decommissioning process.” In making these changes and deletions, the writing group chose to be silent on the issue of applying the standard for contamination control in operational areas. The final language was an attempt to provide a clear interpretation about how NRC licensees are required to proceed, without limiting how DOE might choose to apply the standard.(a)

The building occupancy and building renovation scenarios in the ANSI standard used to derive the surface and volume contamination limits were originally devised by the working group to bound radiological conditions that would be found after operating areas were posted (and de-posted) in accordance with the screening limits in the standard. Therefore, DOE would have a good technical basis for adopting the ANSI screening levels for this additional purpose. For example, Annex B to the standard explains the scenario for the surface contamination screening level (in Section B.1.4.2) as follows:

> To represent a limit for clearance of potentially large surface sources, a scenario analysis was conducted for rooms of facilities that contain materials with surface sources of radioactivity that are cleared from further radiological control. The scenario assumes that a room is occupied as a commercial facility after clearance of the sources in a manner that results in exposure of individuals to the surface sources of radioactivity. The scenario is conservatively assumed to occur during the first year following clearance and involves the external, inhalation, and ingestion exposure pathways.

Clearly, this scenario bounds many of the radiological conditions that might occur after “de-posting” operational areas which were designated as “contaminated” using 10 CFR 835, Appendix D, values but which could be cleared using the ANSI screening levels.

As discussed earlier, the ANSI screening levels for alpha-emitting radionuclides and long-lived fission products are not much different from the values in Appendix D. Thus, the new levels will not help simplify the operation of former production sites with areas of high fixed contamination. They could allow DOE to “de-post” or “down-post” some areas where removable surface contamination currently requires radiological controls.

Using the ANSI values could help a lot with “de-posting” (de-regulating) or “down-posting” general research laboratories using common tracers, resulting in levels of radiological control being more in line with radiological hazard. For example, clean working habits in a fume hood with only ^{3}H, ^{14}C, ^{32}P, and ^{35}S could meet the 100 Bq/cm^{2} (600,000 dpm/100 cm^{2}) limit most of the time. By comparison, the current limit is 10,000 dpm/100 cm^{2} removable for ^{3}H and 5,000 dpm/100 cm^{2} total contamination for the other three tracer radionuclides.

For the occasional spill in a lab not posted as a Contamination Area, procedures could be developed for that contingency. The area near the spill could be posted temporarily as a Contamination Area immediately after a spill and during the clean up. Provided the spill could be cleaned up to meet the ANSI screening levels, the area could then be “de-posted.” Such labs would need to be surveyed occasionally to ensure there were not undetected spills. However, such a program would more efficiently

---

(a) Personal communication from W.E. Kennedy, Jr.

use resources than managing all labs with radionuclides day-in-and-day-out as Contamination Areas. This report does not attempt to quantify the savings of such a use of the ANSI screening levels, but the authors expect it would be significant. Cost savings would also help DOE researchers more effectively compete for research funds from agencies such as The National Institute of Health and The National Science Foundation.

4.5 Decreasing the Number and Frequency of Measurements of Surface Contamination in Workplace Environments

By specifying different limits for removable and total surface contamination, Appendix D essentially requires two measurements for releasing items from Contamination Areas, High Contamination Areas, and Airborne Radioactivity Areas and for routine and pre-job surveying of work areas. By adopting the single limit in ANSI N13.12, DOE could cut the number of required measurements nearly in half. For purposes of keeping worker doses from external and internal sources ALARA, measurements of removable contamination may still be needed to support a contamination control program. However, such measurements could be limited to areas where individuals work routinely or are planning to work and would be needed only when measurements of total contamination or ambient dose rate indicate that radiological conditions have changed since the last measurements of removable contamination.

4.6 Reduce or Eliminate the Need to Count Smears in a Counting Laboratory

The current Appendix D limit for removable contamination for transuranic radionuclides is 20 dpm/100 cm^2 and for ^{90}Sr is 200 dpm/100 cm^2. Smears for these nuclides cannot be reliably “field counted,” that is, assayed with a portable meter by the technician who performs the smear sample, to detect such low levels. Thus, smears for transuranic radionuclides and ^{90}Sr have to be taken and counted in a counting laboratory. As Figure 9 shows, the ANSI screening level is much larger than the removable limit for the transuranic radionuclides. Alpha radioactivity of 600 dpm/100 cm^2 can be measured with field instruments, either by a direct measurement or by field-counting a smear. Similarly, ^{90}Sr contamination of 6,000 dpm/100 cm^2 can be measured with a beta-gamma survey instrument, even in a modest field of external gamma radiation. Shifting from low background counting to field counting of the contamination levels of nuclides in the two lowest categories in Appendix D would significantly reduce the workload on counting laboratories. More important, “field counting” of transuranic and ^{90}Sr smear samples would expedite operational decisions based on survey results, thus saving time and money.

5 ANSI Standard as a Technical Basis for “Solid Effluents”

The top half of Figure 1 shows schematically how regulatory controls are applied, or not applied, to practices that create sources that could expose the public to radiation or radioactive material. For radioactive material exiting from regulatory control, clearance is a parallel path to gaseous and liquid effluents. In fact, clearance (of materials for reuse or recycle and of wastes for disposal without regulation of radioactive content) may be thought of as release of “solid effluents.” ANSI/HPS N13.12-1999 is a consensus standard with a good scientific basis that regulatory agencies could use to allow “solid effluents” in a manner that is safe, that is, does not put undue risk on individuals, groups of individuals, or the environment, present or future. We do not propose to define a new waste category. Rather, we suggest a different perspective on existing wastes.

In Figure 1, exemption and exclusion are the decision-making processes by which a source of radiation exposure may bypass the sphere of regulation. Natural background radiation is a common example of exclusion of a source of radiation exposure. Public use of smoke detectors is a familiar example of exemption.

Release of air and water effluents below concentration limits specified in regulations is a generally accepted way for radioactive material to exit from regulatory control. Once a radioactive material leaves a licensed or permitted facility, in accordance with the license or permit, it is no longer controlled by the facility operator or the regulatory authority. The regulatory authority (usually the NRC, the states, or DOE) is very careful to allow only the amounts, types, and concentrations of gaseous and liquid effluents that it can demonstrate are safe. They seek not to put undue risk on individuals, groups of individuals, or the environment, present or future.

Using the standard as a basis for defining “solid effluents” can help integrate the clearance process into the menu of options the DOE has for managing its environmental cleanup and research missions.

In March 1999, the NRC published a draft report on radiological assessments for clearance of equipment and materials from nuclear facilities (McKenzie-Carter et al. 1999). The report, issued for public comment, gives no dose criterion for clearance. Rather, it examines numerous scenarios for material and equipment reuse, disposal in sanitary landfills, and recycle into manufactured goods. The report specifically examines 85 radionuclides in four materials (aluminum, concrete, copper, and steel) and gives various factors for converting surface contamination and volume contamination to effective dose equivalent to a critical group of individuals. A critical group is that group of individuals that has the largest dose factors calculated for a particular scenario. An example of a critical group is the truck drivers who deliver recycled scrap metal.

This NRC report has not been finalized. In March 2000, the NRC terminated the contract with the firm that wrote the draft report and decided to ask the U.S. National Academy of Sciences (NAS) to study and recommend alternatives for release of slightly contaminated solid materials. The committee formed to do the NAS study met on March 3, 2001. Because the NRC report has not been finalized, its results were not considered in this report.

6 Conclusions and Recommendations

Historically, DOE has managed occupational radiation protection and environmental radiation protection with two separate programs. The requirements for occupational radiation protection are specified in 10 CFR 835, “Occupational Radiation Protection.” The requirements for environmental radiation protection are codified in DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE 1993). To be of most use, the conclusions and recommendations of this report are separated into those that are relevant to both programs, those relevant to occupational radiation protection, and those relevant to environmental radiation protection.

6.1 Conclusions and Recommendations Relevant to Both Occupational and Environmental Radiation Protection

It would be reasonable, prudent and cost-effective for DOE to replace the values currently in 10 CFR 835, Appendix D, and DOE Order 5400.5, Figure IV-1, with the *DSL*s in ANSI/HPS N13.12-1999. This action would ensure consistency between the operational and environmental radiation protection programs operated throughout DOE.

The standard identifies a primary dose criterion of 10 µSv/y (1 mrem/y) TEDE above background. This value is not an absolute limit. The standard permits clearance of materials at higher levels, justified on a case-by-case basis, when it can be ensured that exposures to multiple sources will be maintained ALARA and will provide an adequate margin of safety below the public dose limit of 1 mSv/y (100 mrem/y) TEDE.

In Order 5400.5, the DOE sets the same primary dose limit of 1 mSv/y (100 mrem/y) for a member of the general public. Chapter IV of the Order provides for guidelines for concentrations of radioactivity in soil and surface contamination based on existing radiation protection standards or on the primary dose limit. The same dose limit of 1 mSv/y (100 mrem/y) is used in 10 CFR 835 as the limit for members of the general public entering a controlled area, the dose limit for minors, and the threshold requiring appropriate personnel dosimetry for general workers. Thus, in using the *DSL*s in the standard for clearance or the other potential uses, DOE would have the flexibility to choose a different dose criterion, providing it could show that such level was consistent with the ALARA principle and would not lead to combined doses from multiple sources in excess of the applicable DOE dose limit. For example, a dose criterion of 250 µSv/y (25 mrem/y) would lead to a 25-Bq/g group containing all of the radionuclides in the 1-Bq/g group in the standard.

Both in 10 CFR 835, Appendix D, and DOE Order 5400.5, Figure IV-1, the current limit for removable contamination for transuranic radionuclides is 20 dpm/100 cm^2 and for ^{90}Sr is 200 dpm/100 cm^2. Smears for these nuclides cannot be reliably “field counted,” that is, assayed with a portable meter, and have to be taken to a counting laboratory instead. Since the *DSL*s are much larger than the removable limit for the transuranic radionuclides and ^{90}Sr, smear samples could be measured with field instruments. Shifting from low background counting to field counting of smears of nuclides in the two lowest categories in Appendix D and Figure IV-1 would significantly reduce the workload on counting laboratories.

6.2 Conclusions and Recommendations Relevant to Occupational Radiation Protection

The building occupancy and building renovation scenarios used in the standard to derive the surface and volume contamination *DSL*s were originally devised by the working group to place bounds on radiological conditions that would be found after operating areas were posted (and de-posted) in accordance with the screening limits in the standard. Therefore, DOE would have a good technical basis for adopting the ANSI screening levels for this additional purpose. Such use of the *DSL*s is not excluded by the standard.

Using the standard's *DSL*s could help with "down-posting" or "de-posting" of research laboratories where common biomedical tracers are used. For example, clean working habits in a fume hood with only ^{3}H, ^{14}C, ^{32}P, and ^{35}S, could meet the 100 Bq/cm^{2} (600,000 dpm/100 cm^{2}) limit most of the time. By comparison, the current limit is 10,000 dpm/100 cm^{2} removable for ^{3}H and 5,000 dpm/100 cm^{2} total contamination for the other three tracer radionuclides.

6.3 Conclusions and Recommendations Relevant to Environmental Radiation Protection

Using the standard as a basis for defining "solid effluents" can help integrate the clearance process into the menu of options the DOE has for managing its environmental cleanup and research missions. For two waste streams, metals and hazardous waste contaminated with radionuclides, DOE's policy is based on "detectability" as the primary criterion. Using the risk-based consensus standard ANSI N13.12 could give DOE a credible and valid basis for changing its current policy on these two important waste streams.

Currently, there is no standard for the release of materials with trace amounts of contamination throughout their volume. ANSI N13.12-1999 does provide a technical basis for treating materials with trace amounts of radioactive contamination throughout their volume as ordinary waste.

Some work done at DOE national laboratories involves soft beta-emitting tracer radionuclides that are used for biomedical research. These radionuclides include ^{3}H, ^{14}C, ^{32}P, ^{35}S and others. The ANSI screening level for ^{3}H is 60 times less restrictive than the Appendix D value. For the other three radionuclides and many of the other tracers, the *DSL*s are a factor of 120 less restrictive. With the surface and volume *DSL*s, DOE and its contractors could use the ANSI screening levels to dispose of much of its laboratory waste in ordinary landfills. The cost savings are not estimated in this report but would be considerable.

7 References

10 CFR 20, “Standards for Protection Against Radiation.” U.S. Nuclear Regulatory Commission.

10 CFR 820, “Procedural Rules for DOE Nuclear Activities.” U.S. Department of Energy.

10 CFR 835, “Occupational Radiation Protection.” U.S. Department of Energy.

American National Standards Institute (ANSI). 1989. *Practice for Occupational Radiation Exposure Records Systems. An American National Standard.* ANSI N13.6-1966 (R1989), American National Standards Institute, New York.

American National Standards Institute (ANSI). 1999. *Surface and Volume Radioactivity Standards for Clearance. An American National Standard.* ANSI/HPS N13.12-1999, Health Physics Society, McLean, Virginia.

International Atomic Energy Agency (IAEA). 1987. *Exemption of Radiation Sources and Practices from Regulatory Control*. IAEA-TECDOC-401, International Atomic Energy Agency, Vienna.

International Atomic Energy Agency (IAEA). 1988. *Principles for the Exemption of Radiation Sources and Practices from Regulatory Control*. Safety Series No. 89, International Atomic Enengy Agency, Vienna.

International Atomic Energy Agency (IAEA). 1996a. *Clearance Levels for Radionuclides in Solid Materials. Application of Exemption Principles. Interim Report for Comment*. IAEA-TECDOC-855, International Atomic Energy Agency, Vienna.

International Atomic Energy Agency (IAEA). 1996b. *International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources.* Safety Series No.115, International Atomic Energy Agency, Vienna.

McKenzie-Carter, M.A., M.D. Otis, M.E. Anderson, J.A. Roberts, R.L. Gotchy, and R.A. Meck. 1999. *Radiological Assessments for Clearance of Equipment and Materials from Nuclear Facilities. Main Report. Draft Report for Comment.* NUREG-1640, Vol. 1, U.S. Government Printing Office, Washington, DC.

National Council on Radiation Protection and Measurements (NCRP). 1993. *Limitation of Exposure to Ionizing Radiation*. Report No. 116, NCRP Publications, Bethesda, Maryland.

National Technology Transfer Act of 1995. Public Law 104-113.

U.S. Atomic Energy Commission (USAEC). 1974. *Termination of Operating Licenses for Nuclear Reactors*. Regulatory Guide 1.86, U.S. Government Printing Office, Washington, DC.

U.S. Department of Energy (DOE). 1993. *Radiation Protection of the Public and the Environment*. DOE Order 5400.5, Change 2, [Online]. Available URL: http://www.explorer.doe.gov:1776/

U.S. Department of Energy (DOE) Office of Environment. 1995. *Response to Questions and Clarification of Requirements and Processes: DOE 5400.5, Section II.5 and Chapter IV Implementation (Requirements Relating to Residual Radioactive Material).* U.S. Department of Energy, Washington D.C. (Distributed via memo from Raymond F. Pelletier, Director of the Office of Environmental Policy and Assistance, November 17, 1995.)

Distribution

No. of
Copies

OFFSITE

1 Kelly Beierschmitt
Oak Ridge National Laboratory
P.O. Box 2008 MS6249
Oak Ridge, TN 37831

1 David E. Bernhardt
Rogers & Associates Engineering Corp.
536 E Holstein
Salt Lake City, UT 84107

1 Michael A. Boyd
Environmental Protection Agency
6602J
401 M Street, S.W.
Washington, DC 20460

1 Kenneth Brog
Brookhaven National Laboratory
E, S, H, &Q Directorate
Bldg. 460
PO Box 5000
Upton, NY 11973-5000

1 Kathy Carney
Brookhaven National Laboratory
Waste Management Division
Bldg. 860
PO Box 5000
Upton, NY 11973-5000

1 Shih-Yew Chen
Argonne National Laboratory
Env. Assessment Div.
Building 900
Argonne, IL 60439

1 Arthur E. Derosiers
52 Deer Jump Hill
West Barnstable, MA 02668

No. of
Copies

2 Keith H. Dinger
Health Physics Society
Congressional Liaison
23 Prospect St.
Somersworth, NH 03878-2708

1 Stephen W. Duce
International Technology Corporation
9924 San Madre
Knoxville, TN 37922

1 Ken Eger
Foster Wheeler Environmental
111 Union Valley Road
Oak Ridge, TN 37849

1 Dennis Erickson
Los Alamos National Laboratory
P.O. Box 1663 MS K491
Los Alamos, NM 87545

1 Wayne C. Gaul
STARMET
365 Metal Drive
Barnwell, SC 29812

1 Paul H. Genoa
Senior Project Manager, Plant Support
Nuclear Energy Institute
Suite 400
1776 I Street, NW
Washington, D.C 20006-3708

1 Geoffrey S. Ibbott, PhD
Radiation Physics Dept.
UT M.D. Anderson Cancer Center
Box 547
1515 Holcombe Blvd
Houston, TX 77030

No. of
Copies

1 Tracy A. Ikenberry
Dade Moeller and Assoc., Inc.
1845 Terminal Dr.
STE 140
Richland, WA 99352

1 Robert M. Hallisey
Chair, Conf. of Radiation Control Program Directors
Massachusetts Rad. Ctrl. Program
174 Portland St. 5th Floor
Boston MA 02130

1 Lynette Hendricks
Director, Plant Support
Nuclear Energy Institute
Suite 400
1776 I Street, NW
Washington, D.C 20006-3708

1 Douglas Jamieson
Duratek
1560 Bear Creek Rd.
Oak Ridge TN 37831-2530

1 Alfred N. Johnson
GTS Duratek
PO Box 2530
1560 Bear Creek Road
Oak Ridge, TN 37831-2530.

1 Raymond H. Johnson, Jr.
Health Physics Society
Scientific and Public Issues Committee Chair
Suite 302
481 N. Fredrick Ave.
Gaithersburg, MD 20877

1 Hong-Nian Jow
Sandia National Labs
7009 Pala Mesa NE
Albuquerque, NM 87111

No. of
Copies

2 William E. Kennedy, Jr.
Dade Moeller and Assoc., Inc.
1845 Terminal Dr.
STE 140
Richland, WA 99352

1 Stephen Layendecker
Brookhaven National Laboratory
Radiological Control Division
Bldg. 194
PO Box 5000
Upton, NY 11973-5000

1 William J. Madia
Oak Ridge National Laboratory
P.O. Box 2008 MS6255
Oak Ridge, TN 37831

1 Jerome B. Martin
6771 Beagle Dr.
Hamilton, OH 45011

1 Kathleen McAlister
Chair of CRCPD Committee on Radioactivity
Massachusetts Rad Ctrl Program
79 East Side Dr.
Concord, NH 03301-5460

1 Stephen McGuire
U.S. Nuclear Regulatory Commission
Mail Stop 9 E45
Two White Flint North
Rockville, MD 20555

2 Robert A. Meck
U.S. Nuclear Regulatory Commission
Two White Flint North
Mail Stop 9 F 31
11545 Rockville Pike
Rockville, MD 20852-2738

No. of Copies

1 Charles B. Meinhold
National Council on Radiation Protection and Measurements
7910 Woodmont Avenue, Suite 800
Bethesda, MD 20814-3095

1 Francis R. O'Donnell
Oak Ridge National Laboratory
99 Deerfield Lane
Oak Ridge, TN 37830-8778

1 Carl J. Paperiello
U.S. Nuclear Regulatory Commission
OWFN
11555 Rockville Pike
Rockville, MD 20852-2738

2 Harold T. Peterson
Office of Environmental Policy and
Assistance (EH-412)
1000 Independence Avenue, S.W.
Washington, DC 20585-0119

5 Joel L. Rabovsky
Office of Worker Protection Programs
and Hazards Management
EH-52, GTN, 270 CC
19901 Germantown Road
Germantown, MD 20874

1 Michael T. Ryan
768 Glossy Ibis Ln.
Kiawah Island, SC 29455-5913

1 R. Gene Schreckhise
Washington State Univ. - Tri Cities
2710 University Dr.
Richland, WA 99352

1 Jack M. Selby
M.H. Chew and Associates, Inc.
5504 West Umatilla Street
Kennewick, WA 99336

No. of Copies

1 Anthony Stanford
Los Alamos National Laboratory
P.O. Box 1663 MS K492
Los Alamos, NM 87545

1 Frederick P. Straccia
Radiation Safety & Control Services, Inc.
91 Portsmouth Ave
Stratham, NH 03885

1 Kenneth L. Swinth
2177 Cascade Avenue
Richland, WA 99352

1 Alden N. Tschaeche
Nuclear Standards Unlimited
1250 Orchard Glen Circle
Encinitas, CA 92024

1 Toshihide Ushino
ICN Biomedicals Inc.
Dosimetry Division
3300 Hyland Avenue
Costa Mesa, CA 92626

2 Andrew Wallo, III
Department of Energy
Office of Environmental Safety and Health
(EH-41)
Forrestal Bldg. GA-098
Washington, DC 20585

1 Robert C. Woodard
Canberra Industries
26 Evergreen
Middletown, CT 06457

2 Robert A. Wynveen
Argonne National Laboratory
ESH-HP 201 230
9700 S. Cass Avenue
Argonne, IL 60439

No. of
Copies

ONSITE

2	**Fluor Daniel Hanford Co.**	
	Gregory D. Perkins	H8-67
2	**Bechtel Hanford Co.**	
	James E. Tarpinian	H0-09
34	**Pacific Northwest National Laboratory**	
	(1) Joan F. Adams	K9-64
	(1) Walter J. Apley	K9-01
	(1) Sharon D. Dossett	P7-75
	(1) John J. Fix	K3-55
	(1) Mark E. Hevland	P7-01
	(1) John H. Holbrook	H6-61
	(1) Alice K. Ikenberry	P7-79
	(1) Joseph C. McDonald	K3-53
	(1) Ellyn M. Murphy	K9-76
	(1) Bruce A. Napier	K3-54
	(1) Kelvin L. Soldat	K3-53
	(20) Paul S. Stansbury	K3-54
	(1) Gregory A. Stoetzel	P7-78
	(1) Daniel J. Strom	K3-56
	(1) George J. Vargo	K3-56

No. of
Copies

10	**DOE Richland Operations Office**	
	(1) Terri L .Aldridge	K8-50
	(1) Dianne L. Clark	H6-60
	(6) Wayne M. Glines	A2-15
	(1) Paul Kruger	K8-50
	(1) Brenda M. Pangborn	A5-17
1	**DOE Office of River Protection**	
	Phillip E. Lamont	H6-60