ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 61

[FRL-3657-4]

RIN 2060-AC47

National Emission Standards for Hazardous Air Pollutants; Radionuclides

AGENCY: Environmental Protection Agency [EPA].

ACTION: Final rule and notice of reconsideration.

SUMMARY: This final rule announces the Administrator's final decisions on National Emission Standards for Hazardous Air Pollutants (NESHAPs) under section 112 of the Clean Air Act for emissions of radionuclides from the following source categories: DOE Facilities, Licensees of the Nuclear Regulatory Commission and Non-DOE Federal Facilities, Uranium Fuel Cycle Facilities, Elemental Phosphorus Plants, Coal-Fired Boilers, High-level Nuclear Waste Disposal Facilities, Phosphogypsum Stacks, Underground and Surface Uranium Mines, and the operation and disposal of Uranium Mill Tailings Piles. The final rule also responds to the major public comments on the March 7, 1989 proposed decisions for these categories (54 FR 9612). EPA is conducting this rulemaking pursuant to a voluntary remand and a schedule issued by the U.S. Court of Appeals for the D.C. Circuit which requires final action by October 31, 1989. In addition EPA is granting a reconsideration of the standards of 40 CFR part 61, subpart I concerning emissions from facilities licensed by the Nuclear Regulatory Commission, with respect to the issues of duplicative regulation and possible effects on medical treatment.

DATES: Effective Date: December 15, 1989. Subpart I is stayed until March 15, 1990. Comments on subpart I may be submitted on or before February 13, 1990. The incorporation by reference of certain publications listed in the regulations is approved by the Director of the Federal Register as of December 15, 1989. Under section 307(b)(1) of the CAA, judicial review of decisions under section 112 is available only by filing a petition for review in the United States Court of Appeals for the District of Columbia Circuit within 60 days of today's publication of these rules. Under section 307(b)(2) of the CAA, the requirements that are the subject of today's notice may not be challenged later in civil or criminal proceedings brought by EPA to enforce these requirements.

ADDRESS: Comments on subpart I should be submitted (in duplicate if possible) to: Central Docket (A-130), Environmental Protection Agency, Attn: Docket No. A-79-11, Washington, DC 20460.

FOR FURTHER INFORMATION CONTACT: James M. Hardin, Environmental Standards Branch, Criteria and Standards Division (ANR-460), Office of Radiation Programs, Environmental Protection Agency, Washington DC 20460, (202) 475-9610.

SUPPLEMENTARY INFORMATION:

Motion for Reconsideration

For any party who wishes to present new information to EPA, regarding the appropriateness of these rules, a Petition for Reconsideration may be filed under section 307(d)(7)(B).

Docket

The rulemaking record is contained in Docket No. A-79-11 and contains information considered in determining health effects, listing radionuclides as hazardous air pollutants, and setting standards. It also contains all comments received from the public during the comment period. This docket is available for public inspection and copying between 8:00 a.m. and 3:00 p.m. on weekdays. A reasonable fee may be charged for copying.

A single copy of the Background Information Document and Economic Assessment (which, combined, form the final Environmental Impact Statement (EIS)) have been placed in the docket. Other documents available include: A Guide for Determining Compliance with the Clean Air Act Standards for Radionuclide Emissions from NRC-Licensed and Non-DOE Federal Facilities (October 1989); Procedures Approved for Demonstrating Compliance with 40 CFR part 61, subpart I (October 1989); and User's Guide for the COMPLY Code (October 1989). Copies of these documents may be obtained by writing to: Director, Criteria and Standards Division (ANR-460), Office of Radiation Programs, Environmental Protection Agency, Washington, DC 20460.

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I. Definitions

A. Terms

Activity—The amount of a radioactive material. It is a measure of the transformation rate of radioactive nuclei at a given time. The customary unit of activity, the curie, is 3.7×10^{10} nuclear transformations per second.

Agreement State—Any state with which the Nuclear Regulatory Commission or the former Atomic Energy Commission has entered into an effective agreement under subsection 274(b) of the Atomic Energy Act.

Annualized Cost—A stream of annual payments for a determined time period, equal in value to a one-time payment based on a selected rate of interest.

By-product Material—Any radioactive material (except source material and special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear

material and wastes from the processing of ores primarily to recover their source material content.

Dose Standard—A regulatory standard that requires a regulated facility to limit its emissions to the level necessary to ensure that no individual receives an effective dose equivalent greater than the specified level.

Effective Dose Equivalent (EDE)—The sum of the risk-weighted organ dose equivalent commitments. The effective dose equivalent has the same risk (for the model used to derive the weighting factors) as a uniform dose equivalent to all organs and tissues. For the purposes of these standards, "effective dose equivalent" means the result of the calculation used to determine the dose equivalent to the whole body, by taking into account the specific organs receiving radiation, the dose each organ receives, and the risk per unit dose to that organ. A description of the weighting factors used in the calculation of the EDE is described in detail in the International Commission on Radiological Protection's Publication No. 26, Pergamon Press, New York (1982).

Flux standard—A regulatory standard that limits the amount of radon that can emanate per square meter of regulated material per second, averaged over a single source.

Half-Life—The time in which half the atoms of a particular radioactive substance transform, or decay, to another nuclear form.

Incidence—This term denotes the predicted number of fatal cancers in a population from exposure to a pollutant. Other health effects (non-fatal cancers, genetic, and developmental) are noted separately.

Maximum Individual Risk—The maximum additional cancer risk of a person due to exposure to an emitted pollutant for a 70-year lifetime.

Pathway—A way that radionuclides might contaminate the environment or reach people, e.g. air, water, food.

Radionuclide—A type of atom which spontaneously undergoes radioactive decay.

Source Term—The amount of radioactive material emitted to the atmosphere from a source, either estimated, measured or reported, that is used in the risk assessment.

Transuranic—An element with an atomic number greater than the atomic number of uranium.

Uranium Fuel Cycle—The operations of milling of uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using uranium fuel, and reprocessing of spent uranium fuel, to the extent that these directly support the production of electrical power for public use utilizing nuclear energy. This definition does not include mining operations, operations at waste disposal sites, transportation of any radioactive material in support of these operations, or the reuse of recovered non-uranium special nuclear and by-product materials from the cycle.

B. Acronyms

AEA—Atomic Energy Act, 42 U.S.C. 2011 *et seq.*
ALARA—As low as reasonably achievable
AMC—American Mining Congress
ANPR—Advanced Notice of Proposed Rulemaking
CAA—The Clean Air Act, 42 U.S.C. 7401 *et seq.*
CAP-88—Clean Air Act Assessment Package-1988
CERCLA—Comprehensive Environmental Response Compensation and Liability Act, 42 U.S.C. 9601 *et seq.*
CFR—Code of Federal Regulations
BID—The Background Information Document prepared in support of this rulemaking (Volume 1 of the EIS)
EIA—The Economic Impact Assessment prepared in support of this rulemaking (Volume 2 of the EIS)
EIS—Environmental Impact Statement
DOE—United States Department of Energy
EDF—Environmental Defense Fund
EPA—United States Environmental Protection Agency
HLW—High-Level Radioactive Waste
ICRP—International Commission on Radiological Protection
MSHA—Mine Safety and Health Administration
mrem—millirem, 1×10^{-3} rem
NAAQS—National Ambient Air Quality Standards
NESHAP—National Emission Standard for Hazardous Air Pollutants
NCRP—National Council on Radiation Protection and Measurements
NRC—United States Nuclear Regulatory Commission
NRDC—Natural Resources Defense Council, Inc.
pCi—picocurie, 1×10^{-12} curie
UFC—Uranium Fuel Cycle
UMTRCA—Uranium Mill Tailings Radiation Control Act of 1978, 42 U.S.C. 7901, *et seq.*

II. EPA NESHAPs Policy

This section provides a description of the EPA's approach for the protection of public health under section 112. In protecting public health with an ample margin of safety under section 112, EPA strives to provide maximum feasible protection against risks to health from hazardous air pollutants by (1) protecting the greatest number of persons possible to an individual lifetime risk level no higher than approximately 1 in 1 million and (2) limiting to no higher than approximately 1 in 10 thousand the maximum estimated risk that a person living near a plant would have if he or she were exposed to the emitted pollutant for 70 years. Implementation of these goals is by means of a two-step standard-setting approach, with an analytical first step to determine an "acceptable risk" that considers all health information, including risk estimation uncertainty, and includes a presumptive limit on maximum individual lifetime risk (MIR) of approximately 1 in 10 thousand. A second step follows in which the actual standard is set at a level that provides "an ample margin of safety" in consideration of all health information, including the number of persons at risk levels higher than approximately 1 in 1 million, as well as other relevant factors including costs and economic impacts, technological feasibility, and other factors relevant to each particular decision. Applying this approach to the radionuclide source categories in today's notice results in controls that protect over 90 percent of the persons within 80 kilometers (km) of these sources at risk levels no higher than approximately 1 in 1 million.

A principle that accompanies these numerical goals is that the state of the art of risk assessment does not enable numerical risk estimates to be made with comparable confidence. Therefore, judgment must be used in deciding how numerical risk estimates are considered with respect to these goals. As discussed below, uncertainties arising from such factors as the lack of knowledge about the biology of cancer causation and gaps in data must be weighed along with other public health considerations. Many of the factors are not the same for different pollutants, or for different source categories.

A. Background

On March 7, 1989, EPA proposed decisions on standards under section 112 for twelve source categories of radionuclides. A principal aspect of the proposal, and the basis for the proposed decisions on the source categories, were four proposed approaches for decisions under section 112 as mandated by the D.C. Circuit's decision in *NRDC* v. *EPA*, 824 F.2d at 1146 (1987) (the *Vinyl Chloride* decision). The *Vinyl Chloride* decision required the Administrator to exercise his judgment under section 112 in two steps: first, a determination of a "safe" or "acceptable" level of risk

considering only health factors, followed by a second step to set a standard that provides an "ample margin of safety", in which costs, feasibility, and other relevant factors in addition to health may be considered.

The four proposed approaches were designed to provide for consideration of a variety of health risk measures and information in the first step analysis under the *Vinyl Chloride* decision—the determination of "acceptable risk." Included in the alternative approaches were three that consider only a single health risk measure in the first step: (1) Approach B, which considers only total cancer incidence with 1 case per year as the limit for acceptability; (2) Approach C, which considers only the maximum individual risk ("MIR") with a limit of 1 in 10 thousand for acceptability; and (3) Approach D, which considers only the maximum individual risk with 1 in 1 million as the limit. The fourth approach, Approach A, was a case-by-case approach that considers all health risk measures, the uncertainties associated with them, and other health information.

In the second step, setting an "ample margin of safety", each of the four approaches considers all health risk and other information, uncertainties associated with the health estimates, as well as costs, feasibility, and other factors which may be relevant in particular cases. The proposal solicited comment on each of the approaches for implementing the *Vinyl Chloride* decision. The Agency received many public comments on the approaches from citizen's groups, companies and industry trade groups, state and local governments, and individuals.

B. General NESHAP Policy Considerations

The purpose of this section is to discuss the appropriate criteria for determining an "acceptable risk" and an "ample margin of safety". In its determination, EPA will consider measures of health risk, and limitations and uncertainties of the risk estimation methods and basic data. A discussion of these factors follows. The framework adopted in this proceeding has already been selected in the Benzene NESHAP and will also become the policies for decisions on future NESHAPs but will not apply to other Agency programs or other sections of the Clean Air Act.

1. Selection of Approach

Based on the comments and the record developed in the rulemaking, EPA selected an approach announced in the notice on benzene standards published on September 14, 1989 (54 FR 38044), based on Approaches A and C but also incorporating consideration of incidence from Approach B and consideration of health protection for the general population on the order of 1 in 1 million from Approach D. Thus, in the first step of the *Vinyl Chloride* inquiry, EPA will consider the extent of the estimated risk were an individual exposed to the maximum level of a pollutant for a lifetime. The EPA will generally presume that if the risk to that individual is no higher than approximately 1 in 10 thousand, that risk level is considered acceptable and EPA then considers the other health and risk factors to complete an overall judgment on acceptability. The presumptive level provides a benchmark for judging the acceptability of maximum individual risk, but does not constitute a rigid line for making that determination.

The Agency recognizes that consideration of maximum individual risk—the maximum estimated risk of contracting cancer following a lifetime of exposure to the emitted pollutant—must take into account the strengths and weaknesses of this measure of risk. It is estimated based on the assumption of continuous exposure for 24 hours per day for 70 years. As such, it does not necessarily reflect the true risk, but displays a conservative risk level which is an upperbound that is unlikely to be exceeded. The Administrator believes that an MIR of approximately 1 in 10 thousand should ordinarily be the upper end of the range of acceptability. As risks increase above this benchmark, they become presumptively less acceptable under section 112. They then would be weighed with the other health risk measures and information in making an overall judgment on acceptability. Or, the Agency may find, in a particular case, that a risk that includes MIR less than the presumptively acceptable level is unacceptable in the light of other health risk factors.

In establishing a presumption for MIR, rather than a rigid line for acceptability, the Agency intends to weigh it with a series of other health measures and factors. These include the overall incidence of cancer or other serious health effects within the exposed population, the numbers of persons exposed within each individual lifetime risk range and associated incidence within a radius around facilities, the science policy assumptions and estimation uncertainties associated with the risk measures, weight of the scientific evidence for human health effects, and other quantified or unquantified health effects.

The EPA also considers incidence to be an important measure of the health risk to the exposed population. Incidence measures the extent of health risk to the exposed population as a whole, by providing an estimate of the occurrence of cancer or other serious health effects in the exposed population. The EPA believes that even if the MIR is low, the overall risk may be unacceptable if significant numbers of persons are exposed to a hazardous air pollutant, resulting in a significant estimated incidence. Consideration of this factor would not be reduced to a specific limit or range, such as the 1 case per year limit included in proposed Approach B, but estimated incidence would be weighed along with other health risk information in judging acceptability.

The limitation of MIR and incidence are put into perspective by considering how these risks are distributed within the exposed population. This information includes both individual risk, including the number of persons exposed within each risk range, as well as the incidence associated with the persons exposed within each risk range. In this manner, the distribution provides an array of information on individual risk and incidence for the exposed population.

Particular attention will also be accorded to the weight of evidence presented in the risk assessment of potential human carcinogenicity or other health effects of a pollutant. While the same numerical risk may be estimated for an exposure to a pollutant judged to be a known human carcinogen, and to a pollutant considered a possible human carcinogen based on limited animal test data, the same weight cannot be accorded to both estimates. In considering the potential public health effects of the two pollutants, the Agency's judgment on acceptability, including the MIR, will be influenced by the greater weight of evidence for the known human carcinogen.

In the *Vinyl Chloride* decision, the Administrator is directed to determine a "safe" or "acceptable" risk level, based on a judgment of "what risks are acceptable in the world in which we live." 824 F.2d at 1165. To aid in this inquiry, the Agency compiled and presented a "Survey of Societal Risk" in its March 1989 proposal (54 FR 9621–22). As described there, the survey developed information to place risk estimates in perspective and to provide background and context for the Administrator's judgment on the acceptability of risks "in the world in which we live." Individual risk levels in

the survey ranged from 10^{-1} to 10^{-7} (that is, the lifetime risk of premature death ranged from 1 in 10 to 1 in 10 million), and incidence levels ranged from less than 1 case per year to estimates as high as 5,000 to 20,000 cases/year. Everyday risks include risks from natural background radiation as well as risks from home accidents. Natural background radiation (excluding radon) at sea level creates individual lifetime cancer risks in the range of 3 in 1,000 and an estimated 10,000 cancer cases per year. Naturally occurring radon in homes poses an additional source of radiation risk, and these risks can be as high as 1 in 100 to 1 in 10. EPA estimates that this causes an estimated 8,000 to 40,000 cancer cases per year. In the U.S., accidents, natural disasters, and rare diseases pose individual risks of death from 1 in 10,000 (e.g., tripping and falling which cause approximately 470 deaths per year) to 1 in 10,000,000 (e.g., rabies, which causes an average of 1.5 deaths per year).

Judgments on risks have also spanned a broad range of risk levels. The NCRP, following recommendations of the International Commission on Radiological Protection, has recommended that maximum individual exposures from non-medical, manmade radiation be limited to an amount corresponding to risks of 3 in 1,000. It is important to note that the recommendations of national and international bodies are coupled with recommendations that radiation doses should be "as low as reasonably achievable" (ALARA). The implementation of ALARA requires a site-specific consideration of the cost effectiveness of controls that could be added to reduce radiation doses.

The EPA concluded from the survey that no specific factor in isolation could be identified as defining acceptability under all circumstances, and that the acceptability of a risk depends on consideration of a variety of factors and conditions. However, the presumptive level established for MIR of approximately 1 in 10 thousand is within the range for individual risk in the survey, and provides health protection at a level lower than many other risks common "in the world in which we live." And, this presumptive level also comports with many previous health risk decisions by EPA premised on controlling maximum individual risks to approximately 1 in 10 thousand and below.

In today's decisions, EPA is using this approach based on the judgment that the first step judgment on acceptability cannot be reduced to any single factor. The EPA believes that the level of the MIR, the distribution of risks in the exposed population, incidence, the science policy assumptions and uncertainties associated with the risk measures, and the weight of evidence that a pollutant is harmful to health are all important factors to be considered in the acceptability judgment. The EPA concluded that this approach best incorporates all vital health information and enables the Agency to weigh it appropriately in making a judgment. In contrast, the single measure Approaches B, C, and D, while providing simple decisionmaking criteria, provide an incomplete set of health information for decisions under section 112. The Administrator believes that the acceptability of risk under section 112 is best judged on the basis of a broad set of health risk measures and information. As applied in practice, the EPA's approach is more protective of public health than any single factor approach. In the case of the radionuclide sources regulated here, more than 90 percent of the population living within 80 km would be exposed to risks no greater than approximately 1 in 1 million and, the total number of cases of death or disease estimated to result would be kept low.

Under the two-step process specified in the *Vinyl Chloride* decision, the second step determines an "ample margin of safety," the level at which the standard is set. This is the important step of the standard-setting process at which the actual level of public health protection is established. The first step consideration of acceptability is only a starting point for the analysis, in which a ceiling for the ultimate standard is set. The standard set at the second step is the legally enforceable limit that must be met by a regulated facility.

Even though the risks judged "acceptable" by EPA in the first step of the *Vinyl Chloride* inquiry are already low, the second step of the inquiry, determining an "ample margin of safety," again includes consideration of all of the health factors, and whether to reduce the risks even further. In the second step, EPA strives to provide protection to the greatest number of persons possible to an individual lifetime risk level no higher than approximately 1 in 1 million. In the ample margin decision, the Agency again considers all of the health risk and other health information considered in the first step. Beyond that information, additional factors relating to the appropriate level of control will also be considered, including costs and economic impacts of controls, technological feasibility, uncertainties, and any other relevant factors. After considering all of these factors, the Agency will establish the standard at a level that provides an ample margin of safety to protect the public health, as required by section 112. The Agency terms its approach the "multifactor approach."

2. Format of Standards

The format of the standards for the various source categories varies because of the differing properties of the sources and the radionuclides they emit. Area sources emitting radon are best monitored by flux measurements. Thus, flux standards are most appropriate. For other categories, mixtures of radionuclides are best related to public health through the use of the concept of dose. EPA has promulgated dose standards to limit emissions in those cases where it is appropriate. Where a single radionuclide is emitted or a single radionuclide emission limit would serve to limit all others, EPA has promulgated an emission limit for that radionuclide. All standards include releases from accidents and accidental releases can result in a violation of the standard. However, releases from accidents shall not be considered when determining whether or not a facility should be granted permission to construct or modify under §§ 61.07 and 61.08. Releases that are not routine but are more likely than not to occur are included in determining whether such approval shall be granted.

Plants are required to monitor their operations continuously and keep records of the results of their monitoring onsite for five years. Plant owners will have to certify on a semiannual basis that no changes in operations that would require new testing have occurred. Although the report is based on a calendar year, the emission limit applies to any year, i.e. any period of 12 consecutive months.

III. Historical Background of Radionuclide NESHAPs

On December 27, 1979, EPA listed radionuclides as a hazardous air pollutant under section 112 of the CAA (44 FR 76738, December 27, 1979). EPA determined that radionuclides are a known cause of cancer and genetic damage and that radionuclides cause or contribute to air pollution that may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible or incapacitating reversible illness, and therefore constitute a hazardous air pollutant within the meaning of section 112(a)(1).

EPA then determined that radionuclides presented a risk warranting regulation under Section 112, and listed the pollutant under that section. Once listed, radionuclides became subject to the requirement of section 112(b)(1)(B) that EPA establish National Emission Standards for Hazardous Air Pollutants (NESHAPs) at a "level which (in the judgment of the Administrator) provides an ample margin of safety to protect the public health from such hazardous air pollutant," or find that they are not hazardous and delist them.

On April 6, 1983, EPA proposed standards regulating radionuclide emissions from four source categories: (1) Elemental phosphorus plants, (2) DOE facilities, (3) NRC-licensed facilities and non-DOE federal facilities (NRC-licensees), and (4) underground uranium mines. The Agency simultaneously proposed decisions not to regulate several other categories: (1) Coal-fired boilers, (2) the phosphate industry, (3) other extraction industries, (4) uranium fuel cycle facilities, (5) uranium mill tailings, (6) high level radioactive waste facilities, and (7) low energy accelerators (48 FR 15076, April 6, 1983). In February 1984, the Sierra Club filed suit in the U.S. District Court for the Northern District of California to compel EPA to take final action on the proposed standards. *Sierra Club* v. *Ruckelshaus*, No. 84–0656. EPA was subsequently ordered by the Court to promulgate final standards or make a finding that radionuclides are not hazardous air pollutants and delist them.

In October 1984, EPA withdrew the proposed emission standards for elemental phosphorus plants, DOE facilities, and NRC licensees, finding that the control practices already in effect for those categories protected the public from exposure to radionuclides with an ample margin of safety. EPA, therefore, concluded that no additional requirements were necessary (49 FR 43906, October 31, 1984). In the notice, EPA also withdrew proposed standards for underground uranium mines but stated its intention to promulgate a different standard for that category and simultaneously published an Advance Notice of Proposed Rulemaking (ANPR) for radon-222 emissions from underground uranium mines to solicit additional information on control methods. EPA also published an ANPR for radon-222 emissions from licensed uranium mills. EPA affirmed its decision not to regulate the other categories: coal-fired boilers, the phosphate industry, other extraction industries, uranium fuel cycle facilities, and high level radioactive waste. The Agency also decided to study further the category of phosphogypsum stacks to determine the need for a standard.

On December 11, 1984, the U.S. District Court for the Northern District of California found EPA in contempt of its order to promulgate final standards and again directed that EPA issue final radionuclide emission standards for the original four categories or make a finding that radionuclides are not hazardous air pollutants. EPA complied with the court order by promulgating standards for radionuclides emissions from elemental phosphorus plants, DOE facilities, and NRC-licensees (50 FR 7280, February 6, 1985) and a work practice standard for radon-222 emissions from underground uranium mines (50 FR 15385, April 17, 1985). On September 24, 1986, EPA promulgated a final rule regulating radon-222 emissions from licensed uranium mill processing sites by establishing work practices for new tailings (51 FR 34056, September 24, 1986).

The Environmental Defense Fund (EDF), the Natural Resources Defense Council (NRDC), and the Sierra Club filed petitions for review of the October 1984 withdrawals and final decisions not to regulate, the February 1985 standards for the three source categories and the April 1985 standard for underground uranium mines. The April 1985 standard for underground uranium mines was also challenged by the American Mining Congress (AMC). In November 1986, AMC and EDF filed petitions challenging the standard for licensed uranium mill processing sites.

On July 28, 1987, the U.S. Court of Appeals for the D.C. Circuit remanded to the Agency an emissions standard for vinyl chloride which had also been promulgated under Section 112 of the CAA. *Natural Resources Defense Council, Inc.* v. *EPA*, 824 F.2d 1146 (D.C. Cir. 1987) (*Vinyl Chloride*). The Court in *Vinyl Chloride* concluded that the Agency improperly considered cost and technological feasibility without first making a determination based exclusively on risk to health.

In light of that decision, EPA concluded that the standards for elemental phosphorus plants, DOE facilities, NRC-licensees, and underground uranium mines should be reconsidered and on November 16, 1987, moved the D.C. Circuit Court for a voluntary remand of the challenged decisions. EPA also agreed to reexamine all issues raised by the parties to the litigation. On December 8, 1987, the Court granted EPA's motion for voluntary remand and established a time schedule for EPA to propose regulatory decisions for all radionuclide source categories within 180 days and finalize them within 360 days. On March 17, 1988, the Court granted a subsequent EPA motion and modified the order to require proposed regulatory decisions by February 28, 1989 and final action by August 31, 1989.

On April 1, 1988, EPA also requested a remand for its standard for licensed uranium mill tailings. On August 3, 1988 the Court granted EPA's motion and put the uranium mill tailings NESHAP on the same schedule as the other radionuclide NESHAPs.

On March 7, 1989, EPA published a proposed NESHAP which described four possible policy approaches for regulating emissions of radionuclides. Public hearings were held on April 10, 11, 13, and 14, 1989.

On July 14, 1989, the court granted EPA's request for an extension until October 31, 1989 for final action.

IV. Characterization of the Risks of Radiation

A. Sources of Radiation

Every day each person is exposed to radiation from a variety of natural and manmade sources. Natural sources of radiation include cosmic rays, radon, and other terrestrial sources. Manmade radiation includes medical and dental X-rays, fallout from above ground nuclear weapons testing and industrial sources.

The earth's atmosphere acts as a shield to cosmic rays, absorbing much of the radiation. People receive a higher dose of cosmic rays at higher altitudes because there is less atmosphere to shield them from cosmic rays. For example, people living in the mountains receive a higher dose than people living at sea level, and people are exposed to even higher levels when flying in an airplane. Terrestrial radiation comes from the small amount of radionuclides that are naturally present in all matter: soil, air, food, clothes, and even our bodies.

Radon is a radionuclide that is produced as a radioactive decay product of the radium which is naturally found in soil. Radon is always present in the ambient air at levels which are estimated to pose some health risk. In addition, radon often gets trapped in homes, leading to even higher estimated health risks. EPA has issued recommendations to homeowners for reducing these risks.

This rulemaking deals with sources of radionuclide emissions, including radon, from industrial sources. Although the amount of radiation dose that most

people receive as a result of these emissions is typically lower than their natural background dose, the resulting risk can still be significant. A source does not present an acceptable risk simply by being less than natural background. It is important to note that total background radiation from all sources, including naturally occurring radon, results in a calculated individual lifetime risk of fatal cancer of approximately one in one hundred. In most cases, little can be done to reduce most of this radiation exposure which people receive from natural background.

Industrial sources of radionuclide emissions in the air include a wide variety of facilities, ranging from nuclear power facilities to hospitals to uranium mill tailing piles. Industry uses hundreds of different radionuclides in solid, liquid, and gaseous forms, emitting different types of radiation (alpha, beta, gamma) at various energy levels. Industrial sources of radionuclide emissions fall into two major categories. The first include industries that use radioactive materials and have emissions as a result of an inability to completely contain the materials they use. For example, hospitals use radionuclides as part of their radiology departments. Since many of the radionuclides they use are gases, liquids capable of evaporation, or solids capable of sublimation, some radionuclides inevitably are released into the environment. The other type of source is that which releases radionuclides (usually radon) as an unintended consequence of another activity, such as mining or milling. An example of this is phosphogypsum stacks (piles). These piles of waste material emit radon because radium (from which radon is produced by radioactive decay) is found naturally in the same soils that are the source of phosphate rock.

B. Health Effects of Radiation

The level and type of hazard posed by radionuclides vary, depending on such characteristics as the radionuclide's radioactive half-life, the type of radiation it emits, the energy level of the emission(s), and its ability to concentrate in the body. Different radionuclides will irradiate different parts of the body causing different types of cancers.

There are three major types of long-term health impacts from exposure to radiation: Cancer, hereditary effects, and developmental effects on fetuses such as mental retardation. Since there is such a strong foundation for quantifying the risk of fatal cancer, EPA's consideration of fatal cancers is the principal health consideration in this rulemaking. However, it is important to note that other health effects have also been considered in the rulemaking. The other effects are not specifically addressed in this discussion because none of them pose a more severe risk to health. In addition, risk distribution of health effects from radiation from most of the sources considered for regulation show that fatal cancers occur much more frequently than non-fatal cancers and cancers generally occur more often than genetic or developmental effects. For sources that emit radon, no genetic or developmental effects, and very few non-fatal cancers are expected.

Numerous studies have demonstrated that radiation is a carcinogen. It is assumed that there is no completely risk-free level of exposure to radiation to cause cancer. Health effects from radiation have been observed in studies of occupationally exposed workers and of the survivors of the Hiroshima and Nagasaki atomic bombs. This information has been verified with studies of animals in laboratories. However, the effects of radiation doses at low levels of exposure can only be predicted by extrapolating from the observed effects at higher doses since we do not have direct evidence of cancer causation at low exposure levels. Some pollutants cause diseases that are unique to the pollutant; for example, asbestos causes asbestosis. Radiation, however, causes some of the same types of cancers, e.g. leukemia and lung and liver cancer, that are caused by other factors. Since these cancers are not uniquely associated with radiation, it is not possible to differentiate cancers caused by radiation from other cancers.

The second type of effect is the induction of hereditary effects in descendants of exposed persons, which vary in degree and effect and may even be fatal. It is assumed that there is no completely risk-free level of exposure for hereditary effects. Although hereditary effects have been observed in experimental animals at high doses, they have not been confirmed at low doses in studies of humans.

Based on extensive scientific evidence, EPA believes it prudent to assume that carcinogens, including radionuclides, pose a risk of health effects even at low levels of exposure. Based on this science policy judgment, EPA calculates health risk estimates assuming that the risk of incurring either cancer or hereditary effects is linearly proportional to the dose received in the relevant tissue. However, the severity of either effect is not related to the amount of dose received. That is, once a cancer or an hereditary effect has been induced, its severity is independent of the dose.

Regarding cancer, there continues to be divided opinion on how to interpolate between the absence of radiation effect at zero dose and the observed effects of radiation (mostly at high doses) in order to estimate the most probable effects at doses that represent small increases above natural background radiation. Most scientists believe that available data best support use of a linear model for estimating such effects. Others, however, believe that other models, which usually predict somewhat lower risk, provide better estimates. These differences of opinion have not been resolved to date by studies of the effects of radiation in humans, the most important of which are those of the survivors of the Hiroshima and Nagasaki atomic bombs.

Some studies have recently been completed, and others are now underway to reassess radiation dose calculations for the survivors of the Hiroshima and Nagasaki atomic bombs and to provide improved estimates of risk. These studies may reduce the uncertainty associated with extrapolation from high doses to low doses. These studies may also result in an increase of the estimated risk per unit dose. But they will not address the question of whether a threshold exists. EPA is monitoring the progress of this work and will initiate reviews of the risks of exposure to low levels of radiation upon its completion.

C. Risk Assessment

1. Risk Measures Considered in NESHAP Policy

In decisions on cancer risks from stationary sources of hazardous air pollutants, the Agency has estimated three measures of health risk. These are termed "maximum individual risk", "risk distribution", and "incidence". Each of these combines an estimate of the dose/response for a pollutant with estimates of exposure to the pollutant. The response estimated is the pollutant-related increase in the probability that an individual will contract fatal cancer in his or her lifetime. The exposure estimated is the average daily exposure assuming exposure for 70 years.

a. *Maximum Individual Risk.* Individual risk is expressed as an estimated probability, e.g., 1 in 100 (10^{-2}), 1 in 1,000 (10^{-3}), 1 in 10,000 (10^{-4}). Thus, a 1×10^{-3} individual risk is an added "chance" of 1 in 1,000 of contracting fatal cancer sometime in the individual's lifetime.

In this discussion, the maximum individual lifetime risk is the maximum additional cancer risk of any person due to exposure to an emitted pollutant for a 70-year lifetime. The maximum individual risk is sometimes called the maximum exposed individual risk. This estimate is based on the fact that the concentration of an emission, and the consequent risk, diminishes with distance from its source. For radionuclide NESHAP decisions, the practice has been to estimate exposure according to census data on residence locations. It has also been estimated in some other Agency decisions as the maximum at the source perimeter.

The maximum individual lifetime risk is different from average individual risk which is sometimes estimated for sources like public drinking water systems or food in which the concentration of a pollutant and other factors are assumed to be equal at all distribution locations. This distinction is particularly relevant when considering the maximum risk one might find acceptable from different sources. In using the maximum individual risk in acceptable risk decisions for hazardous air pollutants, its limitations should be considered. Used alone, the measure does not tell how many people may be so affected; it relates only to the risk to the most exposed individual(s).

b. *Risk Distribution.* A risk distribution estimates how many persons within a certain distance (e.g. 80 km) of a source of pollutant emissions are at what level of individual risk. Typically, the distribution is given for 10-fold increments of individual risk. Such a distribution provides the decisionmaker with information on both the individual risk level for those exposed and the number of persons exposed at each level. For NESHAP and other decisions, the Agency has examined risk distributions both as measures of risk and to compare the effects of various strategies for risk reductions across a source category.

In making an acceptable risk decision, one relevant consideration is how many people are exposed at each risk level, e.g. a 10^{-2} risk might be acceptable if only one person were at that level, but not if 1,000 people were subject to it. Similarly, the numbers of persons exposed at various individual risk levels could be an important element in deciding on acceptable risk. The risk distribution could be used in similar ways to consider whether an ample margin of safety exists.

c. *Incidence.* Incidence is an estimate of population, rather than individual, risk. It is derived by multiplying individual risk by the estimate of the number of persons at that level of risk and summing the results over all risk levels. This number, which provides a lifetime population risk figure, is then divided by 70 (years) to give an annual fatal cancer incidence estimate. The incidence parameter can be used as an estimate of impact on the entire exposed population within a given area by totalling the incidence associated with each increment of individual risk. Incidence can also be portrayed along with individual risk and population numbers in a risk distribution. Typically, the Agency weighs incidence estimates in conjunction with maximum individual risk or average individual risk estimates. Estimated incidence generally is a particularly informative parameter when looking at aggregate risk from a category of like sources. One feature to take into account whenever it is used is its dependence on the size of the source category.

2. Uncertainties in Risk Measures

Each of the three risk parameters defined above has three elements. These are the estimated response per unit of pollutant concentration (e.g. pCi/l in air), the estimated exposure concentration, and the estimation of the number and location of the population residing in the area of the sources (usually taken from census data).

Uncertainties exist in estimating each of these elements for a variety of reasons including the fact that the relevant data and our understanding of the biological events involved are not complete. Where data gaps exist, qualitative and quantitative assumptions are made based on our present understanding of the biological mechanisms of cancer causation, estimates of air dispersion, engineering estimates, and other factors. Selection of certain assumptions to be used is a policy decision. The Agency has published guidelines covering many of these for both cancer risk assessment and exposure assessment ("Final Guidelines for Carcinogen Risk Assessment," (51 FR 33992, September 24, 1986) and "Final Guidelines for Estimating Exposures," (51 FR 33042, September 24, 1986)).

The following is a discussion of methods used to calculate the three parameters, together with a few examples of the uncertainties.

Risk assessment, under EPA guidelines, takes into account the nature and amount of evidence that the agent will cause the effect of concern in humans as well as the uncertainties of interpretation of data and its quantification. When the toxicity data from human studies are available, as in the case of radionuclides (which is a known human carcinogen), there is less uncertainty about the hazard of dose/response than when the data is solely from animal studies. Nevertheless, important uncertainties enter into the analysis even when human data is available. Examples include the fact that human epidemiological studies are often retrospective and measure effects of exposure that occurred many years in the past. The level of exposure to the agent at that time usually must be estimated and cannot be verified. Also, in certain categories of human studies, the studies are often of workers exposed to the pollutant. Worker populations are not representative of the general population with respect to age or sex. Workers are also generally the healthier segment of the population. These factors can lead to over- or underestimation of risk.

When data from animal studies are used, uncertainties about exposure can be experimentally controlled, but other uncertainties arise. Many of these concern the extrapolation from data collected in animal tests to estimate effects on humans. The extrapolation has to try to account for many factors, such as the equivalent dose for humans and laboratory animals given the size differences and the potential differences in metabolism and excretion of a chemical pollutant.

In addition, uncertainties arise in extrapolating the observed dose/response relationship from either workplace or animal test exposures to the usually lower dose levels of the general population.

In estimating exposure, the dispersion of a pollutant from a source is usually quantified by a predictive mathematical model using a known or model source emission rate, temperature and velocity characteristics, and weather patterns at a nearby recording weather station. The model predicts the concentration of the dispersed pollutant at various distances from the source. Standard assumptions are that the population around the source resides there for a 70-year lifetime and is continuously exposed to the modeled concentrations. The amount of emissions can be derived from sampling and analysis of emissions at the source or from engineering estimates, with more or less uncertainty associated with each method according to the type of emission. There are varying degrees of accuracy and precision in sampling, analysis, or estimates of emissions. Therefore, the uncertainties involved in the method of estimating individual exposure and the number of individuals exposed are

numerous. Thus, it is evident that uncertainty is difficult to quantify. However, the Agency has completed a preliminary uncertainty analysis of risk from radionuclide emissions from a limited number of facilities using Monte Carlo simulation techniques. Instead of discreet values, distributions were used for factors having a significant effect on outcome. The results suggest that the risks calculated represent essentially median values if the receptor remains at that location for 70 years.

3. Methodology

To take into account the buildup of radioactivity in the body and the environment, the risk assessment models incorporate the concepts of committed dose and the dose committed by an annual release into the environment or, equivalently, the annual dose received at equilibrium as a result of constant annual releases over long periods of time.

In attempting to make these estimates, EPA has tried at all times to give "best estimates" of the radionuclide concentrations in the environment and individual and population risks. Wherever possible, measured or reported data of emissions, meteorology and population were used. Where estimates were used, EPA has tried to use the most likely numbers in its assessments. When model facilities were used, they were designed to be representative of actual facilities. EPA's risk assessments are based on a current "snapshot" of each industrial source category as it now stands. EPA has not estimated the maximum conceivable risks that may result from the facilities analyzed at some point in the future. Future risks may be higher or lower depending on whether people move closer to, or further away from, the facilities studied and whether the emissions from those facilities increase or decrease. This is not to say that there is little or no uncertainty in the final results. As in all such assessments, the analyses have considerable uncertainty. EPA's analyses are not designed to consistently overestimate or underestimate risks.

The level of uncertainty is greater in the estimate of the maximum individual risk than in the estimate of population risk. Many possible errors in the analysis can cancel out in assessments of populations. For example, local meteorological conditions may cause more radionuclides to go in one direction than another. This effect may cause an overestimate or underestimate of the maximum individual risk, depending on where the most exposed individual is located. However, this source of error tends to be less important in population estimates, since the analysis integrates individual doses to a large number of people. If one person gets a larger risk due to local dispersion effects, it means that another person is getting less. Consequently, when the individual risks are summed, local conditions will not cause a serious error in the value for total population risk.

In estimating the radiation exposure to the most exposed individual, EPA assumes that the person receiving the maximum individual risk lives for a 70-year lifetime at the same site. EPA then makes its best estimate of the risks to that individual.

EPA recognizes that most people will not actually live their entire life in the same location. Nevertheless, EPA makes this assumption as a matter of policy and does not believe that it diminishes the validity of its risk assessments. EPA has made this assumption for several reasons. First, EPA is attempting to estimate the maximum individual risk, and it is completely possible that an individual could live in the same place for his or her entire life. Use of different assumptions could lead, in some cases, to underestimating the actual maximum risk.

Second, a large fraction of the risk can occur in less than the same fraction of the 70 years. Risk is not independent of age. Children appear to be more susceptible to the effects of radiation than adults. In addition, due to their youth, they generally have a longer time in which to develop the cancer caused by the radiation (and they are less likely to die of something else before they contract and die of the cancer). Due to these two factors, younger people are at a greater risk from the same dose than older people. (See Table 1). If EPA were to reduce the number of years of assumed exposure to less than a lifetime, it is unclear what number of years should be used or where to place those years within a lifetime. For example, should EPA assume that a person lives in the same place from birth to age 19 or from age 35 to 50? Generally, in the first case, the risk is 6 times greater than in the second case. Finally, the difference that would be caused by assuming a shorter period of exposure is not very significant. For an assumed constant rate of exposure, people receive over 60% of their total lifetime risk during their first nineteen years. To change the period of exposure from 70 years to the first 19 years of life would change the final result by less than a factor of 2.

Many commenters, including the SAB, disagreed with EPA's decision to use 70 year exposures in calculating maximum individual risk. However, as stated above, EPA believes that this is the correct method for doing risk assessments for NESHAPs. Had EPA used another method of calculating the maximum individual risk, it might have found it necessary to find a different, possibly more stringent benchmark for determining acceptable risk.

Third, the conservatism of this assumption counters two important and unknown uncertainties that can lead to an underestimation of risk. The first is the susceptibility of some members of the population to radiation. Scientific studies have shown that not all people respond in the same way to the same biological insult; some members of the population are more susceptible than the population as a whole. This problem is especially acute for the radon sources. Estimates of the risk of exposure to radon are largely based on epidemiological studies of miners, i.e. adult males. It is known that children seem to be more susceptible to radiation than adults. In addition, for some cancers, women are more susceptible than men; this may be true for lung cancer.

The second factor that EPA has been unable to quantify, but which would lead to an underestimation of the risk, is the synergistic effects of radiation with other pollutants. Radiation is not the only carcinogen in the environment. There are large numbers of carcinogens and potential carcinogens in the environment. Radionuclides are not the only carcinogens that cause cancer by first causing genetic damage. In addition, some chemicals may disrupt or stop the body's natural repair mechanisms. It is possible that some of these pollutants work synergistically with radiation to increase the effect of radiation above what it would be otherwise. While EPA's relative risk model takes into account the effect of chemicals that are widely distributed in the environment, there are hundreds of chemicals that are concentrated in local areas, and the effects of these chemicals are not and can not be taken into account. However, EPA's inability to quantify this potential increase in risk does not mean that this effect does not exist or that it should not be considered.

TABLE 1— AGE DEPENDENCE OF RISK DUE TO WHOLE BODY RADIATION

Assumed Percentage of Total Lifetime Risk As A Function Of Ages At Which Radiation Exposure Occurs [1]

Period of exposure (ages)	Percentage of lifetime risk	Cumulative percentage of lifetime risk [1]
0 to 9	30	30
10 to 19	30	60
20 to 34	20	80
35 to 50	10	90
50+	10	100

[1] Exposure is at a constant rate for a lifetime.

4. Technology Availability and Plant Closure Considerations

In the benzene NESHAP, as well as in this NESHAP for radionuclides, EPA has considered only factors relating to risks to public health in deriving alternative "acceptable" levels of risk. However, in evaluating whether to further reduce the risk to provide for an ample margin of safety, EPA has also considered the extent to which plants would be forced to: [a] Install control technologies which are not cost effective or fully demonstrated and/or [b] curtail or stop production. These considerations are reflected in today's proposal to the extent that they apply to affected radionuclide sources.

With regard to the availability of technology to control air pollutants, EPA has in this case considered a technology available if it has been installed on a commercial scale in the United States and adequate data have been collected on plant and control equipment characteristics and performance. However, at various times in the past, EPA has considered emission standards which force plants to install technologies which do not meet these current "availability" criteria or cause facilities to curtail production or shut down. For example, EPA has in the past considered a technology "available" if it has been commercially demonstrated in other countries, even if no units have been installed in the United States. Also, EPA has considered bench- or pilot-scale demonstrations in order to judge reasonableness of expenditures for commercial demonstration of a given technology.

D. Effective Dose Equivalent

Since 1985, when EPA proposed dose standards regulating NRC-licensees and DOE facilities, a different methodology for calculating dose has come into widespread use, the effective dose equivalent (EDE). In 1987, EPA, in recommending to the President new guidance for workers occupationally exposed to radiation, accepted this methodology for the regulation of risks from radiation. This method, which was originally developed by the International Commission on Radiological Protection, will be used in all the dose standards promulgated by EPA in this notice. In the past, EPA dose standards were specified in terms of limits for specific organ doses and the "whole body dose", a methodology which is no longer consistent with current practices of radiation protection.

The EDE is simple, is more closely related to risk, and is recommended by the leading national and international advisory bodies. By changing to this new methodology, EPA will be converting to the commonly accepted international method for calculating dose. This will make it easier for the regulated community to understand and comply with our standards.

The EDE is the weighted sum of the doses to the individual organs of the body. The dose to each organ is weighted according to the risk that dose represents. These organ doses are then added together, and that total is the effective dose equivalent. In this manner, the risk from different sources of radiation can be controlled by a single standard. The weighting factors for the individual organs are listed in Table 2.

TABLE 2—WEIGHTING FACTORS FOR INDIVIDUAL ORGANS

Organ	Factor
Lung	.12
Breast	.15
Thyroid	.03
Gonads	.25
Bone Surface	.03
Red Bone Marrow	.12
Remainder	.30

EPA's risk models differ from those underlying the ICRP recommendations, primarily due to advances in the field of radiation risk estimation since the ICRP recommendations were published. As a result, the risks calculated by EPA are not strictly proportional to the EDE derived using ICRP quality factors and organ weighting factors. While the risk methodology underlying the ICRP EDE differs from that used by EPA, the widespread acceptance of the EDE approach make it a reasonable basis for regulation under the CAA.

E. Science Advisory Board Review

Beginning in 1984, EPA's Science Advisory Board (SAB) has conducted reviews of the risk assessment methods used in this rulemaking. EPA has worked closely with the SAB with respect to their comments and findings and believes it has been responsive to them.

In 1984, the SAB recommended that available scientific information be integrated into an assessment document that would lead from identification of emission sources through calculation of radiation dose and health risk and the associated degrees of uncertainty. This has been done in the Environmental Impact Statement accompanying this rulemaking.

In 1988 and again in 1989, the SAB considered the scientific merits of the EIS prepared by the Agency in support of this rulemaking. Estimates of health risk factors were found to be acceptable. Given below are some important specific SAB comments and the Agency's responses.

SAB Comment: EPA should use the effective dose equivalent concept for regulations protecting people from exposure to radiation.

EPA Response: This has been done in the final rules.

SAB Comment: EPA should use simple screening methods in implementation procedures such that only the largest users of radionuclides are required to report annually to EPA.

EPA Response: A simple screening procedure has been made part of the final rule.

SAB Comment: EPA should be certain that the data used to derive its estimates of risk are the most current available, and wherever practicable to base their assessments on consensus documents.

EPA Response: EPA agrees. The SAB has given specific advice on risk factors for low-LET radiation and for radon. The SAB approaches to these risk factors have been used in the risk assessments supporting this rulemaking. The Agency acknowledges that the BEIR–III report on which some of the risk factors are based may become out of date due to new data that are becoming available. EPA's risk factors will be revised to reflect these recent developments and to incorporate this newer data as soon as it is practical to do so. Preliminary information indicates that the most probable effect of this new information will be to increase somewhat the estimate of the number of health effects due to a unit dose of radiation. The size of this increase is not likely to be large enough to affect the decisions made under this rulemaking.

SAB Comment: The actual objective of the risk assessment should be made clear.

EPA Response: EPA has improved the presentation of risk in the EIS by more clearly stating overall assessment objectives. In particular, assessment objectives are carefully defined in terms of the individual and populations at risk. The number of people at risk and incidence is presented by range of risk. Radiation risks are compared with other risks and other radiation control recommendations. The objective of obtaining a best estimate of the dose and health implications for real persons and for populations is now explained in more detail together with explanations of how these groups are to be defined.

SAB Comment: EPA should use best estimates and ranges in the specification of risk and provide a detailed explanation of the uncertainties in the estimates themselves.

EPA Response: EPA agrees, but this is a large task. For the short term, we have performed a sensitivity analysis of the most important parameters using simplifying assumptions and have performed preliminary uncertainty analyses using a Monte Carlo simulation. These analyses have been presented in support of the final rule. For the long term, an Agency task group has been formed to plan and conduct more complete studies of the uncertainty question. This longer term effort will take a number of years to complete and will be dependent on the resources available.

EPA acknowledges the uncertainty in risk estimates, considers them when making risk management decisions and recognizes that a more complete quantitative analysis of uncertainty would be an improvement. However, it does not believe that such a complete analysis would change the decisions made in this rulemaking. A more complete discussion of uncertainty is to be found in chapter 7, volume 1 of the EIS.

V. Decision to List Under Section 112

Section 122(a) of the CAA required EPA to determine whether or not "emissions of radioactive pollutants * * * will cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health." Once an affirmative determination is made, that section requires EPA to list the substance under section 108(a)(1), governing National Ambient Air Quality Standards (NAAQS), 111(b)(1)(A), governing New Source Performance Standards, or 112(b)(1)(A), governing NESHAPs. The initial decision to list a substance does not constitute a decision to regulate any particular source category. EPA analyzed numerous studies which indicated that exposure to radionuclides can cause three major types of health effects: cancer, genetic damage, and developmental effects. After considering these health effects, EPA judged that radionuclides cause or contribute to air pollution which "may reasonably be anticipated to endanger public health" and that they should be listed under section 112(b)(1)(A) (44 FR 76738, Dec. 27, 1979). That decision was the first step in the regulatory process, and it was challenged in the current litigation. As a result, EPA has reevaluated the decision and the comments from the public during this rulemaking and has come to the conclusion that the original listing under section 112 is correct.

The first part of the listing decision, the "hazardousness" of radionuclides, is unchallenged. The evidence that radionuclides can cause cancer has, if anything, increased since 1979; see Volume 1 of the BID. The evidence now suggests that the risks from radiation exposure are higher than was believed at that time. While some people have expressed the view that, even though radiation can cause cancer, the amount of radionuclides that are released from a given source or industry is insignificant and do not present a risk, EPA believes that the results of the risk assessments for the source categories demonstrate the risk to public health that results from radionuclide emissions from industrial sources. Furthermore, as already discussed, EPA assumes radiation to be a non-threshold pollutant. This assumption, and EPA's risk assessments, support the listing decision.

Section 112(b)(1)(A) applies not merely to any "air pollutant" as do sections 108 and 111, but to a "hazardous air pollutant" that is defined as a pollutant that "causes or contributes to air pollution which may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible or incapacitating reversible illness." Once a pollutant is determined to be a hazardous air pollutant, the only remaining step is for the Administrator to determine whether emissions of the pollutant present a risk warranting regulation under section 112—that is, whether it is a hazardous air pollutant "for which he intends to establish an emission standard" under that section. EPA has determined that radionuclides not only pose a risk of carcinogenicity and mutagenicity when emitted into the air (see, National Academy of Sciences, Commission on Biological Effects of Ionizing Radiation, Reports Number 3 and 4) but also are emitted in sufficient quantities as to create a risk warranting listing under section 112. Therefore, EPA reaffirms its prior conclusion that radionuclides should be listed for regulation under section 112.

EPA notes that several sources included among the source categories addressed by this rulemaking present very small risks when viewed individually. Several are predicted to emit a level resulting in an incidence of less than one case of cancer every 1000 years, and an associated MIR well below 1×10^{-4}, or even 1×10^{-6}. Based on this, it has been suggested that EPA should apply a significance test to these sources, and determine that they do not warrant regulation based on the insignificance of the risks presented.

EPA considers it unnecessary to reach that argument here. EPA applied the significance test of the Supreme Court's OSHA benzene opinion in its prior rulemakings on radionuclides to determine whether each source category warranted regulation. See *Industrial Union Dept., AFL-CIO* v. *American Petroleum Institute*, 448 U.S. 607 (1980) (interpreting the Occupational Safety and Health Act of 1970 as requiring that benzene sources be regulated only if they present "significant" risks); see also 50 FR 5189–5194 (Feb. 6, 1985), 49 FR 43905–43915 (Oct. 31, 1984) (discussing the requirement that risks from radionuclide air emission sources be significant in order to be regulated under Clean Air Act Section 112); Memorandum of A. James Barnes, General Counsel, to the Administrator of EPA entitled "Final Action on Radionuclides" (Oct. 23, 1984) (same); but see *Sierra Club* v. *Ruckelshaus*, 602 F. Supp. 892 (N.D. Cal. 1984). However, EPA believes it is unnecessary to reach this issue at this time since EPA believes that its standards should have no practical effect on the facilities to which such a test might have applicability. But see CAA section 307(d)(7)(B). Based on the record, EPA judges that the facilities that might be deemed to pose insignificant risks individually already emit radionuclides at levels well below the final standard. And, implementation of a significance test to each individual source would, for some source categories such as the NRC licensee category which contains several thousand sources, present huge implementation and resource problems for the Agency to examine each source individually.

The standards would have no practical impact on operations of sources that might be deemed to pose insignificant risks, other than to assure that emissions from these sources could not increase so as to exceed the

standard. Moreover, imposition of standards assure that EPA would be notified of significant increases in emissions at these sources, or other relevant changes in circumstances, such as changes in the location or exposure of the most exposed individual, that might require additional regulatory attention.

VI. Discussion of Source Categories

The regulatory decisions reached today are based on the risk assessments and other factors available in the rulemaking record. This rule is also based on consideration of information received during the comment period to the rulemaking.

A. Department of Energy Facilities

1. Introduction

The DOE administers many facilities, including government-owned, contractor-operated facilities across the country. Some facilities conduct nuclear energy and weapons research and development, some enrich uranium and produce plutonium for nuclear weapons and reactors, and some process, store and dispose of radioactive wastes. These facilities contain significant amounts of radioactive material and emit radionuclides into the air. Other facilities contain large stockpiles of waste ore which emit large quantities of radon. A discussion of these DOE facilities appears as a separate section later in this Preamble. EPA is considering the two categories separately in this rulemaking because the two categories employ different control methods. Some of the DOE facilities emitting radionuclides are on large sites covering hundreds of square miles in remote locations. Some of the smaller sites resemble typical industrial facilities and are located in suburban areas.

In total, DOE has approximately 30 major sites that emit radionuclides. These facilities emit a wide variety of radionuclides in various physical and chemical states. Emissions from various DOE facilities represent many types of radionuclides and both internal and external dose pathways (although specific facilities may emit only one or two radionuclides affecting only one pathway).

DOE facilities are presently covered by a radionuclide NESHAP which limits emissions such that no individual receives a whole body dose of 25 mrem/y or receives a dose of 75 mrem/y to any organ. DOE also controls releases from these facilities under DOE orders which limit calculated doses to the general public to less than 100 mrem/y from all sources and pathways. By incorporating the ALARA concept into its Orders, DOE has kept the dose to the public well below 100 mrem/y. The NESHAP also mandates that DOE send annual reports of emissions to EPA. The information gathered from these reports contributed to EPA's risk assessment of DOE facilities.

2. Estimates of Exposure and Risk

EPA's risk assessment of DOE facilities is a site-by-site assessment. Emissions are based on DOE's 1986 report of emissions, meteorological data are from on-site towers or from nearby weather stations, and population distributions within 80 km are based on U.S. census tract data. EPA has updated its risk assessment with information received during the comment period. EPA has a high degree of confidence in the results of this risk assessment.

According to EPA's analysis, all DOE facilities are in compliance with the current NESHAP. The risk to the most exposed individual is approximately 2.0×10^{-4}. DOE facilities are estimated to cause 0.28 fatal cancers per year to the exposed populations within 80 km of all DOE facilities. Most of the exposed population has a lifetime fatal cancer risk of less than 1×10^{-6}.

Table 3 presents example scenarios to show how different emission levels would result in different health risk profiles. The table presents the risk estimates at baseline in terms of estimated annual fatal cancer incidence, maximum individual lifetime risk, total population exposed at or above particular risk levels (i.e., risk distribution), and annual incidence attributable to the population exposed at each risk level. The table also presents available estimates of annual incidence and maximum individual lifetime risk for a lower emission level.

3. Application of Decision Methodology to the DOE Facilities Source Category

The decision that results from the application of the multifactor policy approach to the DOE source category is described below.

Decision on Acceptable Risk. As stated earlier, the maximum individual risk to any individual is 2.0×10^{-4}. In establishing the policy for setting NESHAPs in the context of benzene, the Agency determined that emissions resulting in a lifetime MIR no greater than approximately 1×10^{-4} are presumptively acceptable. In light of the numerous uncertainties in both establishing the parameters for the risk assessment and in modelling actual emissions and exposure, as well as the recognition that in achieving compliance, sources will generally control so as to ensure that a buffer exists below the actual level of a standard, EPA judges that the MIR of 2.0×10^{-4} is essentially equivalent to the presumptively safe level of approximately 1×10^{-4}. EPA then considered the other risk factors in order to determine whether the baseline level is acceptable.

The estimated annual incidence is 0.28 fatal cancers per year, or 1 case every 4 years; in addition, there would be an approximately equal number of non-fatal cancers per year. Very few people are at risks greater than 1.0×10^{-4}, and approximately 98% of people within 80 km of DOE facilities receive risks of less than 1×10^{-6}.

After examining these factors, the Administrator has determined that the baseline emission levels and risks from DOE facilities are acceptable.

Decision on Ample Margin of Safety. In addition to reexamining all the health-related factors discussed above, EPA has also examined the cost, scientific certainty, and technological feasibility of control technology necessary to lower emissions from DOE facilities. The results of this analysis may be seen in Table 4. Alternative I, a standard of 10 mrem/y, representing the current baseline emissions, was compared with alternative II, a standard of 3 mrem/y a standard, equivalent to 1×10^{-4}.

A comparison of the two alternatives indicates that only a very small reduction in incidence would occur, from 0.28 to 0.25, or 1 case every 33 years, with a concommitant reduction in MIR from 2×10^{-4} to 1×10^{-4}. Based on this very small reduction in incidence, the small decrease in individual risk that would result, and on the costs of achieving Alternative II, EPA has determined that a 10 mrem standard provides an ample margin of safety by continuing regulation of this category to insure that the current levels of emissions are not increased. Requirements of the rule, such as the submission of yearly reports and obtaining prior approval of new construction or modification, assure that DOE facilities will keep emissions at or below an acceptable level insuring an ample margin of safety. Moreover,

because each facility subject to this rule must demonstrate compliance with the 10 mrem/y ede emissions standard, it is likely that most, if not all, exposed individuals will receive a dose significantly less than 10 mrem/y ede. Therefore, EPA believes that limiting emissions to their current level by imposition of a standard of 10 mrem/y EDE to replace the previous standard, will protect public health with an ample margin of safety. EPA is promulgating a NESHAP mandating that radionuclide emissions from DOE facilities shall not cause any individual to receive a dose of greater than 10 mrem/y ede.

TABLE 3.—DOE FACILITIES

[*Description:* The facilities owned and controlled by DOE. These include nuclear weapons production, testing and research facilities and other nuclear research and production facilities. There are 30 major DOE facilities that release radionuclides into the air.]

	Alternative I (baseline)	Alternative II
Maximum individual risk (lifetime)	2.0×10^{-4}	1×10^{-4}
Incidence within 80 km (death/y)	0.28	0.25
Risk individual		
E-2 to E-1	0	0
E-3 to E-2	0	0
E-4 to E-3	(*)	(*)
E-5 to E-4	590,000	560,000
E-6 to E-5	1M	250,000
less E-6	65M	66M
Risk incidence		
E-2 to E-1	0	0
E-3 to E-2	0	0
E-4 to E-3	(*)	(*)
E-5 to E-4	0.23	0.22
E-6 to E-5	0.032	0.0074
less E-6	0.010	0.014

Other Health Impacts: Total cancers no more than twice fatal cancers.

* There are fewer than 25 people at this risk. However, we cannot quantify the number because detailed demographics have not been obtained.

TABLE 4.—DOE FACILITIES

Alternative	MIR	Incidence	Increment incidence reduction	Total incidence reduction	Increment capital cost	Increment annualized cost	Total annualized cost
I (Baseline)	2.0×10^{-4}	0.28					
II	1.0×10^{-4}	0.25	0.03	0.03	$ 5.9M	$ 0.2M	$ 0.2M

Comments: Alternative I: Baseline rule, emission limit of 10 mrem/y ede—highest emissions are from Los Alamos and Oak Ridge.
Alternative II: Emission limit of 3 mrem/y ede (equivalent to a MIR of 1×10^{-4})—the following controls are needed: Los Alamos—beam stops and delay lines; Oak Ridge—HEPA filters, particulate scrubbers, and tritiated water capture.

4. Implementation

a. *Introduction.* ORP's experience in implementing the existing radionuclide NESHAP covering DOE facilities has shown that implementation of the current standard has several problems. EPA has developed a new system for implementing the NESHAP designed to overcome the limitations in the present standard.

b. *Yearly Reports.* The implementation system for the NESHAP is designed to provide EPA with yearly reports on the levels of emissions from regulated facilities and resulting doses. Presently, DOE facilities monitor their emissions and make annual reports to EPA. These reports shall continue under the new NESHAP. Although the report is based on a calendar year the dose standard applies to any year, i.e. any period of 12 consecutive months. Since these reports provide EPA with the information it needs, DOE facilities are exempted from the requirements of 61.10.

c. *Methods of Measurement.* Because the thresholds for measurement are much lower than the standard, under certain circumstances the concentration and potential doses associated with release points that are above the threshold may be so low that direct measurement may not be practical. With prior EPA approval, DOE may determine these emissions through alternate procedures.

d. *Definition of a Facility.* A problem in implementing the current standard is the ambiguity associated with the present definition of a facility. To resolve this ambiguity, the new rule specifies that all the buildings, structures and operations within one contiguous site shall be considered a single facility. For example, the entire DOE facility at Oak Ridge, Tennessee must meet the current standard of 10 mrem/y ede, instead of each individual building meeting the 10 mrem/y ede standard.

e. *Distinction Between Construction and Modification.* A potential problem resulting from EPA's definition of a facility as all the buildings, structures and operations within a given plant site, is confusion over whether the construction of a new building is part of an existing facility, is new construction, or is a modification of an existing facility. This rule specifies that the construction of a new building is new construction at the facility and not a modification of the facility. This distinction is important because all new construction needs to be checked to see whether or not it needs prior approval but modifications which do not cause a net increase in the rate of emissions from the facility do not need prior approval.

f. *Prior Approval of New Construction or Modification.* EPA will not change the basic definition of modification that exists at 40 CFR 61.15. A change that will result in any increase in the rate of emissions is a modification, no matter how small that increase is. This includes cases where the modification has the potential to increase emissions above prior actual emissions. However, to reduce unnecessary paperwork, it is appropriate to avoid applications for approval in cases of small changes.

Therefore, EPA is promulgating a system under which DOE facilities will use CAP-88 to determine the dose to the most exposed individual due to the modification or new construction. If the estimated maximum individual dose added by the new construction or modification is less than 1% of the standard, then the modification or new construction does not need prior approval.

In making the determination of dose for this purpose, DOE must use the emission factors and source term determination from "BID: Procedures Approved for Demonstrating Compliance with the Dose Limits Established by 40 CFR part 61, subpart I." (BID: Compliance) or other procedures for which EPA has granted prior approval.

B. Nuclear Regulatory Commission Licensed and Non-DOE Federal Facilities

1. Introduction

NRC-licensed, Agreement state-licensed, and non-DOE federal facilities include over 6,000 different facilities. These facilities include research and test reactors, hospitals, clinics, the radiopharmaceutical industry, low level nuclear waste disposal facilities, and other research and industrial facilities. These facilities are located in all fifty states. EPA estimates that virtually every American lives within 80 km of an NRC licensee.

The facilities in this category emit a large number of radionuclides. These radionuclides affect individuals by inhalation, ingestion, ground deposition and immersion pathways. Individual facilities may emit only one or two radionuclides affecting only one or two pathways.

Emissions from this source category are presently covered by a radionuclide NESHAP which mandates that emissions do not cause any individual to receive a whole body dose of more than 25 mrem/y or receive a dose of 75 mrem/y to any organ. Two categories of NRC-licensees have been exempted from coverage by the existing NESHAP: High-level nuclear waste (HLW) facilities and uranium fuel cycle (UFC) facilities. There are two types of HLW facilities, management and disposal facilities. The disposal of HLW, which occurs at a few unique facilities, is considered as a separate source category. The management, processing and storage of HLW that occurs at a NRC-licensee is included in the estimate of emissions of the licensee used in the analysis that underlies the rule for this category. UFC facilities, which are distinctly different facilities, are being analyzed as a separate source category.

2. Estimates of Exposure and Risk

EPA's risk assessment of this category combined an analysis of the nine sub-categories that make up this category. Due to the wide scope of this category, EPA's risk assessment of this source category includes both the largest known emitters and model facilities with model populations. The estimates of maximum individual risk are based on the assessment of the largest known emitters.

The analysis of the largest sources was based on information compiled from previously existing databases and information received from some of the sources themselves. The model facilities were developed after reviewing data from surveys conducted by the NRC and the Conference of Radiation Control Program Directors. The use of model facilities increases the uncertainty of the risk assessment. Especially uncertain are estimates of the population within given risk ranges.

The estimates of population risks are based on extrapolations from model facilities using census tract data. Frequency distributions do not take into account overlapping sources.

The results of this analysis show a maximum individual risk of 1.6×10^{-4}. EPA estimates that this category results in 0.16 fatal cancers per year. Although virtually the entire U.S. population is exposed to emissions from this category, EPA's analysis shows that less than 0.5% of the U.S. population receives a lifetime fatal cancer risk greater than 1×10^{-6}. Some of the larger NRC-licensees release small amounts of iodine-125 and iodine-131; these radionuclides can cause thyroid cancer, which is usually non-fatal.

Table 5 presents example scenarios to show how different emission levels would result in different health risk profiles. The table presents the risk estimates at baseline in terms of estimated annual fatal cancer incidence, maximum individual lifetime risk, total population exposed at or above particular risk levels (i.e., risk distribution), and annual incidence attributable to the population exposed at each risk level. The table also presents available estimates of annual incidence and maximum individual lifetime risk for a lower emission level.

3. Application of the Decision Methodology to the NRC Licensees and non-DOE Federal Facilities Source Category

The decision that results from the application of the multifactor approach to the NRC-licensees and non-DOE Federal facilities source category is described below.

Decision on Acceptable Risk. As stated earlier, the maximum individual risk to any individual is 1.6×10^{-4}. In establishing the policy for setting NESHAPs in the context of benzene, the Agency determined that emissions resulting in a lifetime MIR no greater than approximately 1×10^{-4} are presumptively acceptable. In light of the numerous uncertainties in both establishing the parameters for the risk assessment and in modelling actual emissions and exposure, as well as the recognition that in achieving compliance sources will generally control so as to ensure a buffer exists below the actual level of a standard, EPA judges that the MIR of 1.6×10^{-4} is essentially equivalent to the presumptively safe level of approximately 1×10^{-4}. EPA then considered the other risk factors in order to make an overall determination on acceptability.

Very few people are at risks greater than 1.0×10^{-4} and approximately 99% of people within 80 km of NRC licensees are at risk levels of less than 1×10^{-6}. The estimated annual incidence is 0.16 fatal cancers per year, or 1 case every 6 years. In addition, there would be an estimated annual incidence of approximately 0.8 non-fatal cancers per year, most of which is attributable to thyroid cancer caused by emissions of radioactive iodine from hospitals and radiopharmaceutical manufacturers (thyroid cancer is also treated with iodine treatments).

After examining these factors, the Administrator concludes that baseline emissions are acceptable for this source category.

Decision on Ample Margin of Safety. In addition to re-examining all the health-related factors discussed above, EPA has also examined the cost, scientific certainty, and technological feasibility of control technology necessary to lower emission from NRC facilities. The results of this analysis may be seen in Table 6. Due to a lack of detailed information on all NRC licensees, EPA has analyzed model facilities. Alternative I, a standard of 10 mrem/y representing the current baseline emissions, was compared with Alternative II, a standard of 3 mrem/y, a standard equivalent to 1×10^{-4}.

EPA's risk assessment indicates that no reduction in incidence would occur and only a small reduction of the MIR would occur if reduction of current emissions to Alternative II levels were required. In this source category almost all the incidence comes from people whose risk level is less than 1×10^{-6}. This means that small reductions in the emissions of a few licensees have little, if any, effect on the number of health effects, both fatal and non-fatal, in the population. The costs associated with these reductions are $5,000,000 with an annualized cost of $2,400,000 for compliance with Alternative II. Based on the very small reductions in the risks to public health and the costs of achieving Alternative II, EPA has determined that Alternative I protects the public health with an ample margin of safety.

EPA has decided to continue regulation of this category to insure that the current levels of emissions are not increased. Requirements of the rule, such as the submission of yearly reports and obtaining prior approval of new construction or modification, will assure

that NRC licensees will keep emissions at or below levels insuring an ample margin of safety. Moreover, because each facility subject to this rule must demonstrate compliance with the 10 mrem/y ede emissions standard, it is likely that most, if not all, exposed individuals will receive a dose significantly less than 10 mrem/y ede. EPA believes that limiting emissions with a baseline standard, represented by a level of 10 mrem/y ede, will therefore protect public health with an ample margin of safety. Furthermore, to insure that the risk of nonfatal thyroid cancer does not increase, the standard further provides that no more than 3 mrem/y ede out of the 10 mrem/y ede can come from any of the isotopes of iodine. Therefore, EPA is promulgating a NESHAP mandating that radionuclide emissions from NRC licensees shall not cause any individual to receive a dose of greater than 10 mrem/y ede, of which no more than 3 mrem/y ede can come from isotopes of iodine.

TABLE 5—NRC LICENSEES

[*Description*: There are about 6,000 NRC material licensees: Radiopharmaceutical manufacturers and users, sealed sources manufacturers, research reactors, industrial and university laboratories, and low-level waste disposal facilities.]

	Alternative I (baseline)	Alternative II
Maximum individual risk (lifetime)	1.6×10^{-4}	1×10^{-4}
Incidence within 80 km (death/y)	0.16	0.16
Risk individual:		
E-2 to E-1	0	0
E-3 to E-2	0	0
E-4 to E-3	(*)	(*)
E-5 to E-4	5,000	5,000
E-6 to E-5	780,000	780,000
less E-6	240M	240M
Risk incidence:		
E-2 to E-1	0	0
E-3 to E-2	0	0
E-4 to E-3	(*)	(*)
E-5 to E-4	0.0024	0.0024
E-6 to E-5	0.027	0.027
less E-6	0.13	0.13

* There are fewer than 25 people at this risk. However, we cannot quantify the number because detailed demographics have not been obtained.

Other Health Impacts: Total cancers are approximately 5 times higher than the number of fatal cancers because risks from some of the largest facilities in this source category are caused predominately by iodine which causes thyroid cancer.

TABLE 6—NRC LICENSEES

Alternative	MIR	Incidence	Increment incidence reduction	Total incidence reduction	Increment capital cost	Increment annualized cost	Total annualized cost
I (Baseline)	1.6×10^{-4}	0.16					
II	1.0×10^{-4}	0.16	<0.01	<0.01	$5M	$2.4M	$2.4M

Comments: For this category, non-fatal cancer risk is appreciably higher than the fatal cancer risk because most of the risk is due to I-131 and I-125 exposure (thyroid).

Alternative I: Baseline rule, 10 mrem/y ede—As a practical matter, this alternative is the same as the current NESHAP.

Alternative II: Emission limit of 3 mrem/y ede (equivalent to a MIR of 1×10^{-4})—cost estimates are very uncertain. Several hundred facilities would install controls or measure emissions to demonstrate compliance. Thousands would have to report to EPA.

4. Implementation

a. *Introduction.* The system for implementing this NESHAP is described in "A Guide for Determining Compliance with Clean Air Act Standards for Radionuclide Emissions From NRC-Licensed and Non-DOE Federal Facilities." The Agency has also developed the COMPLY Computer Code, for use with "MS-DOS" or "PC-DOS," computers to assist the regulated community in determining compliance with the standard. For more information, see "Draft User's Guide for the COMPLY Code" and "Background Information Document—Procedures Approved for Demonstrating Compliance with 40 CFR part 61, subpart I."

b. *Yearly Reports.* The implementation system for the NESHAP is designed to provide EPA with yearly reports on the levels of emissions and the dose caused by those emissions from regulated facilities. There are over 6,000 NRC-licensees, many of which possess very small amounts of radionuclides. EPA considers that the emissions from most sources in this category are so low that reporting should not be necessary. EPA has developed a system to determine whether or not reporting is required by estimating the dose caused by a facility's emissions. As long as the dose to the maximum individual is 10% of the standard or less, the facility does not have to report. With this provision, EPA currently estimates that less than 300 facilities would have to report to EPA.

The Agency has developed a system for dose determination that is based on screening models originally developed by the NCRP. This system is a series of screening tests each more complicated and more realistic than the previous one. Using this system, each affected facility will, annually, have to check to see whether or not it needs to report to EPA. Even if it does not have to report, it must keep records of the results for 5 years to demonstrate that it has checked to see whether or not it needs to report. Although the report is based on a calendar year, the dose standard applies to any year, i.e. any period of 12 consecutive months.

In order to simplify calculation of the source term, the Agency will allow the use of EPA-approved emission factors. The derivation of these emission factors is explained in "BID: Compliance." These factors are applied to the quantity of radionuclides used annually at the facility. Radionuclides in sealed containers are excluded. The results of these calculations are used as the input of emissions for the screening model mentioned above.

For the calculation of dose from low level radioactive waste, facilities must use CAPP-88 or another model which has prior approval from EPA.

Since these reports will provide EPA with the information it needs, NRC-licensees are exempted from the requirements of § 61.10.

c. *Prior Approval for Modification or New Construction.* EPA has decided that the system discussed for DOE facilities also be used for this source category except that the sources will not use CAP-88 to calculate the doses. Instead they will use the screening models (COMPLY code) described in the BID.

5. Reconsideration of NRC Licensee Category

Late in the rulemaking, issues related to the application of the standard in Subpart I to NRC licensees were presented to EPA which raised serious concerns about possible effects of

duplicative, and perhaps conflicting, standards on NRC-licensees, including, for example, the use of radioisotope therapies by the National Institutes of Health (NIH) and other medical facilities. The concerns arise from the fact that these licensees would be regulated by both a Clean Air Act standard under Subpart I and an existing NRC standard under 10 CFR part 20. While the level of health protection achieved under the NRC standard is generally comparable to that required by EPA's rule, the two standards are very different in form, and the means of demonstrating compliance with each standard impose significantly different regulatory requirements. The basic issue is whether these different regulatory requirements will discourage the use of radioisotopes in medical and experimental therapies. In addition, NRC has raised the issue of whether regulation of its licensees under a Clean Air Act standard provides any additional public health benefits.

EPA has expressed similar concerns in past proceedings on this regulation. In its **Federal Register** notice of October 31, 1984, EPA stated, with respect to NRC-licensed facilities, that the record "does not support the conclusion that regulation of (these) * * * facilities is necessary to protect public health with an ample margin of safety." 49 **Federal Register** at 43912. In its **Federal Register** notice of February 6, 1985 (50 FR 5190) EPA stated that:

> EPA continues to believe existing emissions from these sources are already so low that the public health is already protected with an ample margin of safety * * *

Nevertheless, due to the court-ordered deadline for completion of the rulemaking by October 31, EPA has determined that it must promulgate the final standard under Subpart I at this time. However, in recognition of the serious nature of these concerns, and the need to further investigate and resolve these matters, EPA has concluded that it should treat the comments and information filed by NIH and NRC as petitions for reconsideration of the standard with respect to the range of issues raised by NRC and NIH, and EPA is granting reconsideration. For this purpose, a comment period of 60 days from the date of publication of this notice is hereby established for the purpose of receiving further information and comments on these issues, and a 3 month stay of subpart I, as provided for under 307(d)(7)(B), shall commence on the [date of publication]. Comments should be submitted (in duplicate if possible) to: Central Docket (A–130), Environmental Protection Agency, Attn: Docket No. A–78–11, Washington, DC 20460. After considering the information received, and other available information pertaining to these issues, EPA will issue a decision on the need for further rulemaking on the standard in subpart I.

C. Uranium Fuel Cycle Facilities

1. Introduction

Uranium Fuel Cycle (UFC) facilities are the facilities used in the conversion of uranium ore to electric power. They include uranium mills and tailings (non-radon emissions), uranium hexafloride conversion plants, light-water uranium fuel fabrication plants, commercial light-water nuclear power plants, and fuel reprocessing plants. These facilities are licensed by the NRC. (Uranium fuel enrichment facilities are not included in this category because they are included in the DOE facilities source category. Reprocessing plants are not included since the only one ever operated is being decommissioned and no reprocessing can occur under current policies. If a new one were to be opened in the future, it would be covered by the rule.) These facilities involve operations with the potential for large releases of radionuclides.

These facilities are not currently covered by a NESHAP. However, all releases from these facilities (air, water and direct gamma radiation) are covered under the Uranium Fuel Cycle Standard, 40 CFR part 190. This standard was promulgated by EPA under the authority of the AEA and is implemented and enforced by NRC. Under the standard, the combined releases of all UFC facilities must not cause any member of the public to receive a dose of more than 25 mrem/y to the whole body or to any organ except the thyroid (which can receive 75 mrem/y). In the past, the Administrator decided not to regulate this category under section 112, because he determined that the AEA standard protected public health with an ample margin of safety. EPA's decision not to regulate this category is one of the issues in the current litigation.

2. Estimates of Exposure and Risk

EPA's risk assessment for this category is the combination of the results of the assessments of the different types of facilities included in this category. The source term for emissions from uranium mill tailing piles is estimated for operable mills using NRC's methodology. Fugitive dust emissions from a tailing pile are assumed to be a function of meteorological conditions (wind, rainfall, temperature), ore composition, particle size and other factors. The estimate does not include radon releases which are covered by a separate NESHAP. Meteorological and population data are based on actual mill sites. The assessment of the two uranium hexafluoride conversion plants is based on reported emissions and census population distributions and meteorological data from nearby airports.

The assessment for fuel fabrication plants is based on reported emissions and census population distributions from the largest facility. The emission estimate for nuclear power plants is based on actual releases from operating plants. Population data is taken from NRC reference populations. Assessments consider effects of multiple reactors at a site, but not the overlap of multiple sites. The results of the analysis show that the most exposed individual receives a dose associated with an increased risk of fatal cancer of 1.5×10^{-4}. There is a predicted incidence of 0.1 fatal cancer per year in the population, with almost all the population risk received by people with a lifetime risk of less than 1×10^{-6}. Virtually the entire U.S. population lives within 80 km of at least one UFC facility.

Table 7 presents example scenarios to show how different emission levels would result in different health risk profiles. The table presents the risk estimates at baseline in terms of estimated annual fatal cancer incidence, maximum individual lifetime risk, total population exposed at or above particular risk levels (i.e., risk distribution), and annual incidence attributable to the population exposed at each risk level. The table also presents available estimates of annual incidence and maximum individual lifetime risk for a lower emission level.

3. Application of Decision Methodology to the Uranium Fuel Cycle Source Category

The decision that results from the application of the multifactor approach to the UFC facilities source category is described below.

Decision on Acceptable Risk. As stated earlier, the maximum individual risk to any individual is approximately 1.5×10^{-4}. In establishing the policy for setting NESHAPs in the context of benzene, the Agency determined that emissions resulting in a lifetime MIR no greater than approximately 1×10^{-6} are presumptively acceptable. In light of the numerous uncertainties in both establishing the parameters for the risk

assessment and in modelling actual emissions and exposure, as well as the recognition that in achieving compliance, sources will generally control so as to ensure a buffer exists below the actual level of a standard, EPA judges that the MIR of 1.5×10^{-4} is essentially equivalent to the presumptively safe level of approximately 1×10^{-4}. EPA then considered the other risk factors in order to make an overall decision on acceptability. The estimated annual incidence is 0.1 fatal cancer per year, and approximately 99% of that risk is borne by people whose risk is less than 1×10^{-6}. Only 60 individuals incur a risk greater than 1×10^{-4}, and the incidence in the level greater than 1×10^{-4} is only 0.00093.

After examining these factors, the Administrator has determined that the baseline risks from UFC facilities are acceptable.

TABLE 7—URANIUM FUEL CYCLE FACILITIES

[Description: The facilities that convert uranium ore into electric power. They include operating uranium mills (nonradon emissions), uranium hexafluoride conversion plants, fuel fabrication plants, nuclear power reactors. About 135 facilities make up this category.]

	Alternative I (baseline)	Alternative II
Maximum individual risk (lifetime)	1.5×10^{-4}	3.0×10^{-5}
Incidence within 80 km (death/y)	0.1	0.1
Risk individual:		
E-2 to E-1	0	0
E-3 to E-2	0	0
E-4 to E-3	80	0
E-5 to E-4	6,600	4,000
E-6 to E-5	42,000	20,000
less E-6	240M	240M
Risk incidence:		
E-2 to E-1	0	0
E-3 to E-2	0	0
E-4 to E-3	0.0002	0
E-5 to E-4	0.0012	0.001
E-6 to E-5	0.0002	0.0006
less E-6	0.094	0.094

Other Health Impacts: Total cancers no more than twice fatal cancers.

TABLE 8—URANIUM FUEL CYCLE FACILITIES

Alternative	MIR	Incidence	Increment incidence reduction	Total incidence reduction	Increment capital cost	Increment annualized cost	Total annualized cost
I (Baseline)	1.5×10^{-4}	0.1					
II	3.0×10^{-5}	0.1	<0.01	<0.01	$75M	$31M	$31M

Comments:
Alternative I: Baseline rule, 10 mrem/y ede—the dose from one uranium mill is of this magnitude.
Alternative II: Emission limit of 1 mrem/y ede (equivalent to a MIR of 3×10^{-5})—Most of the incidence is due to power reactors and only a few are affected by this alternative, so there is little reduction in incidence. Additional controls are required for uranium mills and uranium conversion plants.

Decision on Ample Margin of Safety. In addition to reexamining all the health-related factors discussed above, EPA has also examined the cost, scientific certainty, and technological feasibility of control technology necessary to lower emissions from UFC facilities. The results of this analysis may be seen in Table 8. To reduce the complexity of studying the costs and benefits of all different control options, EPA has concentrated on the facilities with the largest emissions. Alternative I, a standard of 10 mrem/y representing the current baseline emissions, was compared with Alternative II, a standard of 1 mrem/y, equivalent to 3×10^{-5}.

EPA's risk assessment indicates that a small reduction in the MIR and an estimated reduction of incidence by less than one case every 100 years would occur by reducing emissions from their present levels to a level equivalent to 1×10^{-4}. This occurs because the incidence from this source category is caused by the large number of people, each of whom is at very low risk levels. This results in a situation where small reductions in emissions from a couple of facilities that are above the level of Alternative II, achieve effectively no reduction in the public health impact from the source category. Based on these factors and on the costs of achieving Alternative II (Table 8), EPA has determined that the current emission level provides an ample margin of safety. Therefore, EPA believes that limiting emissions to their current level by imposition of a standard of 10 mrem/y ede, will protect public health with an ample margin of safety.

EPA has decided to regulate this category to insure that the current levels of emissions are not increased. The requirements of the rule assure that UFC facilities will keep emissions at or below the level of the standard, thereby insuring an ample margin of safety. The reporting provisions also provide the public with information on the emissions from the facility and provides them with assurance that the emissions will remain safe with an ample margin of safety, regardless of changes in the facility or the local population. Moreover, because each facility subject to this rule must demonstrate compliance with the 10 mrem/y ede emissions standard, it is likely that most, if not all, exposed individuals will receive a dose significantly less than 10 mrem/y ede. Therefore, EPA is promulgating a NESHAP mandating that radionuclide emissions from UFC facilities shall not cause any individual to receive a dose greater than 10 mrem/y ede.

4. Implementation

EPA has determined that the same level of regulation is appropriate for both UFC facilities and NRC-licensees. Therefore, EPA has removed the exemption for UFC facilities in the NRC-licensee NESHAP and will regulate them exactly the same as other licensees, including reporting and recordkeeping requirements.

EPA approves the use of the current version of NRC regulatory guidances for use in determining the emissions from UFC facilities and will consider making a technical change to this rule to allow use of updated versions when they become available.

D. Elemental Phosphorus Plants

1. Introduction

Elemental phosphorus plants extract pure phosphorus from ore for use in the chemical industry. These facilities emit radionuclides into the air because phosphate ore is high in uranium and its decay products. These decay products, especially polonium-210 and lead-210, become volatilized during the extraction process and are released into the

atmosphere. There are eight (5 operational, 3 standby) elemental phosphorus plants located in four different states. However, most of the emissions come from two plants in Idaho.

Due to the types of radionuclides emitted by these plants, virtually all the dose is received by the lung through the inhalation pathway causing an increased risk of lung cancer. This risk can be controlled through the use of a standard which directly limits emissions of polonium-210 (control measures which limit polonium-210 also limit emissions of lead-210). There is no need to write dose standards.

Elemental phosphorus plants are currently regulated by a NESHAP that limits their emissions to no more than 21 curies of polonium-210 annually.

2. Estimates of Exposure and Risk

EPA's risk assessment of elemental phosphorus plants is a site-by-site assessment of operating and standby plants, based on monitored data and throughput. Changes in the risk assessment since the proposal are the result of corrected meteorological data. Maximum individual risks were assessed at actual residences or at a location 1500 m in the predominant wind direction. The location of nearby populations was taken from census tract data.

According to the assessment, EPA estimates that the most exposed individual receives a lifetime fatal cancer risk of 5.7×10^{-4}. There is an increased incidence of 0.072 fatal cancer per year in the nearby (within 80 km) population, or 1 case every 14 years. Over 75% of the exposed population receives risks of less than 1×10^{-6}.

Table 9 presents example scenarios to show how different emission levels would result in different health risk profiles. The table presents the risk estimates at baseline in terms of estimated annual fatal cancer incidence, maximum individual lifetime risk, total population exposed at or above particular risk levels (i.e., risk distribution), and annual incidence attributable to the population exposed at each risk level. The table also presents available estimates of annual incidence and maximum individual lifetime risk for a lower emission level.

3. Application of Decision Methodology to the Elemental Phosphorus Plants Source Category

The decision that results from the application of the multifactor approach to the elemental phosphorus plants source category is described below.

Decision on Acceptable Risk. As stated earlier, the maximum individual risk to any individual is 5.7×10^{-4}. This is higher than the presumptively safe level. The estimated annual incidence is 0.072 fatal cancer per year. There are an estimated 5000 people that are exposed to risk levels greater than 1×10^{-4}, and an estimated 365,000 people that are exposed to risk levels greater than 1×10^{-6}. After examining these factors, the Administrator has determined that the risk level represented by the baseline is unacceptable. EPA then considered Alternatives II and III to determine an acceptable risk level. A reduction in emissions to 2 curies/y Po-210 would reduce the incidence to 0.024, or 1 case every 40 years and expose no one to a risk level greater than 1×10^{-4}. This equals the level that is presumptively safe. Therefore, the acceptable level of emissions of polonium-210 is a level that limits the maximum individual risk to any individual of 1×10^{-4}, represented by an emissions level of 2 curies/y Po-210.

TABLE 9—ELEMENTAL PHOSPHORUS PLANTS

[Description: These plants extract pure phosphorus for use in the chemical industry. They emit polonium-210 and lead-210 because these materials are present in phosphate ore and are vaporized by the high temperature in the process. There are 8 elemental phosphorus plants, of which 5 are currently operating. The majority of emissions come from 2 plants in Idaho.]

	Alternative I (baseline)	Alternative II	Alternative III
Maximum individual risk (lifetime)	5.7×10^{-4}	1×10^{-4}	1×10^{-5}
Incidence within 80 km (death/y)	0.072	0.024	0.0022
Risk individual:			
E-2 to E-1	0	0	0
E-3 to E-2	0	0	0
E-4 to E-3	5,000	0	0
E-5 to E-4	110,000	20,000	0
E-6 to E-5	250,000	330,000	17,000
less E-6	1.5M	1.5M	1.8M
Risk incidence:			
E-2 to E-1	0	0	0
E-3 to E-2	0	0	0
E-4 to E-3	0.010	0	0
E-5 to E-4	0.040	0.0051	0
E-6 to E-5	0.016	0.013	0.00040
less E-6	0.0058	0.0059	0.0018

Other Health Impacts: Non-fatal cancers no more than 5% of deaths.

TABLE 10—ELEMENTAL PHOSPHORUS PLANTS

Alternative	MIR	Incidence	Increment incidence reduction	Total incidence reduction	Increment capital cost	Increment annualized cost	Total annualized cost
I (Baseline)	5.7×10^{-4}	0.072					
II	1×10^{-4}	0.024	0.048	0.048	$8.5M	$2.4M	$2.4M
III	1×10^{-5}	10.0022	0.022	0.070	$35M	$18M	$20M

Comments:
Alternative I: Baseline rule, emission limit of 10 Ci/y Po-210—highest current emission rate is 10 curies/y Po-210.
Alternative II: Emission limit of 2 Ci/y Po-210, high energy scrubbers on the two largest plants.
Alternative III: Fabric filters on the two largest plants. High energy scrubbers on all other plants.

Decision on Ample Margin of Safety. In addition to reexamining all the health-related factors discussed above, EPA has also examined the cost, scientific certainty, and technological feasibility of control technology necessary to lower emissions from elemental phosphorus plants. The results of this analysis may be seen in Table 10. Alternative II, a standard of 2 curies/y of polonium-210 representing the acceptable level, was compared with Alternative III, which would require a collection of work practices.

A comparison of the two alternatives indicates that in absolute terms, a very small reduction in incidence would occur, from 0.024 to 0.0022, representing an estimated savings of 1 life every 45 years. Level III would also lower the MIR by one order of magnitude to 1×10^{-5}. EPA examined these very small reductions in risks, and the relatively large costs of achieving Alternative III, and has determined that Alternative II protects the public health with an ample margin of safety. Therefore, EPA is establishing a NESHAP limiting emissions from elemental phosphorus plants to 2 curies/y of polonium-210, as compared to the existing standard of 21 curies/y.

4. Implementation

The current NESHAP for elemental phosphorus plants required each plant to either conduct an initial test on its emissions or get a waiver from testing. After this original report no further testing was required, unless plant operations were changed significantly. EPA plans to continue this system, without the waiver provisions. Tests conducted under the current NESHAP are still valid if conditions have not changed.

Plants will be required to monitor their operations continuously and keep records of the results of their monitoring onsite for five years. Plant owners will have to certify on a semiannual basis that no changes in operations that would require new testing have occurred. Although the report is based on a calendar year the emission limit applies to any year, i.e. any period of 12 consecutive months.

Since the reports provide EPA with the information it needs, elemental phosphorous plants are exempted from the requirements of § 61.10.

E. Coal-Fired Utility and Industrial Boilers

1. Introduction

This category covers electrical utility and industrial boilers which emit the radionuclides naturally present in coal. Coal contains only minute amounts of radionuclides. This category is being considered because large boilers burn large quantities of coal and are so widely dispersed throughout the nation that the radionuclide emissions are estimated to cause 0.8 fatal cancer a year among the U.S. population.

Emissions from coal-fired boilers are presently regulated under National Ambient Air Quality Standards for particulate matter. In addition, the larger new coal-fired boilers have to meet New Source Performance Standards (NSPS). Coal-fired boilers are regulated for the other pollutants they emit including SO_2 and particulates.

2. Estimates of Exposure and Risk

EPA's risk assessment of coal-fired boilers is based on extrapolations of estimated radionuclide emissions based on actual particulate emissions with model populations. Estimates of emissions are from the reference facilities with the largest emissions. Population risks are based on emissions from typical plants. These emissions were analyzed on four sites: urban, suburban, rural and remote. Further information was received from a recent study of emissions from coal-fired boilers done by the Office of Air Quality, Planning and Standards. EPA assumed that the entire U.S. population lives within 80 km of at least one coal fired boiler.

EPA estimates that the maximum individual risk is 2.5×10^{-5} and that there are 0.8 fatal cancer a year caused by radionuclide emissions from both utility and industrial coal fired boilers. Virtually all the fatal cancer risk is borne by individuals whose lifetime fatal cancer risk is less than 1×10^{-6}.

Table 11 presents example scenarios to show how different emission levels would result in different health risk profiles. The table presents the risk estimates at baseline in terms of estimated annual fatal cancer incidence, maximum individual lifetime risk, total population exposed at or above particular risk levels (i.e., risk distribution), and annual incidence attributable to the population exposed at each risk level. The table also presents available estimates of annual incidence and maximum individual lifetime risk for a lower emission level.

3. Application of Decision Methodology to Coal-Fired Boilers Source Category

The decision that results from the application of the multifactor approach to the coal-fired boilers source category is described below.

Decision on Acceptable Risk. As stated earlier, the maximum individual risk to any individual is 2.5×10^{-5} which is below the presumptively safe level. The estimated annual incidence within 80 km is 0.8 fatal cancer per year. Over 99% of the incidence comes from people whose individual risk is less than 1×10^{-6}. Almost everyone in the U.S. lives within 80 kilometers of a coal-fired boiler, which results in a risk which is very evenly and equitably distributed. Therefore, EPA concludes that the baseline risk level is acceptable.

TABLE 11—COAL-FIRED BOILERS

[Description: Over 1,500 electrical utility and large industrial boilers release the small amounts of radionuclides naturally found in coal along with the non-radioactive particulates.]

	Alternative I (Baseline)	Alternative II
Maximum individual risk (lifetime)	2.5×10^{-5}	1×10^{-6}
Incidence within 80 km (death/y)	0.8	0.4
Risk individual:		
E-2 to E-1	0	0
E-3 to E-2	0	0
E-4 to E-3	0	0
E-5 to E-4	(*)	0
E-6 to E-5	130,000	(*)
less E-6	240M	240M
Risk incidence		
E-2 to E-1	0	0
E-3 to E-2	0	0
E-4 to E-3	0	0
E-5 to E-4	(*)	0
E-6 to E-5	0.001	(*)
less E-6	0.8	0.4

* We believe that people are at this risk level but all 1,500 facilities in this category have not been characterized.

Other Health Impacts: Total cancers no more than twice fatal cancers.

TABLE 12—COAL-FIRED BOILERS

Alternative	MIR	Incidence	Increment incidence reduction	Total incidence reduction	Increment capital cost	Increment annualized cost	Total annualized cost
I (Baseline): (util)	2.5×10^{-5}	0.4					

TABLE 12—COAL-FIRED BOILERS—Continued

Alternative	MIR	Incidence	Increment incidence reduction	Total incidence reduction	Increment capital cost	Increment annualized cost	Total annualized cost
(inds)	*7×10^{-6}	*0.4					
Alternative II:							
(util)	1×10^{-7}	0.2	0.2	0.2	$13B	$4.4B	$4.4B
(inds)	*1×10^{-6}	*0.2	*0.2	*0.2		*$1.7B	*$1.7B

*Office of Air Quality Planning and Standards values (Draft—Coal and Oil Combustion Study, 1988).

Comments:
Alternative I: Baseline, no rule—utility boilers: current emissions as controlled by NSPS, PSD, and SIP; industrial boilers: current emissions as controlled by SIP.
Alternative II: Utility boilers: retrofit of all sources to meet NSPS (particulate standard). Assumes ESPs are used to retrofit to an emission limit of 13 ng/joule (NSPS revised). Retrofit would yield additional health benefits due to reductions in particulate emissions.
Industrial boilers: retrofit all units >2MM Btu/h with ESPs.

Decision on Ample Margin of Safety. In addition to reexamining all the health-related factors discussed above, EPA has also examined the cost, scientific certainty, and technological feasibility of control technology necessary to lower emissions from coal-fired boilers. The results of this analysis may be seen in Table 12. Alternative I, baseline emissions, was compared with Alternative II, which would require retrofitting existing sources to meet the NSPS. EPA's risk assessment indicates that the baseline MIR from coal-fired boilers, 2.5×10^{-5}, is very low, well below the presumptively safe level of approximately 1×10^{-4}. The risk is very evenly distributed among the population. The costs of Alternative II are extremely large. EPA examined the small risks presented by coal-fired boilers and the very large costs of achieving Alternative II, and determined that the current level of emissions represents an ample margin of safety. In addition, since all new facilities will have to meet NSPS, the effect of the NESHAP would solely be to require retrofitting of existing boilers. The NSPS provides assurance that the risks from coal-fired boilers will be reduced over time.

Therefore, EPA has determined that current levels of radionuclide emissions from coal-fired boilers represent a level of risk that protects the public health with an ample margin of safety.

F. High-Level Nuclear Waste Disposal Facilities

1. Introduction

Management and storage operations for high-level nuclear waste, spent fuel and transuranic waste are addressed in the categories for DOE facilities and NRC-licensed and non-DOE Federal facilities described above. This category addresses facilities constructed and dedicated to long term disposal of such materials pursuant to regulations to be promulgated at 40 CFR 191. Site characterization studies for the first such repository are being conducted by DOE and currently center on Yucca Mountain, Nevada. In addition, DOE is constructing an experimental Waste Isolation Pilot Plant (WIPP) which may be dedicated as a disposal facility.

2. Estimates of Exposure and Risk

EPA's risk assessment of HLW disposal facilities is based upon DOE engineering estimates for conceptual designs for the WIPP in New Mexico, and a permanent repository at Yucca Mountain. They were analyzed by EPA and are believed to be reasonable. Population data was taken from U.S. census data at these sites. Although the decision on Yucca Mountain's acceptability as a disposal site has not yet been made, EPA has analyzed the Yucca Mountain site in order to incorporate site specific information into the analysis.

EPA estimates that the maximum individual risk is 7×10^{-8} and that there would be 0.0000043 fatal cancers a year caused by radionuclide emissions from HLW disposal facilities to less than 1 million people within 80 km of these facilities. All the fatal cancer risk is borne by individuals whose total fatal cancer risk is less than 1×10^{-6}.

The reason that the emissions and risks are so low is the nature of the disposal operations. Most material will be brought to the site already sealed and buried below ground. Normal operations preclude any significant air emissions.

Table 14 presents the risk estimates at baseline in terms of estimated annual fatal cancer incidence, maximum individual lifetime risk, total population exposed at or above particular risk levels (i.e., risk distribution), and annual incidence attributable to the population exposed at each risk level.

3. Application of Decision Methodology to the High Level Waste Source Category

The decision that results from the application of the multifactor approach to the HLW disposal facilities source category is described below.

Decision on Safe With an Ample Margin of Safety. As stated above, the individual risks from HLW disposal facilities are very small, 7×10^{-8}, much less than the 1×10^{-4} benchmark. In addition, there would be 0.0000043 fatal cancer a year from radionuclide emissions from disposal of HLW, see Table 13. The emissions and risk levels are so low that it was not necessary to evaluate any alternatives. The Administrator determines that the estimate of emissions from disposal of HLW represents a level that will protect public health with an ample margin of safety.

Operations involving the management, processing or storage of high-level waste, the operations from which an increase in emissions are more likely to occur, are regulated under NESHAPS controlling emissions from NRC-licensees, uranium fuel cycle facilities and DOE facilities. Disposal operations involve burying sealed containers of radioactive material, operations from which emissions are unlikely to occur. Therefore, EPA believes that there is no reason to expect that emissions to air would significantly increase, and, since the expected emissions are so low, no NESHAP is needed.

TABLE 13—HIGH LEVEL NUCLEAR WASTE DISPOSAL FACILITIES

[Description: Facilities designed to dispose of high level nuclear waste. There are no currently operating facilities. A geological repository is being considered for Yucca Mountain, Nevada. The Waste Isolation Pilot Plant now under construction in New Mexico, may also become a disposal facility. Baseline emissions are estimates of expected emissions. No alternatives are given due to expected risks well below 1×10^{-6}.]

	Alternative I (Baseline)
Maximum individual risk (lifetime)	7.0×10^{-8}
Incidence within 80 km (death/y)	0.0000043
Risk individual:	
E-2 to E-1	0
E-3 to E-2	0

TABLE 13—HIGH LEVEL NUCLEAR WASTE DISPOSAL FACILITIES—Continued

[Description: Facilities designed to dispose of high level nuclear waste. There are no currently operating facilities. A geological repository is being considered for Yucca Mountain, Nevada. The Waste Isolation Pilot Plant now under construction in New Mexico, may also become a disposal facility. Baseline emissions are estimates of expected emissions. No alternatives are given due to expected risks well below 1×10^{-6}.]

	Alternative I (Baseline)
E-4 to E-3	0
E-5 to E-4	0
E-6 to E-5	0
less E-6	101,000
Risk incidence:	
E-2 to E-1	0
E-3 to E-2	0
E-4 to E-3	0
E-5 to E-4	0
E-6 to E-5	0
less E-6	0.0000043

Other Health Impacts: Total cancers no more than twice fatal cancers.

G. Radon Releases from Department of Energy Facilities

1. Introduction

The DOE administers many facilities, including government-owned, contractor-operated facilities across the country. Some of these facilities have large stockpiles of radium-containing material. Because this material has a high radium content it emits large quantities of radon. This material is stored in at least six different sites (at five locations) owned or controlled by DOE in Missouri, New Jersey, New York, Ohio and Utah. DOE is presently in the process of taking remedial action at these sites to dispose of the material on a long-term basis under procedures defined by Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), or has completed required action and placed residues in interim storage. DOE has entered into or is negotiating a CERCLA compliance agreement for these remedial actions in accordance with CERCLA requirements, EPA policy and Executive Order 12580. The agreement for the DOE Monticello site has incorporated a 20 pCi/m^2-s flux standard through reference to DOE guidelines and 40 CFR 192.

The current NESHAP covering DOE facilities does not regulate radon emissions. Environmental groups challenged EPA in court to address the problem of radon emissions from DOE facilities. In March, EPA proposed that these facilities be regulated under a NESHAP; one option in that proposal would have limited emissions of radon from DOE facilities to no more than 20 pCi/m^2-s.

2. Estimates of Exposure and Risk

EPA's risk assessment of DOE facilities is a site-by-site assessment of current emissions. Radon emission estimates were mostly measured values provided by DOE or estimated from measured radium-226 concentrations in the wastes. The meteorological data were taken from nearby stations and populations are based on U.S. census tract data.

According to EPA's analysis, lifetime fatal cancer risk to the most exposed individual is 1.4×10^{-3}. DOE facilities cause an estimated 0.08 fatal cancer per year, or approximately 1 case every 12 years to the 28 million persons within 80 km of the DOE facilities. Approximately 75% of the risk to that population comes from individuals whose risk is over 1×10^{-6}. It is noted that this analysis does not consider the planned remedial actions which will be implemented under CERCLA, as amended, in conjunction with either Interagency Agreements or Federal Facilities Agreements with EPA.

Table 14 presents example scenarios to show how different emission levels would result in different health risk profiles. The table presents the risk estimates at baseline in terms of estimated annual fatal cancer incidence, maximum individual lifetime risk, total population exposed at or above particular risk levels (i.e., risk distribution), and annual incidence attributable to the population exposed at each risk level. The table also presents available estimates of annual incidence and maximum individual lifetime risk for lower emission levels identified as Alternatives II, and III.

3. Application of Decision Methodology to the Radon Emissions From DOE Facilities Source Category

The decision that results from the application of the multifactor approach to the DOE radon source category is described below.

Decision on Acceptable Risk. As stated earlier, the maximum individual risk to any individual is 1.4×10^{-3} which is higher than the presumptively safe level. EPA has considered other risk factors to determine whether the baseline risk is acceptable. The estimated annual incidence is approximately 0.072 fatal cancers per year, and approximately 75% of that risk is borne by people whose risk is over 1×10^{-6}. Over 2,000 people are exposed to risks greater that 1×10^{-4}. Considering all of these factors, especially the high level of maximum individual risk, the baseline is unacceptable.

EPA next examined several alternatives before determining the acceptable level; those alternatives and the risks they present are presented in Table 14. After examining these different options, the Agency determined that Alternative II, setting a NESHAP limiting radon emissions to 20 pCi/m^2-s, is acceptable. The maximum individual risk that results from this alternative, 1.8×10^{-4}, which in light of the numerous uncertainties in both establishing the parameters for the risk assessment and in modelling actual emission and exposure, as well as the recognition that in achieving compliance sources will generally control so as to ensure that a buffer exists below the actual level of a standard, is essentially equivalent to the presumptively safe level of approximately 1×10^{-4}. Over 99% of the population would be exposed to risks of less than 1×10^{-6}. In addition, the incidence level is only 0.040 fatal cancers per year and 0.0021 non-fatal cancers annually. Only a few people (approximately 100) would be exposed to risks greater than 1×10^{-4}; the predicted rate of fatal cancer among this group is less than 1 every 5,000 years.

Decision on Ample Margin of Safety. In addition to reexamining all of the health-related factors discussed above, EPA has also examined the cost, scientific certainty, and technological feasibility of control technology necessary to lower radon emissions from DOE facilities. The results of this analysis can be seen in Table 15. When EPA examined the control technology necessary to lower radon emissions from DOE facilities it concluded that the only technologically feasible control is burying the sources of radon emissions. The examined options Alternative II, and Alternative III, differ only in the amount of dirt that is used to bury the radium bearing waste. The costs and benefits of controlling emissions to various levels can be seen in Table 15.

A comparison of the two alternatives indicates that a very small reduction in incidence of 0.009, would result from imposing Alternative III, representing an estimated savings of 1 life every 111 years; the change in maximum individual risk would also be very small. EPA examined this very small reduction in incidence and maximum individual risk and the costs of achieving Alternative III and has determined that Alternative II provides an ample margin of safety. Therefore, EPA has decided to regulate this category by setting a

NESHAP limiting emissions from these sources to 20 pCi/m²-s. This rule will assure that all DOE radon sites (radium-226 byproduct material disposal and storage sites) resulting from DOE cleanup and restoration under CERCLA will be covered by the rule. This standard will protect public health with an ample margin of safety.

TABLE 14—RADON FROM DOE FACILITIES

(Description: Radon released from waste materials left behind from the Manhattan project and the early days of the Atomic Energy Commission. These wastes are currently stored at six facilities controlled by DOE.)

	Alternative I (baseline)	Alternative II	Alternative III
Maximum individual risk (lifetime)	1.4×10^{-3}	1.8×10^{-4}	1×10^{-4}
Incidence within 80 km (death/y)	0.072	0.040	0.012
Risk individual:			
E-2 to E-1	0	0	0
E-3 to E-2	30	0	0
E-4 to E-3	2,000	100	0
E-5 to E-4	8,200	3,800	470
E-6 to E-5	360,000	92,000	19,000
less E-6	28M	28M	28M
Risk incidence:			
E-2 to E-1	0	0	0
E-3 to E-2	0.00056	0	0
E-4 to E-3	0.0058	0.00019	0
E-5 to E-4	0.0031	0.0014	0.00015
E-6 to E-5	0.0087	0.0026	0.00052
less E-6	0.054	0.036	0.011

Other Health Impacts: Non-fatal cancers no more than 5% of deaths.

TABLE 15—RADON FROM DOE FACILITIES

Alternative	MIR	Incidence	Increment incidence reduction	Total incidence reduction	Increment capital cost	Increment annualized cost	Total annualized cost
I (Baseline)	1.4×10^{-3}	0.072	—	—	—	—	—
II	1.8×10^{-4}	0.040	0.032	0.032	$29M	$1.5M	1.5M
III	1.0×10^{-4}	0.012	0.029	0.060	$26M	$1.3M	$2.8M

Comments:
Alternative I: Baseline, no rule—Self regulated by DOE.
Alternative II: Cover source to limit emissions to 20 pCi/m²-s—This is the same level as the current AEA rule set by EPA for uranium mill tailings.
Alternative III: Cover source to limit emissions to 2 pCi/m²-s—Most of the cost is to control emissions from the Monticello tailings pile.

4. Implementation

This NESHAP is a flux standard that limits the emission of radon from DOE facilities. The standard limits the amount of radon that can be emitted per unit area (m^2) per unit of time (s). This standard is not an average per facility but is an average per radon source. This will require that all radon sources must be disposed of in a manner that will reduce the radon flux to meet the standard.

Currently, all DOE radon sites have completed construction of interim storage facilities or have signed or are negotiating cleanup agreements under CERCLA with EPA regional offices. All existing agreements require that the waste be covered to reduce the radon flux to 20 pCi/m²-s. This rule will assure that all future agreements will require that the radon flux be reduced to at least this level.

While EPA believes that DOE will be able to meet this standard, EPA recognizes that in some cases DOE may need some time to perform all the actions necessary to reduce radon emissions to the required levels. In such a case, DOE may request a waiver of the compliance deadline of up to two years, under section 112(c)(1)(b)(ii) of the CAA. If two years is not sufficient time to complete remediation of the sites, EPA is prepared to discuss extended schedules for compliance. EPA recognizes that the requirements of CERCLA and other environmental laws will have to be considered in these discussions. This process will ensure that these sites are cleaned up as quickly as possible.

EPA believes that the existing oversight of DOE sites through the CERCLA program is sufficient to protect the public health, therefore, EPA is requiring no additional reporting or implementation requirements for this source category. Unlike the other categories that may be regulated by other laws, these sites are reporting and will continue to report to EPA regional offices, providing EPA with all the information it needs to assure compliance with this standard. Therefore, these DOE facilities are exempted from the requirements of § 61.10.

H. Phosphogypsum Stacks

1. Introduction

Phosphogypsum stacks are large piles of waste from wet acid phosphorus fertilizer production. Phosphogypsum stacks are found at 41 different sites in 12 states. Because phosphate ore contains a relatively high concentration of uranium and radium, phosphogypsum stacks are also high in these elements. The presence of radium in the stacks causes them to release radon into the atmosphere.

2. Estimates of Exposure and Risk

EPA has performed a pile-by-pile assessment of radon releases at 58 phosphogypsum stacks at 41 sites. Radon emissions are based on measured radon fluxes at stacks in Florida and Idaho which, combined with the radium content of the phosphate rock, allowed EPA to estimate emissions from the other stacks. The maximum individual risks estimates are based on the

locations of nearby residents obtained from industry or topographical maps. Where information was unavailable, people were assumed to be 800 meters from the site boundary. Populations within 80 km were taken from census tract data. The risk assessment presented with the proposal has been updated in response to new information provided from the comments.

The estimated maximum individual risk of fatal cancer from radon emissions from phosphogypsum stacks is 9×10^{-5}. The radon emissions are estimated to cause 0.95 fatal cancers and 0.047 non-fatal cancers per year to the 95 million people within 80 km. Approximately 90% of the risk to the population is borne by people whose risk is less than 1×10^{-5}, and 33% of the risk is borne by people whose risk is less than 1×10^{-6}.

Table 16 presents example scenarios to show how different emission levels would result in different health risk profiles. The table presents the risk estimates at baseline in terms of estimated annual fatal cancer incidence, maximum individual lifetime risk, total population exposed at or above particular risk levels (i.e., risk distribution), and annual incidence attributable to the population exposed at each risk level. The table also presents available estimates of annual incidence and maximum individual lifetime risk for a lower emission level identified as Alternative II.

3. Application of Decision Methodology to Phosphogypsum Source Category

The decision that results from the application of the multifactor approach to the phosphogypsum source category is described below.

Decision on Acceptable Risk. As stated earlier, the maximum individual risk to any individual is 9×10^{-5} which is less than the benchmark of approximately 1×10^{-4} and is, therefore, presumptively safe. While the incidence is 0.95, it results from the low levels of risk to the millions of persons included within the modelling radius, with the bulk of the incidence from people whose individual risk is less than 1×10^{-5}. Over 77% of the population is exposed to risks of less than 1×10^{-6}. EPA has concluded that the baseline risk is acceptable.

Decision on Ample Margin of Safety. In addition to reexamining all of the health-related factors discussed above, EPA has also examined the cost, scientific certainty, and technological feasibility of control technology necessary to lower radon emissions from phosphogypsum stacks. The results of this analysis can be seen in Table 17. The examined options, Alternative I and Alternative II, differ only in the amount of dirt that is used to bury the radium bearing waste. The costs and benefits of controlling emissions to various levels can be seen in Table 17.

A comparison of the two alternatives indicates that a small reduction in incidence would occur from imposing Alternative II, 0.16; this represents an estimated incidence reduction of 1 life every 6 years. Simultaneously the maximum individual risk would be reduced only marginally, from 9.1×10^{-5} to 8.2×10^{-5}. EPA examined this small reduction in incidence and maximum individual risk and the relatively large costs to achieve these small reductions in risks and determined that Alternative I provides an ample margin of safety. EPA has concluded that a standard is warranted for this category. Setting a standard will treat phosphogypsum stacks the same way that other radium bearing wastes (uranium mill tailings) are being treated. A standard will also ensure that the public will be protected with an ample margin of safety in all cases. Therefore, EPA has decided to regulate this category by setting a NESHAP limiting emissions from these sources to no more than 20 pCi/m^2-s.

4. Implementation

This standard is in the form of a work practice standard that initially directs that the phosphogypsum by-product be disposed into stacks or old phosphate mines, and imposes on those stacks or mines a standard to ensure that they do not emit radon into the ambient air in an amount greater than a flux of 20 pCi/m^2-s. EPA has settled on this form of a standard pursuant to its authority under CAA section 112(e) to set a work practice standard when it is "not feasible to prescribe or enforce an emission standard" because the hazardous air pollutant cannot be emitted through a conveyance designed or constructed to emit or capture such air pollutant. Given the size of the stacks, use of a conveyance to capture the radon emitted by the stacks is utterly impractical. Without requiring the radium-rich phosphogypsum be first disposed into large, manageable stacks or mines, which is generally what has been done with the existing phosphogypsum, the phosphogypsum may be incorporated into other products or otherwise diffused throughout the country, such that the Agency will be unable to ensure that the phosphogypsum's radon emissions do not present an unacceptable risk to public health.

Once the phosphogypsum is deposited in stacks, an additional requirement of 20 pCi/m^2-s is sufficient to ensure the continued safety of the public with an ample margin of safety. This numerical standard simply ensures maintenance of the status quo as EPA believes all existing phosphogypsum stacks meet these requirements without the need for additional control technology.

Under this NESHAP, all phosphogypsum stacks will be limited in the amount of radon they may release. The standard limits the amount of radon that can be emitted per unit area (m^2) per unit of time (s). This standard is an average per stack.

Ninety days after the effective date of this rule or sixty days after the stack becomes inactive, whichever is later, the operator must test the stack to determine whether or not the stack is in compliance with the flux standard. The stack is considered inactive if it is no longer being used for the disposal of phosphogypsum or for waste water management operations associated with the mining and milling of phosphogypsum. If a stack has not been used for two years, it is presumed to be inactive.

Once testing demonstrates that the stack is in compliance, it does not have to be tested again. EPA expects that few, if any, stacks will be used after they are tested; however, if the stack is used again, it ceases to be inactive. When it ceases to be used subsequently, it again becomes inactive and must be retested.

Since EPA has all the current information it needs on phosphogypsum stacks, they are exempted from the requirements of § 61.10.

TABLE 16—DISPOSAL OF PHOSPHOGYPSUM STACKS

[Description: Large piles of waste from wet acid phosphorous fertilizer production. Radon is released from the uranium decay product found in phosphate ore. There are about 60 stacks on 40 sites.]

	Alternative I (baseline)	Alternative II
Maximum individual risk (lifetime)	9.1×10^{-5}	8.2×10^{-5}
Incidence within 80 km (death/y)	0.95	0.79
Risk individual:		
E-2 to E-1	0	0
E-3 to E-2	0	0
E-4 to E-3	0	0
E-5 to E-4	400,000	250,000
E-6 to E-5	17M	14M
less E-6	77M	81M
Risk incidence:		
E-2 to E-1	0	0
E-3 to E-2	0	0
E-4 to E-3	0	0
E-5 to E-4	0.092	0.055
E-6 to E-5	0.54	0.41
less E-6	0.32	0.33

Other Health Impacts: Non-fatal cancers no more than 5% deaths.

TABLE 17—DISPOSAL OF PHOSPHOGYPSUM STACKS

Alternative	MIR	Incidence	Increment incidence reduction	Total incidence reduction	Increment capital cost	Increment annualized cost	Total annualized cost
I (Baseline)	9.1×10^{-5}	0.95					
II	8.2×10^{-6}	0.79	0.16	0.16	$450M	$43M	$43M

Comments:
Alternative I: Baseline rule, cover source to limit emissions to 20 pCi/m²-s—Stacks have emissions of 4 to 15 pCi/m²-s; no cover would be needed. This rule would be equivalent to the current AEA rule set by EPA for uranium mill tailings.
Alternative II: Cover source to limit emissions to 6 pCi/m²-s—Stacks are covered with 0.5 meters of dirt. Usually dirt is not locally available and must be hauled to the site.

I. Underground Uranium Mines

1. Introduction

When these mines are operating, their ventilation systems emit large amounts of radon into the atmosphere. The levels of radon in an unventilated mine are a hazard to the miners. Ventilating to reduce radon exposure to the miners increases exposure to the general population.

Underground uranium mines are regulated by an existing NESHAP. This NESHAP requires bulkheading of unused portions of the mines in an effort to reduce the internal wall surface area of the mine and thereby reduce radon emissions into the mine air. EPA has found that this system is unworkable for existing mines, and it is unproven for new mines. The interiors of existing mines are so extensively interconnected that any attempt at bulkheading either produces no results or prevents fresh air from getting to the miners.

2. Estimates of Exposure and Risk

EPA's risk assessment of underground uranium mines is a site-by-site assessment of all operating or operable mines. Emission estimates were based on radon concentration or working level measurements and ventilation rates provided by mine operators. The meteorological data were taken from nearby stations and populations from 5 to 80 km are based on U.S. census tract data. Population distributions within 5 km were taken from site visits or obtained from mine owners.

The maximum individual risk of fatal cancer from radon emissions from underground uranium mines is 4×10^{-3}. The radon emissions are estimated to cause 0.79 fatal cancers per year to the population within 80 km.

Table 18 presents example scenarios to show how different emission levels would result in different health risk profiles. The table presents the risk estimates at baseline in terms of estimated annual fatal cancer incidence, maximum individual lifetime risk, total population exposed at or above particular risk levels (i.e., risk distribution), and annual incidence attributable to the population exposed at each risk level. The table also presents available estimates of annual incidence and maximum individual lifetime risk for lower emission levels identified as alternatives II and III.

Unlike other tables in this notice, Table 18 includes two different estimates of risks for each option. The reason for the two calculations is the large uncertainty of how the regulated community would comply with a standard at the level represented by the alternative. Options available include bulkheading, reducing their hours of operation, or shutting down. The wide range of options available to mine owners greatly increases the difficulty of predicting what will be the impacts of the various regulatory options.

EPA has calculated the possible risks resulting from the regulatory options using two different methods. The first method assumes that all mines whose emissions result in doses higher than the standard will reduce their emissions sufficiently to meet the standard. EPA then uses these reduced emissions to calculate the new health impacts. This method creates what EPA considers to be the expected risks associated with that option.

However, to achieve the standard by reducing emissions, some mines will have to make very dramatic reductions in emissions, reductions that may be too costly for the mine to remain in operation. The second method used to calculate risks (marked with a + on the tables) assumes that all mines causing doses in excess of the standard simply shut down, except in those cases where the mine owner could meet the standard by reducing their emissions by less than 25%. EPA believes that this method will calculate the maximum health benefit that could occur as a result of this rulemaking. This second method of calculating risks shows a lower figure for the total population exposed because the mines which are assumed to be shut down would expose no one.

TABLE 18—UNDERGROUND URANIUM MINES

[Description: Underground mines used to produce uranium ore. Only 15 are still operating. Emissions come from operations when mines are ventilated to reduce radon exposure to miners.]

	Alternative I (baseline)	Alternative II	Alternative II+	Alternative III	Alternative III+
Maximum individual risk (lifetime)	4.4×10^{-5}	3×10^{-4}	3×10^{-4}	1×10^{-4}	1×10^{-4}
Incidence within 80 km (death/y)	0.79	0.24	0.05	0.09	0.009
Risk individual:					
E-2 to E-1	0	0	0	0	0
E-3 to E-2	(*)	0	0	0	0
E-4 to E-3	90,000	3,500	3,500	0	0
E-5 to E-4	1.6M	330,000	76,000	120,000	11,000
E-6 to E-5	450,000	1.8M	240,000	1.5M	110,000
less E-6	51,000	100,000	26,000	600,000	20,000

TABLE 18—UNDERGROUND URANIUM MINES—Continued

[Description: Underground mines used to produce uranium ore. Only 15 are still operating. Emissions come from operations when mines are ventilated to reduce radon exposure to miners.]

	Alternative I (baseline)	Alternative II	Alternative II+	Alternative III	Alternative III+
Risk incidence:					
E-2 to E-1	0	0	0	0	0
E-3 to E-2	(*)	0	0	0	0
E-4 to E-3	0.21	0.008	0.008	0	0
E-5 to E-4	0.55	0.13	0.037	0.032	0.0038
E-6 to E-5	0.030	0.11	0.011	0.055	0.0047
less E-6	0.00040	0.0006	0.0002	0.0060	0.00017

+ Analysis assumes closure of all mines that do not meet the standard, if the mines operate in such a way that they meet the standard population risks will increase.

* Less than 25 people at this risk. However, we cannot quantify the number because detailed demographics have not been obtained.

Other Health Impacts: Non-fatal cancers no more than 5% of deaths.

TABLE 19—UNDERGROUND URANIUM MINES

Alternative	MIR	Incidence	Increment incidence reduction	Total incidence reduction	Increment capital cost	Increment annualized cost	Total annualized cost
I (baseline)	4.4×10^{-3}	0.79					
II	3.0×10^{-4}	0.24	0.55	0.55	$0	$0.4M	$0.4M
II+	3.0×10^{-4}	0.05	0.74	0.74	(1)	(1)	(1)
III	1.0×10^{-4}	0.09	0.15	0.70	$0	$0.4M	$0.8M
III+	1.0×10^{-4}	0.009	0.04	0.78	(1)	(1)	(1)

[1] Costs not calculated.

Comments:

Alternative I: Baseline, no rule.

Alternative II: 10 mrem/y ede. Affects 9 mines, estimates assume all mines over the standard reduce emissions by a sufficient amount to meet the standard. This is assumed to be equivalent to the expected results of the standard.

Alternative II+: 10 mrem/y ede. Affects 9 mines, estimates assume that 5 mines that exceed the standard by more than 25% close down, the other 4 mines reduce emissions. This represents the maximum reduction in health effects to be expected.

Alternative III: 3 mrem/y ede. Affects 9 mines, estimates assume all 9 mines over the standard reduce emissions by a sufficient amount to meet the standard. This is assumed to be equivalent to the expected results of the standard.

Alternative III+: 3 mrem/y ede. Affects 9 mines, estimates assume that all 9 mines that exceed the standard close down. This represents the maximum reduction in health effects to be expected.

3. Application of Decision Methodology to the Underground Uranium Mine Source Category

The decision that results from the application of the multifactor approach to the underground uranium mines source category is described below.

Decision on Acceptable Risk. As stated earlier, the maximum individual risk to any individual is 4×10^{-3} which is much higher than the presumptively safe level. Considering the high level of individual risk, the presumption is very strong that the baseline is unacceptable. The estimated annual incidence is approximately 0.79 fatal cancers per year, and over 90 percent of that risk is borne by people whose risk is over 1×10^{-5}. Over 90,000 people are exposed to risks greater than 1×10^{-4}. These factors support the judgment that the risk level represented by the baseline is unacceptable.

EPA examined several alternatives before determining the acceptable level; those alternatives and the risks they present are illustrated in Table 18. After examining these different Alternatives, the Agency determined that Alternative II, setting a NESHAP limiting emissions from underground uranium mines to 10 mrem/y ede which results in a maximum individual risk of 3×10^{-4} less than 10 percent of the population exposed to risks less than 1×10^{-4} (this is due to the unusual demographics of the risk assessment area, which contains unevenly distributed population centers as opposed to the more normal situation where the population is more evenly distributed), and an incidence of 0.24 fatal cancers per year is acceptable.

In establishing the policy for setting NESHAPS in the context of the earlier benzene decision, the Agency determined that emissions resulting in a lifetime MIR no greater than approximately 1×10^{-4} are presumptively acceptable. In light of the numerous uncertainties in both establishing the parameters for the risk assessment and in modelling actual emission and exposure, as well as the recognition that in achieving compliance sources will generally control so as to ensure that a buffer exists below the actual level of a standard, EPA judges that the MIR of 3×10^{-4} is essentially equivalent to the presumptively safe level of approximately 1×10^{-4}. Next, EPA examined the other risk information on this category. Radon causes only lung cancer, which means that emissions from underground uranium mines will cause only 0.012 non-fatal cancers a year. In addition, it must be noted that for most of the people whose risks are above 1×10^{-4}, very few, if any, would receive risks as high as 3×10^{-4}, the risk level equivalent to 10 mrem/y. Only the few individuals who are closest to the mines would receive a dose approaching 10 mrem/y. Everyone else would receive progressively smaller doses and risks as distance from the mine increases. For the vast majority of people whose risk is above 1×10^{-4}, their dose will be much closer to 3 mrem/y than it will be to 10 mrem/y.

Decision on Ample Margin of Safety. In addition to reexamining all of the health-related factors discussed above, EPA has also examined the cost, scientific certainty, and technological feasibility of control technology necessary to lower emissions from underground uranium mines. The results of this analysis can be seen in Table 19. EPA has considered Alternatives II and III for underground uranium mines. Since different mine owners may use

different methods to reduce the risk to the maximum individual, there is a great deal of uncertainty in assessing the costs and the benefits going from Alternative II to Alternative III. The range of the benefits of controlling emissions to various levels can be seen in Table 19.

A comparison of the two alternatives indicates that a small reduction in incidence would occur, from a range of 0.24 to 0.05 (approximately 1 every 4 to 20 years), to a range of 0.09 to 0.009 (approximately 1 every 11 to 111 years). This reduction must be compared to the increased difficulty and expense that would be incurred by 9 of the 15 underground uranium mines in further reducing the dose to the maximum individual by a factor of 3 and the questionable feasibility of the control technology. EPA has determined that the level of Alternative II protects public health with an ample margin of safety. Therefore, EPA is setting a NESHAP limiting the dose to the maximally exposed individual to 10 mrem/y ede.

4. Implementation

This standard is an effective dose equivalent standard. Mines are limited in the amount of dose their radon emissions can cause to the nearby population. Due to Mine Safety and Health Administration (MSHA) regulations, which are designed to protect the miners from high levels of radon in the mine, the exhaust fans must be operating whenever there are miners working in the mine. This limits EPA flexibility in developing other types of standards to control radon emissions.

Under this rule, uranium mine owners will have to measure their emissions of radon, find the location of the maximally exposed individual, use that information as input into the COMPLY computer code, calculate the dose to the maximum exposed individual, and report the results to EPA. Since enforcement of the standard will be based on the results of these calculations, mine owners can comply with the new limit by whatever method or combinations of methods they choose.

J. Surface Uranium Mines

1. Introduction

Surface mining is accomplished by the excavation of one or more pits to expose uranium ore for removal. This technique accounted for about 45 percent, on average, of the uranium ore tonnage produced in this country between 1956 and 1985. However, much of today's uranium production is from underground mines and other sources.

In the past, annual production from surface mines ranged from a few hundred tons of ore to 100,000 tons or more from as many as 1200 mines. Due to the dramatic decline in the uranium industry since 1981, the number of surface mines in operation in the U.S. has dropped from 50 in 1981 to just 2 in 1987; one of these is scheduled to close in 1993.

During surface mining, topsoil (called overburden) may be segregated and saved for reclamation; overburden is piled on land beside the pit. The pit and overburden represent a large surface area from which radon can escape into the atmosphere. Radon emissions from the pit and overburden are higher than normal soil because the rock surrounding uranium deposits has higher radium concentrations than normal soil.

Health, safety and environmental hazards associated with uranium mining are regulated by a variety of Federal and State laws. As a result of the laws and regulations, many of the inactive uranium mines, are in various stages of reclamation by the placement of an earthen cover over the pit and the overburden. This reclamation of the mines significantly reduces radon emissions. In the past, EPA decided not to promulgate a NESHAP for this category. That decision was challenged in litigation and is being reexamined in this rulemaking.

2. Estimates of Exposure and Risk

EPA conducted a field study during the summer of 1988 to obtain information with which to model the surface mining industry so that estimates of risk from surface mining could be made. Radiometric surveys were conducted of the two active mines, located in Texas and Wyoming, and 25 inactive mines located in Arizona, New Mexico, Colorado, South Dakota, Texas and Wyoming. In addition, the demographic and meteorologic data were gathered in and around each mining site.

The maximum individual risk of fatal cancer from radon emissions from surface uranium mines is 5×10^{-5}. The radon emissions are estimated to cause 0.026 fatal cancers per year to the population within 80 km. Over 95 percent of the risk to the population is borne by people whose risk is less than 1×10^{-5}, and over 75 percent of the risk is borne by people whose risk is less than 1×10^{-6}.

Table 20 presents example scenarios to show how different emission levels would result in different health risk profiles. The table presents the risk estimates at baseline in terms of estimated annual fatal cancer incidence, maximum individual lifetime risk, total population exposed at or above particular risk levels (i.e., risk distribution), and annual incidence attributable to the population exposed at each risk level. The table also presents available estimates of annual incidence and maximum individual lifetime risk for a lower emission level identified as Alternative II.

3. Application of Decision Methodology to Surface Uranium Mine Source Category

The decision that results from the application of the multifactor approach to the surface uranium mine source category is described below.

Decision on Acceptable Risk. As stated earlier, the maximum individual risk to any individual is 5×10^{-5} which is lower than the benchmark of approximately 1×10^{-4}. The estimated annual incidence within 80 km is 0.026 fatal cancers per year. In addition, only 24,000 people out of 30 million (<0.1 percent) are exposed to risks greater than 1×10^{-6}. Based on these factors EPA concludes that the baseline risk is acceptable.

Decision on Ample Margin of Safety. In addition to reexamining all of the health-related factors discussed above, EPA has also examined the cost, scientific certainty, and technological feasibility of control technology necessary to lower radon emissions from surface uranium mines. The results of this analysis can be seen in Table 21. The examined options, Alternative I and Alternative II, differ only in the amount of dirt that is used to bury the radium bearing waste. The costs and benefits of controlling emissions to various levels can be seen in Table 21.

A comparison of the two alternatives indicates that a very small reduction in incidence would occur from moving to Alternative II, 0.022, representing an estimated incidence reduction of 1 life every 45 years. In addition, a small reduction in maximum individual risk would result, from 4.8×10^{-5} to 2.4×10^{-5}. EPA examined these small reductions in incidence, and maximum individual risk and the costs of achieving Alternative II and has determined that Alternative I would provide an ample margin of safety to protect public health.

In addition, this source category is already regulated by a host of state and federal mine reclamation laws. Due to the depressed state of the uranium mining industry, there is no reason to believe that new surface mines will be constructed. The presence of these laws, the very low maximum individual risk and incidence level associated with this

category, and the depressed nature of the industry lead EPA to the decision that it is unnecessary for EPA to set a NESHAP for this source category. Therefore, no standard is promulgated regulating emissions from surface uranium mines.

TABLE 20.—SURFACE URANIUM MINES

[Description: Open pit mines excavations to unearth uranium ore. Only two are operating (one of which will close in 1993); about twelve hundred are closed and will not reopen.]

	Alternative I (baseline)	Alternative II
Maximum individual risk (lifetime)	4.8×10^{-5}	2.4×10^{-5}
Incidence within 80 km (death/y)	0.026	0.0038
Risk individual		
E-2 to E-1	0	0
E-3 to E-2	0	0
E-4 to E-3	0	0
E-5 to E-4	4,000	3,000
E-6 to E-5	200,000	80,000
less E-6	30M	30M
Risk incidence		
E-2 to E-1	0	0
E-3 to E-2	0	0
E-4 to E-3	0	0
E-5 to E-4	0.001	0.0008
E-6 to E-5	0.005	0.0020
less E-6	0.020	0.0010

Other Health Impacts: Non-fatal cancers no more than 5% of deaths.

TABLE 21.—SURFACE URANIUM MINES

Alternative	MIR	Incidence	Increment incidence reduction	Total incidence reduction	Increment capital cost	Increment annualized cost	Total annualized cost
I (Baseline)	4.8×10^{-5}	0.026					
II	2.4×10^{-5}	0.0038	0.022	0.022	$15M	$0.8M	$0.8M

Comments:

Alternative I: Baseline, no rule—State reclamation rules apply. Analysis assumes larger production mines characterize the risk associated with surface uranium mining. Analysis is based on 25 mines. States with reclamation requirements included Colorado, Texas, Utah, Wyoming and South Dakota.

Alternative II: Cover source to limit emissions to 40 pCi/m²-s—Assumes 0.2 meters of dirt cover.

K. Operating Uranium Mill Tailings Piles

I. Introduction

The process of separating uranium from its ore creates waste material called uranium mill tailings. Since uranium ore generally contains less than 1 percent uranium, uranium milling produces large quantities of tailings. These tailings are collected in impoundments that vary in size from 20 to 400 acres. The tailings contain large amounts of radium, and, therefore, they emit large quantities of radon. There are 26 NRC-licensed uranium mills in the western United States. Due to the depressed state of the uranium industry, most of these mills are not currently operating.

The Uranium Fuel Cycle standard, 40 CFR part 190, does not regulate radon emissions from the tailings piles. Radon emissions during operations are currently regulated by a NESHAP 40 CFR part 61, subpart W, which is a work practice standard specifying two methods, one of which must be used in the construction of any new tailings impoundment. The piles must ultimately be disposed of in accordance with an EPA Atomic Energy Act regulation, 40 CFR part 192, which is implemented by the NRC.

For the current radionuclides NESHAP rulemaking, EPA is promulgating rules for three different subcategories that deal with mill tailings: operating mill tailings—existing piles, operating mill tailings—new technology, and disposal of uranium mill tailings (as a separate source category; see section VII.L of this notice).

This source category, operating mill tailings, has two subcategories because existing and future mill tailings piles present different problems. Existing mill tailings piles are large piles of wastes that emit radon. Radon emissions from these piles are retarded by the presence of water. However, if operations cease, and the pit is allowed to dry out, emissions can increase significantly.

New piles can be designed to overcome this problem in one of two ways: (1) Limit the size of the pile, which limits the radon source; or (2) utilize a disposal system, continuous disposal, that does not allow large piles to accumulate. The new technology is not feasible for old piles, as it is easier and cheaper and releases less radon to simply cover up the existing piles, rather than to break them up into a series of smaller piles and dispose of them separately.

2. Estimates of Exposure and Risk

EPA's risk assessment of operating uranium mill tailings is a site-by-site assessment of all 12 licensed mills that are either currently operating or on standby. Emissions were estimated from the radium-226 concentrations in the tailings, the amount of tailings, and the assumption that 1 pCi/g of radium-226 in the tailings produces 1 pCi/m²-s of radon. The meteorological data was taken from nearby stations and populations from 5 to 80 km are based on U.S. census tract data. Populations within 5 km were counted at each of the sites. EPA analyzed current emissions and the emissions that would be expected when new tailings impoundments are created in the future.

EPA estimates that the lifetime fatal cancer risk to the most exposed individual is 3×10^{-5} from the twelve licensed piles that are either operating or on standby. Uranium mill tailings are estimated to cause 0.004 fatal cancers per year, approximately 1 case every 250 years to the 2 million persons within 80 km of the tailings piles. This risk is much lower than the estimated risks presented in the proposed rule. The reason for the great reduction in the risk calculated is that EPA has received and confirmed information during the comment period that these piles are mostly wet or covered with clay. This greatly reduces the rate of radon emissions from the

piles, greatly reducing the risks that they pose.

EPA's analysis of new technologies is based on one set of model mills. By creating a set of model mills the analysis provides a meaningful comparison of the different technological alternatives, unaffected by assumptions about the number and locations where new mills and new piles might be constructed. However, this may understate the incidence from these piles if more mills are constructed, than are included in this analysis.

Tables 22, 23, 24 and 25 present example scenarios to show how different emission levels would result in different health risk profiles. Tables 22 and 23 provide information on existing piles; Tables 24 and 25 provide information on the options for new piles. The tables present the risk estimates at baseline in terms of estimated annual fatal cancer incidence, maximum individual lifetime risk, total population exposed at or above particular risk levels (i.e., risk distribution), and annual incidence attributable to the population exposed at each risk level.

3. Application of Decision Methodology to the Operating Mill Tailings Piles Source Category

The decisions that result from the application of the multifactor approach to the operating uranium mill tailings piles source category is described below. Two separate decisions were made: one for existing piles and the other for new piles.

a. *Existing Mill Tailings Piles.* Decision on Acceptable Risk. As stated earlier, the maximum individual risk is 3×10^{-5} which is clearly below the benchmark level of approximately 1×10^{-4} and is, therefore, presumptively safe. The estimated annual incidence within 80 km is 0.0043 fatal cancers per year, which is less than one case every 200 years. Only 240 people are exposed to risks greater than 1×10^{-5} and 97 percent of the people exposed have risks less than 1×10^{-6}. Based on these factors, EPA has concluded that the baseline risks are acceptable.

Decision on Ample Margin of Safety. In addition to re-examining all of the health-related factors discussed above, EPA has also examined the cost, scientific certainty, and technological feasibility of control technology necessary to lower emissions from operating uranium mill tailings piles. The results of this analysis can be seen in Table 23. As explained above, the risks from current emissions are very low. A NESHAP requiring that emissions from operating mill tailings piles limit their emissions to no more than 20 pCi/m^2-s represents current emissions. EPA has determined that the risks are low enough that it is unnecessary to reduce the already low risks from the tailings piles further.

However, EPA recognizes that the risks from mill tailings piles can increase dramatically if they are allowed to dry and remain uncovered. An example of how high the risks can rise if the piles are dry and uncovered can be seen in the proposed rule, 54 FR 9645. That analysis assumed that the piles were dry and uncovered and the risks were as high as 3×10^{-3} with 1.6 fatal cancers per year. Therefore, EPA is promulgating a standard that will limit radon emissions to an average of 20 pCi/m^2-s. This rule will have the practical effect of requiring the mill operators to keep their piles wet or covered. At the point that a mill decides to no longer keep the piles emissions below the standard, the pile should be disposed of, otherwise the piles increased radon emissions are likely to present unacceptably high risks.

EPA recognizes that in the case of a tailings pile which is not synthetically or clay lined (the clay lining can be the result of natural conditions at the site) water placed on the tailings in an amount necessary to reduce radon levels, can result in ground water contamination. In addition, in certain situations the water can run off and contaminate surface water. EPA cannot allow a situation where the reduction of radon emissions comes at the expense of increased pollution of the ground or surface water. Therefore, all piles will be required to meet the requirements of 40 CFR 192.32(a) which protects water supplies from contamination. Under the current rules, existing piles are exempt from these provisions, this rule will end that exemption.

b. *New Mill Tailing Impoundments.* Decision on Acceptable Risk. In establishing the policy for setting NESHAPS in the context of the earlier benzene decision, the Agency determined that emissions resulting in a lifetime MIR no greater than approximately 1×10^{-4} are presumptively acceptable. In light of the numerous uncertainties in both establishing the parameters for the risk assessment and in modelling actual emission and exposure, as well as the recognition that in achieving compliance sources will generally control so as to ensure that a buffer exists below the actual level of a standard, EPA judges that the maximum individual risk to any individual from Alternative I, which represents a continuation of current practice, is 1.6×10^{-4} is essentially equivalent to the presumptively safe level of approximately 1×10^{-4}. The estimated annual incidence is 0.014 fatal cancers per year or approximately 1 case every 70 years. In addition there would be an estimated 0.0007 non-fatal cancers per year. Only 20 people are at risks greater than 1.0×10^{-4} and approximately 18 percent of people within 80 km of mill tailings piles receive risks of less than 1×10^{-6}. After examining these factors, the Administrator has determined that the baseline risks from new uranium mill tailings impoundments are acceptable.

Decision on Ample Margin of Safety. In addition to re-examining all of the health-related factors discussed above, EPA has also examined the cost, scientific certainty, and technological feasibility of control technology necessary to lower emissions from new uranium mill tailings impoundments. The results of this analysis can be seen in Table 25. The examined options, Alternative I, Alternative II, and Alternative III, represent different methods of disposal. Alternative I is the use of one large impoundment, Alternative II is the use of phased disposal, and Alternative III is the use of continuous disposal.

A comparison of the alternatives indicates that very small reductions in incidence would occur, 0.005 in going from Alternative I to Alternative II, and 0.008 in going from Alternative I to Alternative III. In addition, the maximum individual risk would be reduced from 1.6×10^{-4} to 9×10^{-5} or 6×10^{-5}. In addition both Alternatives II and III will assure that over 97 percent of the population will be exposed to risks less than 1×10^{-6}. EPA examined this small reduction in incidence and maximum individual risk and the small costs of changing work practices, but also considered the uncertainties in this analysis. EPA believes that for this category, the economic assessment is especially uncertain. This uncertainty make this analysis different from the other analyses conducted by EPA in this rulemaking.

The uncertainty arises because it assumes a steady state industry over time. If the uranium market once again booms there would be increased risks associated with Alternative I. If the industry then experienced another economic downturn, the costs of Alternative I would increase because of the economic waste that occurs when a large impoundment is constructed and not filled. The risks can also increase if a company goes bankrupt and cannot afford the increased costs of closing a large impoundment and the pile sits uncovered emitting radon. The risks can

also increase if many new piles are constructed, creating the potential for the population and individual risks to be higher than EPA has calculated.

These uncertainties significantly affect the accuracy of the analysis and given the small cost of going to Alternatives II and III, EPA has determined that in order to protect the public with an ample margin of safety, both now and in the future, new mill tailings impoundments must use phased or continuous disposal.

EPA believes that in the long run mill owners will save money using continuous disposal, however, this technology has not been used in uranium operations in this country. Given the resulting uncertainty about the technological feasibility of this disposal method, EPA is also allowing them to use Alternative II which is phased disposal, since it also protects public health with an ample margin of safety. Either one of these technologies will assure that future risks will be kept under control by assuring that only small amounts of tailings are uncovered at any time. This will prevent mill tailings from becoming a large problem in the future.

TABLE 22.—OPERATING URANIUM MILL TAILINGS PILES—EXISTING PILES

[Description: Piles of uranium mill tailings at the 11 licensed operating uranium mill sites.]

	Alternative I (baseline)
Maximum individual risk (<lifetime exposure)	2.9×10^{-4}
Incidence within 80 km	0.0043
Risk individual	
E-2 to E-1	0
E-3 to E-2	0
E-4 to E-3	0
E-5 to E-4	240
E-6 to E-5	60,000
less E-6	1.9M
Risk incidence	
E-2 to E-1	0
E-3 to E-2	0
E-4 to E-3	0
E-5 to E-4	0.000057
E-6 to E-5	0.0023
less E-6	0.0020

Other Health Impacts: Non-fatal cancers no more than 5 percent deaths.

TABLE 23.—OPERATING URANIUM MILL TAILINGS—EXISTING PILES

Alternative	MIR	Incidence	Increment incidence reduction	Total incidence reduction	Increment capital cost	Increment annualized cost	Total annualized cost
I (Baseline)	2.9×10^{-4}	0.0043					

Comments:
Alternative I: Baseline rule—Flux standard for operating piles of 20 pCi/m^2–s.

TABLE 24.—OPERATING URANIUM MILL TAILINGS PILES—NEW TECHNOLOGIES [1]

[Description: The different methods of disposal that can be used for the construction of new uranium mill tailings piles by uranium milling companies.]

	Alternative I (baseline)	Alternative II	Alternative III
Maximum individual risk (lifetime)	1.6×10^{-4}	9×10^{-5}	6×10^{-5}
Incidence within 80 km (death/y)	0.014	0.009	0.006
Risk individual			
E-2 to E-1	0	0	0
E-3 to E-2	0	0	0
E-4 to E-3	20	0	0
E-5 to E-4	6,800	100	100
E-6 to E-5	680,000	20,000	20,000
less E-6	120,000	780,000	780,000
Risk incidence			
E-2 to E-1	0	0	0
E-3 to E-2	0	0	0
E-4 to E-3	0.00009	0	0
E-5 to E-4	0.0014	0.00009	0.00005
E-6 to E-5	0.012	0.0001	0.0005
less E-6	0.001	0.009	0.0055

[1] Risks are for only one model mill. Numbers should be used for comparison purposes only.

Other Health Impacts: Non-fatal cancers no more than 5 percent of deaths

TABLE 25.—OPERATING URANIUM MILL TAILINGS—NEW TECHNOLOGIES [1]

Alternative	MIR	Incidence	Increment incidence reduction	Total incidence reduction	Increment capital cost	Increment annualized cost	Total annualized cost
I (Baseline)	1.6×10^{-4}	0.014					
II	9.0×10^{-5}	0.009	0.005	0.005	$ 6.3M	$ 0.5M	$ 0.5M
III	6.0×10^{-5}	0.006	0.008	0.008	<$ 1.0M>	<$ 0.08M>	<$ 0.06M>

[1] All estimates for a single model mill Alternative II and III are each compared to Alternative I.

Comments:

Alternative I: Baseline, no rule—current technology is used. Single large impoundment.

Alternative II: Current NESHAP—several small impoundments with 40 acre limit (phased disposal).

Alternative III: Current NESHAP—tailings are dried and disposed of immediately (continuous disposal). Total capital cost is less than other two alternatives. Costs and incidence reductions are compared to baseline alternative.

4. Implementation

The NESHAP for existing mill tailings piles is a flux standard that limits the emission of radon from the piles. The standard limits the amount of radon that can be emitted per unit area (m^2) per unit of time (s). This standard is not an average per facility but is an average per radon source. The mill will annually test its impoundments and report the results to EPA.

The NESHAP for new impoundments is a work practice standard that requires mill operators to manage their tailings in a way that will reduce radon emissions. Mill operators will not be allowed to build any new mill tailings impoundment which does not meet this work practice standard. EPA will receive information on the construction of new impoundments through the requirements for EPA to approve of new construction under 40 CFR part 61, subpart A.

Since EPA already has or will receive through these reports the information it needs, uranium mill tailings are exempted from the requirements of § 61.10.

L. Disposal of Uranium Mill Tailings Piles

1. Introduction

After uranium mill tailings impoundments can no longer be used, they must be disposed of. In addition to the fourteen licensed piles that commercial licensees are decommissioning, DOE controls 24 abandoned uranium mill tailings piles. The 1978 Uranium Mill Tailings Radiation Control Act (UMTRCA) gave DOE responsibility for remedial actions at these latter sites. This Act also required EPA to set environmental standards to control releases from uranium mill tailings impoundments. EPA promulgated standards for both types of sites at 40 CFR part 192. That regulation limits post-closure radon releases to 20 pCi/m^2-s from the tailings piles.

In the past, EPA decided not to regulate under the CAA the disposal of uranium mill tailing impoundments which are regulated under UMTRCA. That decision was challenged in the litigation, so EPA is reexamining it.

2. Estimates of Exposure and Risk

EPA's risk assessment of uranium mill tailings is a site-by-site assessment of all 24 inactive piles and the 14 licensed piles that are being decommissioned. An uncertainty in this risk assessment occurs because DOE currently has plans to relocate eleven of the inactive mill tailings piles to unpopulated areas; in addition, DOE plans to stabilize the remaining 13 piles pursuant to the 40 CFR part 192 standards. EPA has considered information in the rulemaking record concerning DOE's plans in its determination on this category.

Emissions were estimated from the area of each tailings pile and an assumed radon flux of 20 pCi/m^2-s for reclaimed piles unless information existed which demonstrated that the radon flux would be less, and 1 pCi/m^2-s per pCi/g of radium for unreclaimed piles. Where specific documentation existed, such as contracts or agreements with regulatory agencies, EPA assumed that piles would be disposed of according to existing plans at the time scheduled. Meteorological data were taken from nearby stations, and populations from 5 to 80 km are based on U.S. census tract data. Populations within 5 km were measured at the sites. According to EPA's analysis, the lifetime fatal cancer risk to the most exposed individual is 3×10^{-4}. These tailings piles are estimated to cause 0.070 fatal cancers per year or approximately 1 case every 14 years, to the 9.4 million persons within 80 km.

Table 26 presents two alternative scenarios to show how different emission levels would result in different health risk profiles. The table presents the risk estimates at baseline, Alternative I, in terms of estimated annual fatal cancer incidence, maximum individual lifetime risk, total population exposed at or above particular risk levels (i.e., risk distribution), and annual incidence attributable to the population exposed at each risk level. The table also presents available estimates of annual incidence and maximum individual lifetime risk for a lower emission level identified as Alternative II.

3. Application of Decision Methodology to the Disposal of Uranium Mill Tailings Category

The decision that results from the application of the multifactor approach to the disposed uranium mill tailings source category is described below.

Decision on Acceptable Risk. In establishing the policy for setting NESHAPS in the context of the earlier benzene decision, the Agency determined that emissions resulting in a lifetime MIR no greater than approximately 1×10^{-4} are presumptively acceptable. In light of the numerous uncertainties in both establishing the parameters for the risk assessment and in modelling actual emission and exposure, as well as the recognition that in achieving compliance sources will generally control so as to ensure that a buffer exists below the actual level of a standard, EPA judges that the maximum individual risk of 3×10^{-4} is essentially equivalent to the presumptively safe level of approximately 1×10^{-4}. The estimated annual incidence is 0.070 fatal cancers per year or 1 case every 14 years; in addition, there would be 0.0035 non-fatal cancers per year. Only 200 people are at risks greater than 1.0×10^{-4}, and approximately 86 percent of the people within 80 km are at risk levels of less than 1×10^{-5}.

After examining these factors, the Administrator has determined that the baseline risks from the disposal of uranium mill tailings impoundments are acceptable.

Decision on Ample Margin of Safety. In addition to reexamining all of the health-related factors discussed above, EPA has also examined the cost, scientific certainty, and technological feasibility of control technology necessary to lower radon emissions from the disposal of uranium mill tailings piles. The results of this analysis can be seen in Table 27. The examined options, Alternative I and Alternative II, differ only in the amount of dirt that is used to bury the radium bearing waste.

A comparison of the two alternatives indicates that a small reductions in incidence would occur, 0.044; this represents an estimated incidence reduction of 1 life every 23 years. In addition, the maximum individual risk is reduced from 3.0×10^{-4} to 8.7×10^{-5}. EPA examined these small reduction in incidence and maximum individual risk and the relatively large costs of achieving Alternative II, $158 million in capital costs and $13 million in annualized costs and determined that

Alternative I protects public health with an ample margin of safety.

Although this category is already regulated under 40 CFR part 192, EPA believes that a NESHAP would still serve a useful purpose. The existing UMTRCA regulations set no time limits for the disposal of the piles. Some piles have remained uncovered for decades emitting radon. Although recent action has been taken to move toward disposal of these piles, some of them may still remain uncovered for years. In addition, a rule would assure that piles which are not ready for disposal at this time will be disposed of in a timely manner after they are removed from service. As a result, this NESHAP would reduce radon emissions from uncovered piles and assure that the public will be protected. Therefore, EPA has decided to regulate this category by setting a NESHAP limiting emissions from these sources to no more than 20 pCi/m^2-s.

TABLE 26.—DISPOSAL OF URANIUM MILL TAILINGS

[Description: The disposal of uranium mill tailings piles when they are no longer used for the disposition of new tailings. Twenty-four piles are controlled by DOE; 26 piles are controlled by individual uranium milling companies.]

	Alternative I (baseline)	Alternative II
Maximum individual risk (lifetime)	3.0×10^{-4}	8.7×10^{-5}
Incidence within 80 km (death/y)	0.070	0.026
Risk individual		
E-2 to E-1	0	0
E-3 to E-2	0	0
E-4 to E-3	200	0
E-5 to E-4	33,000	3,000
E-6 to E-5	1.3M	138,000
less E-6	8.1M	9.3M
Risk incidence		
E-2 to E-1	0	0
E-3 to E-2	0	0
E-4 to E-3	0.00052	0
E-5 to E-4	0.0089	0.0014
E-6 to E-5	0.030	0.0049
less E-6	0.031	0.020

Other Health Impacts: Non-fatal cancers no more than 5% of deaths.

TABLE 27.—DISPOSAL OF URANIUM MILL TAILINGS

Alternative	MIR	Incidence	Increment incidence reduction	Total incidence reduction	Increment capital cost	Increment annualized cost	Total annualized cost
I (Baseline)	3.0×10^{-4}	0.070					
II	8.7×10^{-5}	0.026	0.044	0.044	$200M	$16M	$16M

Comments:

Alternative I: Baseline rule: Cover source to limit emissions to 20 pCi/m^2-s—the same level as the current AEA rule set by EPA.

Alternative II: Cover source to limit emissions to 6 pCi/m^2-s.

4. Implementation

Under this NESHAP, all uranium mill tailings will have to be covered to reduce the amount of radon they release. The standard limits the amount of radon that can be emitted per unit area (m^2) per unit of time (s). This standard is an average per mill tailings pile.

Piles must be tested when disposal operations are completed but before the disposed pile is turned over to a government organization charged with long term ownership. Since these reports of the testing will provide EPA with the additional information it needs, uranium mill tailings are exempted from the requirements of § 61.10.

This standard, like all NESHAPs, requires compliance by existing sources within 90 days after the effective date in accordance with the CAA, 42 U.S.C. 7412(c)(1)(B)(i). However, EPA is aware that many sources covered by this subpart will not be able to come into compliance that quickly. EPA is making a generic finding that at least two years is required for the disposal of uranium mill tailings and that during that period all persons will be protected from imminent endangerment from uranium mill tailings piles. This finding also applies to piles that are not yet ready for disposal but will cease to be operational at some point in the future.

If the two year period is not enough time for these piles to dry out and be covered and disposed of then EPA is prepared to develop expeditious compliance schedules in consultation with affected parties within the framework of the enforcement mechanisms of 42 U.S.C. 7413, as appropriate. In these discussions with DOE, EPA will consider the restraints on DOE discussed in Senate Report No. 100-543, accompanying Pub. L. 100-616, 100th Congress, 2nd Sess., reprinted in 1988 U.S. Code Cong. & Ad. News, 4329 *et seq.* EPA recognizes that the requirements of CERCLA and other environmental laws will also have to be considered in these consultations.

VII. Responses to Legal and Policy Comments

On March 7, 1989, the EPA published in the **Federal Register** proposed National Emission Standards for Hazardous Air Pollutants (NESHAPs) for radionuclides emitted to ambient air from 12 source categories. The **Federal Register** notice requested public comments on the proposed NESHAPs, and the specific risk management approaches that were used to develop the standards. Informal public hearings were held in Washington DC and Las Vegas, NV., to give interested parties an opportunity to present their views, and

written comments were solicited. Comments were received from almost 300 individuals and organizations representing government agencies, industry and other members of the regulated community, environmental and public interest groups, and the general public. This section of the preamble discusses the legal and policy-related comments received during the comment period. A separate Response to Comments Document was prepared which addresses comments relating to modeling and compliance procedures, as well as comments particular to each source category.

1. Interpretation of Vinyl Chloride Decision

Comment: Several commenters discussed the fact that the D.C. Circuit decision in *Natural Resources Def. Council, Inc.* v. *EPA*, 824 F.2d 1146 (1987) (*Vinyl Chloride*) recognizes that EPA may deem some level of cancer risk as acceptable, in light of the fact that many carcinogenic substances are assumed not to have a threshold value below which they pose no risk. The issue raised by these commenters is what level of risk from radionuclide emissions could be characterized as "acceptable" under the Court of Appeals' ruling, particularly in light of such court decisions as *Alabama Power Co.* v. *Costle*, 636 F.2d at 323 (D.C. Cir. 1979) and *Public Citizen* v. *Young*, 831 F.2d at 1108 (D.C. Cir. 1987).

In the context of the *Vinyl Chloride* decision, the issue is whether the "acceptable" risk is equated with *de minimis* risk, and is thereby defined as "trivial" or "of no value," or whether some higher level of risk is considered acceptable under the court's ruling.

It was argued that the *Alabama Power* and *Public Citizen* cases support the contention that acceptable risk and *de minimis* risk are synonymous, and that, consequently, only "trivial" risk "of no value" can be interpreted as "acceptable risk" under the *Vinyl Chloride* decision. Moreover, the risk cannot be dismissed as "trivial" unless EPA demonstrates a public consensus that the risk levels are unworthy of preventive response. Hazardous air pollutant-induced cancer risks of 6×10^{-3}, 1×10^{-3}, or 1×10^{-4} are not in this category, and EPA may not be able to show such consensus even for risks of 1×10^{-6}. Similarly, it was posited that *Public Citizen* and *Vinyl Chloride* support the position that only a *de minimis* level of risk (e.g., 1×10^{-6} or lower) can be considered acceptable, and that this position is consistent with the CAA focus on public health and providing an ample margin of safety.

Several commenters disagreed with the previous comments. These commenters argued that a safe level is not the equivalent of a *de minimis* risk level and distinguished between *de minimis* risks, which are too trivial to warrant regulation, and a broad zone of higher risks that may still satisfy the court's definition of "acceptable risk." The commenters pointed to the fact that the court used the latter term intentionally in the *Vinyl Chloride* decision, and was aware of the differing legal meaning of *de minimis*. The commenters also cited the *Alabama Power* and *Public Citizen* cases, stating that those decisions held *de minimis* risk to be applicable except for those instances where Congress had already been "extraordinarily rigid" in establishing regulatory requirements.

Commenters also pointed out that the court in the *Vinyl Chloride* decision specifically stated that "acceptable risk" does not necessarily mean risk free. They argued that the court defined something as "unsafe" when it exposes humans to a "significant risk of harm." The fact that a risk is not *de minimis* does not mean that it poses a "significant risk of harm." For instance, the examples of "acceptable risk" cited by the court, such as driving a car or breathing city air have a higher than *de minimis* risk. Therefore, using this example as a guide, there is no basis for regulation of certain categories of sources since risks significantly above this level may be judged "acceptable" under the *Vinyl Chloride* decision.

Some commenters stated that the "acceptable risk" finding derives directly from the text and legislative history of Section 112 of the CAA, while the *de minimis* concept is a nonstatutory doctrine identified as a risk test by the court in the *Alabama Power* and *Public Citizen* cases. Thus, the "acceptable" and *de minimis* risk test serve much different functions in public health regulation.

Response: As the commenters acknowledge, the *Vinyl Chloride* decision recognizes that EPA may find some level of cancer risk to be "acceptable." In its explanation of the term, the court cited the preamble to the **Federal Register** notice announcing the final *Vinyl Chloride* regulations:

> Scientific uncertainty, due to the unavailability of dose/response data and the 20-year latency period between initial exposure to vinyl chloride and the occurrence of disease, makes it impossible to establish any definite threshold below which there are no adverse effects to human health." [citation omitted] 824 F.2d 1146, (D.C. Cir. 1987).

The court explained that "the Congressional mandate to provide "an ample margin of safety" to "protect the public health" requires the Administrator to make an initial determination of what is "safe." This determination must be based exclusively upon the Administrator's determination of the risk to health at a particular emission level. The Administrator's decision does not require a finding that "safe" means "risk free." 824 F.2d at 1164.

Where the commenters differ is over what level of risk from radionuclides emissions can be considered an "acceptable risk" within the meaning of the *Vinyl Chloride* decision. Some argue that in order to be "acceptable", the risk must be no more than *de minimis* within the meaning of *Alabama Power* and *Public Citizen*, while others dispute this position.

The EPA does not interpret "acceptable risk", for purposes of Section 112, as synonymous with or limited to *de minimis* risk as described in *Alabama Power* and *Public Citizen*. The *Vinyl Chloride* decision, while going into great detail in discussing the concepts of both "acceptable risk," and "ample margin of safety," never mentioned the concept of *de minimis* risk. What the court did say was that Congress exhibited no intent to require EPA to prohibit emissions of all nonthreshold pollutants, and, citing the Supreme Court decision in *Industrial Union Dept., AFL–CIO* v. *American Petroleum Institute*, 448 U.S. 607 (1980) stated that "safe does not mean risk free." 824 F.2d at 1153.

The court declined to restrict the Administrator to any particular method of determining what constitutes an acceptable risk but explained simply that "the Administrator must determine what inferences should be drawn from available scientific data and decide what risks are acceptable in the world in which we live." 824 F.2d at 1166.

By way of example, the court referred to language in the Supreme Court's *Industrial Union* decision, to the effect that driving a car or breathing city air are risk-laden activities that society does not consider "unsafe." 824 F.2d at 1165. Thus, the determination of what is an "acceptable risk" is discretionary with the Administrator, and involves evaluation of existing scientific data and uncertainties concerning that data.

The EPA disagrees with the commenters' contention that *Public Citizen* demonstrates that "acceptable risk" is limited to *de minimis* risk. *Public Citizen* involved a Food and Drug Administration (FDA) statute

prohibiting use of any food coloring additive "found * * * to induce cancer in man or animal." 831 F.2d at 1109. The FDA in that case argued that a *de minimis* exception, allowing use of the challenged additives when the cancer risks involved are trivial, could properly be interpreted into the statute. The court however, while acknowledging that the cancer risks were indeed trivial, held that the statute imposed an absolute ban once a finding of carcinogenicity had been made, and therefore no *de minimis* exception could be employed.

The situation in *Public Citizen* involving a "no-risk" statute is markedly different from the facts of the *Vinyl Chloride* case. In the *Vinyl Chloride* case the court interpreted the Clean Air Act as *not* equating "safe" with "risk free." 824 F.2d at 1153 [citations omitted]. Indeed, as explained above, the *Vinyl Chloride* court specifically used examples of activities having acceptable levels of risk "in the world in which we live" 824 F.2d at 1165 [citations omitted], but which exceed the *de minimis* concept described in *Alabama Power*. Thus, unless the *Vinyl Chloride* decision is read to broaden the *de minimis* concept from triviality to a level which is acceptable in the world in which we live, the dicta in *Public Citizen* is an apparent misconstruction of the *en banc Vinyl Chloride* opinion. Furthermore, *Public Citizen* did not deal with a statute requiring a determination of a "safe" level, and therefore cannot reasonably be compared to Section 112 of the CAA, and the court's analysis of risk in the *Vinyl Chloride* opinion.

Finally, the *Vinyl Chloride* court's citation of *Alabama Power* does not constitute adoption of the *de minimis* concept. As stated above, the *Vinyl Chloride* decision makes no mention of the *de minimis* concept, and cites *Alabama Power* following a discussion of risks found acceptable by the Supreme Court in *Industrial Union* which clearly exceed *de minimis*. Therefore, at most, *Alabama Power* was apparently cited as *an example* of a risk level, which would, of course, be considered "acceptable." Obviously, the enumeration of other, higher, risks precludes the interpretation that the court was equating the *de minimis* concept and "safe" or "acceptable risk" in *Vinyl Chloride*. In conclusion, EPA does not believe that the terms *de minimis* and "acceptable risk" are synonymous. Further, EPA believes that it is not required by *Vinyl Chloride* to reduce risk to a *de minimis* level.

Comment: One commenter argued that EPA has ignored the precedent established in the D.C. Circuit decision in *Ethyl Corp.* v. *EPA*, 541 F.2d 1 (1976) (*en banc*). This commenter argued that the decision established a "significant increment" test that must be satisfied before EPA can set a standard under section 112, a test that Congress adopted in amending section 112 in 1977.

Response: The commenter has misconstrued not only the teaching of the D.C. Circuit in *Ethyl*, but the Congressional intent in modifying section 112 to follow the court's ruling. First, the *Ethyl* decision does not apply directly to section 112, as the court was construing the language of section 211(c)(1)(A) as it then existed in that case; in addition, the decision involved lead, which unlike radionuclides, is a threshold pollutant. Second, while the court did describe a portion of its reasoning by using the phrase "significant increment", that was not the basic holding of the case. In fact, the court rejected exclusive use of such a test, in stating that Congress " * * * did not mean for 'endanger' to be measured only in incremental terms." 541 F2d. at 30–31. Third, while Congress did adopt language for section 112(a)(1) prescribing the definition of a "hazardous air pollutant" ("an air pollutant * * * which in the judgment of the Administrator causes or contributes to air pollution which may reasonably be anticipated to result in") from the reasoning of the *Ethyl* court, its purpose was to emphasize the preventive or precautionary nature of the Act. *1977 Legislative History*, 2516. In adopting this approach, the House Report stated that the " * * * language is intended to emphasize the necessarily judgmental element in the task of predicting future health risks of present action and to confer upon the Administrator the requisite authority to exercise such judgment." *Id.* at 2518. Finally, the Administrator has, in this rulemaking, used a significance test in its decisions on listing radionuclides and on standards for each of the source categories, as described in the **Federal Register** notice. But, it has not used it in the manner that the commenter has urged, which would eviscerate the true meaning of the *Ethyl* decision and Congressional endorsement of it. EPA believes that its use of a "significance" test here is fully consistent with the statute, its legislative history, and applicable case law, including the Supreme Court's decision in the OSHA benzene case.

Comment: Several commenters addressed the *Vinyl Chloride* court's finding on acceptable risk versus zero risk. Several commenters felt that "acceptable" risk which the court equated with being "safe" is not zero risk; while the scientific approach can reduce uncertainty, life cannot be risk free.

Response: The D.C. Circuit Court in *Vinyl Chloride* held that the Administrator is required, under section 112, to make an initial determination of what is "safe." 824 F.2d 1164. The court went on to state specifically that the "Administrator's decision does not require a finding that "safe" means "risk free" *Id.*, and further stated that the Administrator must decide "what risks are acceptable in the world in which we live." 824 F.2d at 1165. Thus, the *Vinyl Chloride* court made it clear that "safety" or "acceptable risk" is not to be equated with zero risk. The *Vinyl Chloride* court cites the Supreme Court decision in *Industrial Union Dept., AFL–CIO* v. *American Petroleum Institute*, 448 U.S. 607 (1980) as support for the proposition that zero risk is not mandated, stating that *Industrial Union* holds that "something is 'unsafe' only when it threatens humans with a 'significant risk of harm'." 824 F.2d at 1153. *Industrial Union* is clearly an appropriate precedent here.

Comment: The EPA's proposed approaches were based on a two-step decision process, and some commenters also interpreted the *Vinyl Chloride* decision as requiring a two-step process. Other commenters disagreed, stating that the the *Vinyl Chloride* decision does not mandate a two-step procedure for making section 112 decisions, but made clear that an integrated, single-step procedure could be used as long as the decision satisfied both the "acceptable risk" and the "ample margin of safety" criteria. Thus, for example, if existing emissions pose risks that are well below the acceptable risk, the Administrator could determine that both the acceptable risk criterion and the reasonable degree of protection criterion are satisfied in one step.

Response: The court in *Vinyl Chloride* specifically addressed the one or two-step process question, stating as follows:

> In response to the facts presented in this case we have analyzed this issue by using a two-step process. We do not mean to indicate that the Administrator is bound to employ this two-step process in setting every emission standard under section 112. If the Administrator finds that some statistical methodology removes sufficiently the scientific uncertainty present in this case, then the Administrator could conceivably find that a certain statistically determined level of emissions will provide an ample margin of safety. If the Administrator uses this methodology, he cannot consider cost and technological feasibility: these factors are no longer relevant because the

Administrator has found another method to provide an "ample margin" of safety. 824 F.2d at 1165 n. 11.

Thus, *Vinyl Chloride* does not mandate a two-step process in all cases. However, if a one-step process were utilized, the Administrator could not consider cost or technological feasibility.

Comment: One commenter wrote that the *Vinyl Chloride* opinion states that "the Administrator 'may, and perhaps must' include additional control measures where technologically feasible, in order to reduce public exposure by a cancer-causing chemical 'to the lowest feasible level'." The commenter therefore believed the correct interpretation of section 112 of the CAA according to *Vinyl Chloride* is that "EPA must provide such additional protection as is feasible at the second-step 'ample margin of safety' determination."

Response: In the March 7, 1989, notice proposing emission standards for radionuclides, EPA raised the question of whether to require all technically feasible controls for which costs are reasonable no matter how small the risk reduction. The *Vinyl Chloride* case provided that technological feasibility can be considered under section 112, so long as it is not considered in the "acceptable risk" determination, but only in the "ample margin of safety" determination. ("Since we cannot discern clear Congressional intent to preclude consideration of cost and technological feasibility in setting emission standards under section 112, we necessarily find that the Administrator may consider these factors." 824 F.2d at 1163.) The court explained that "it is not the court's intention to bind the Administrator to any specific method of determining what is 'safe' or what constitutes an 'ample margin'." 824 F.2d at 1166. Thus, the court provided that technological feasibility may be considered under section 112, at the "ample margin of safety" step in the analysis, and that it is within the discretion of the Administrator to determine what weight it is to be given, along with other relevant considerations such as the cost of additional controls. Because the court has specifically sanctioned the consideration of costs as well as feasibility of controls, it is clear that *Vinyl Chloride* does not require imposition of the maximum feasible controls without regard to cost or effectiveness: "Section 112(b)(1)'s command to provide an ample margin of safety to protect public health is self-contained, and the absence of enumerated criteria may well evince a Congressional intent for the Administrator to supply reasonable ones." 824 F.2d at 1159.

2. Regulatory Approaches

The comments on the four approaches proposed by EPA for making the acceptable risk decision and for providing an ample margin of safety were generally polarized: Approach A was favored largely by industry; Approach D was favored by many private citizens, State regulatory agencies, and public interest groups; Approach B received essentially no support; and, while approach C was criticized by many industries, private citizens, State regulatory agencies and public interest groups, it received some support from other commenters within these groups. In addition, alternative approaches were suggested by several commenters with some favoring a higher acceptable risk level and others a zero emissions approach.

The EPA considered all of these comments in selecting the final policy for setting standards under section 112. This was done in light of the *Vinyl Chloride* decision; the final policy is described above in this **Federal Register** notice. The EPA response to these comments are presented below.

In considering the comments on the proposed approaches and alternative suggestion for a policy under section 112, EPA viewed the comments in the context that some positions and concerns expressed by the commenters were diametrically opposed to one another. Thus, EPA realized that no response could completely resolve these positions and concerns. Accordingly, after thoroughly viewing and considering these comments, EPA selected a final policy for setting standards under section 112.

The following sections are split into discussions of the four alternative approaches presented in the March 7, 1989 **Federal Register** notice and by ancillary issues that were relevant to selecting the final policy for setting NESHAPs. The main position and concerns presented by commenters are followed by an EPA response to the comments in the context of the final policy.

Approach A Comments: Many commenters favored Approach A on the basis that it would be flexible, not overly simplistic nor based on a single risk measure, that it would take into account all relevant health information and uncertainties in risk estimation, and it would be a more balanced and rational approach than the other approaches. Many commenters rejected Approach A because they did not find it stringent enough. On the other hand, some commenters felt the preferred level for the MIR of 10^{-4} or less was unnecessarily restrictive. One commenter suggested that Approach A should be modified to increase the maximum lifetime risk limit to 25 mrem/y ede. Several commenters found Approach A unacceptable because it does not establish a consistent and equitable policy, thereby allowing different acceptable risk decisions for different pollutants and source categories.

Response: The EPA agrees with many of these comments and, thus, the final policy, like proposed Approach A, is flexible, provides an equitable response to regulation of air toxics under section 112, and takes into account all the relevant health information and uncertainty in the risk assessment. The final policy is not overly simplistic (that is, based on a single risk measure) and is clearly consistent with the EPA's guidelines for cancer risk assessment for full disclosure of risk uncertainties and quantitative range of risks. The EPA appreciates the position of commenters who supported the EPA's concern that risk estimates less than 1×10^{-5} should be given less weight than risk estimates greater than 1×10^{-4}. The EPA believes, though, that it should reduce risks to less than 1×10^{-6} for as many exposed people as reasonably possible. The EPA also agrees with commenters that proposed Approach A may not be stringent enough, and, therefore, even though the final policy is similar to proposed Approach A, the application to the final policy results in lower levels of emissions. Regarding the maximum lifetime risk limit, the EPA has considered the recommendation of the NCRP, ICRP, and other expert advisory committees and in the context of the source categories herein considered, has concluded that individual dose levels greater than 10 mrem/y ede are inconsistent with the requirements of section 112.

The EPA also does not agree with commenters who said that several aspects of Approach A (e.g., its flexibility and consideration of uncertainty) would lead to an inconsistent policy allowing different acceptable risk decisions for different pollutants and source categories. The EPA believes that the uncertainties within different risk assessments can appropriately result in different acceptable risk decisions. For example, while EPA believes that the risk assessment may be overstated or understated in certain cases, there is no

specific way to account for this belief other than to qualitatively consider it in the acceptable risk decision; EPA sees this as an appropriate use of its expert judgment. In addition, EPA does not agree with commenters who said that the uncertainty of a risk assessment should only be considered in the ample margin of safety decision. Risk assessments are only as good as the weakest information and modeling tools used in the assessments, and the value of the results of these assessments must be considered every time they are used; to ignore the uncertainty of these assessments is scientifically unsound and could result in similarly unsound decisions that may be viewed as inconsistent.

Approach B Comments: No commenters favored Approach B. The commenters who opposed this approach generally fell into two groups: industries, who generally felt that Approach B was too conservative and narrow; and State governments, private citizens, and public interest groups, who felt that Approach B was not stringent enough.

Many commenters rejected Approach B (also C and D) because it is based on a single measure of acceptable risk (incidence in Approach B) and does not allow EPA to consider the full range of available health information. Some commenters opposed Approach B because the incidence is often greatly dependent on the definition of the source category. Most of these commenters felt that Approach B did not consider the maximum exposed individual and did not protect smaller populations from high risk when total incidence is low.

Response: The EPA agrees with most of these comments. The final policy, unlike proposed Approach B, provides an equitable response to regulation of air toxics under section 112 by providing for the consideration of the MIR, yet takes into account all the other relevant health information and uncertainty in the risk assessment, including incidence. The final policy is not overly simplistic (that is, based on a single risk measure) and is clearly consistent with the EPA's guidelines for cancer risk assessment for full disclosure of risk uncertainties and quantitative range of risks. The EPA appreciates the concern of commenters that incidence is often greatly dependent on the definition of the source category.

Approach C Comments: Approach C was supported by several commenters as being a straight-forward, bright-line approach. In contrast, some commenters found Approach C too conservative, inflexible, and limiting of the information which could be considered by the Administrator in making the acceptable risk decision. Many other commenters rejected Approach C because they did not find it stringent enough.

Response: The EPA agrees with many of these comments. The EPA utilizes a level of approximately 1×10^{-4} as an appropriate presumptive benchmark of acceptability in employing its selected policy approach. At the same time, EPA agrees with commenters that Approach C was inflexible and did not consider all the relevant health information and uncertainty in the risk assessment. Accordingly, as indicated in the discussion of the final policy, EPA believes that MIR levels greater than approximately 1×10^{-4} are presumptively unacceptable, but that the risk estimates must be considered in light of all the relevant health information and the uncertainties in the risk assessment. As part of this perspective, EPA agrees that exposures to background concentrations and multiple sources of a pollutant may be considered to the extent that it is practical and reasonable to do so.

Approach D Comments: A large group of public interest groups, and private citizens supported this approach. Their primary reason for support was because this was the most stringent approach, but other reasons included consistency with existing State air toxics programs and Federal regulations and accounting for underestimation of risk. A few commenters favored Approach D in order to protect public health in a multiple carcinogen environment.

The commenters who rejected Approach D did so for a variety of reasons. Some found Approach D too conservative, inflexible, and limiting in the information which could be considered in the acceptable risk decision. Several commenters disagreed with those who argue that a 1×10^{-6} acceptable risk level is justified due to concern about exposure to multiple chemicals; these commenters said that section 112 regulatory decisions should not be based on concerns about chemical exposures that have little relevance to the pollutant and source category being regulated.

Many commenters felt either that even the risk level of 1×10^{-6} given in Approach D was unacceptable or not protective enough of public health, or that "acceptable" risk should mean zero risk.

Response: The EPA agrees with commenters that felt that Approach D was too conservative, inflexible, and limiting of the information which could be considered in the acceptable risk decision. However, much of the intent of Approach D has been incorporated in the methodology adopted which seeks to protect as large a portion of the exposed population as possible to risks no higher than approximately 1×10^{-6}. The EPA also agrees with commenters who stated that consistency with State and Federal regulations must be viewed in light of the purpose and actual implementation of those regulations and, specifically, agrees that comparing NESHAP requirements with State programs (many of which are guidelines and contain waivers or flexibility if technology cannot achieve the programs' stated goals) is inappropriate. Also, EPA finds the comment that there is a public consensus that only an MIR of 1×10^{-6} or less is acceptable to be difficult to support given the wide range of positions expressed in this rulemaking.

While EPA agrees that multiple exposures to hazardous air pollutants are important to understand and consider in the EPA's overall implementation of its public health mandates, EPA disagrees that these exposures should be routinely evaluated and considered in selecting standards under section 112. In taking this position, EPA is agreeing with commenters who said using these exposures explicitly in selecting standards would be very difficult and possibly impractical. The EPA also disagrees with commenters who said that even the risk level of 1×10^{-6} given in Approach D was unacceptable or not protective enough of public health, or that "acceptable" risk is zero risk.

Alternative Acceptable Risk Approaches: Several commenters proposed variations on, or alternatives to, the EPA's four proposed approaches for determining acceptable risk. Several of these were modifications to the case-by-case approach. Another group argued for more stringent criteria than Approach D, with a ultimate goal of zero risk. A third group provided various other alternative acceptable risk levels.

Comment: Several commenters advocated higher levels of acceptable risk than those proposed in any of the EPA's approaches. Some did so by explicitly referencing guidance issued by the ICRP, the NCRP, or other groups involved with radiation health protection that sanction greater risks than those proposed by EPA.

Response: The EPA does not agree with the commenters who advocated higher levels of risk than any considered in the March 7, 1989, Federal Register notice. While some commenters interpreted the *Vinyl Chloride* decision to mandate these high risk levels, EPA believes that the *Vinyl Chloride* decision requires EPA to consider

societal risks in making an expert judgment on acceptability. The EPA completed such considerations, made an expert judgment and, consequently, selected a presumptive MIR level of approximately 1×10^{-4}. For the sources considered in this notice, EPA believes that associated risks in the range of 1×10^{-3} and 1×10^{-5} are too high, and presumptively unacceptable.

3. *Risk Comparisons in the Acceptable Risk Decision:* Several commenters expressed positions on whether comparison of hazardous air pollutant risk with other risks encountered by society should be considered in making the acceptable risk decision. Some commenters thought comparisons were appropriate while others did not.

Comment: Several commenters thought that as part of the acceptable risk decision, EPA should compare risks from radiation with other risks that are encountered in ordinary life and accepted by society. They generally used comparative risks as an argument in favor of Approach A and as evidence that risks of 1×10^{-4}, or even higher, could be considered acceptable. The commenters said such comparisons are consistent with the *Vinyl Chloride* decision's reference to consider the acceptability of risk in "the world in which we live." Many commenters listed several activities encountered in daily life which entail lifetime risks in the 1×10^{-3} to 1×10^{-4} range as evidence that this level of risk could be considered acceptable.

Others said the comparison is not valid because risks such as driving a car are voluntary, whereas pollutant exposures are involuntary.

Response: The *Vinyl Chloride* decision provides for such comparisons and for EPA to make an expert judgment of the acceptability of the risks for sources of hazardous air pollutants. However, EPA believes that it is prudent to view such comparisons cautiously and to reflect the uncertainty in such comparisons in the EPA's decisions on the acceptability of the risks for sources of hazardous air pollutants. Factors, such as whether the risks are voluntary, controllable, man-made, and uncertain, lead EPA to be cautious in making such comparisons. After considering these risks, EPA has determined that MIR's greater than approximately 1×10^{-4} are presumptively unacceptable and are considered in making an overall judgment on acceptability along with other relevant health and risk factors, including uncertainty.

However, in this regard, it is important to point out that MIR estimates are based on a different and, more conservative, concept than average risk expressions such as the risks associated with motor vehicles, or the risk of being killed by lightning. Average risks generally apply to the total population and do not reflect the distribution of risks across a population. For example, the average lifetime risk of death due to motor vehicle accidents is about 5×10^{-3}. A city with a population of 2 million might, therefore, expect about 150 traffic-related deaths every year even though some members of this population are at greater risk. On average, this 150 deaths every year does not express the incidence rate for those members of the population. In contrast, if the MIR at a typical industrial facility located in a city of 2 million population is 5×10^{-3}, the annual estimated incidence would only be about 1 death in 20 years (0.05 cases/year). And, the "average" individual risk to the exposed population is typically much lower, by orders of magnitude, than the MIR. Thus, while EPA believes that MIR risks greater than approximately 1×10^{-4} are presumptively not acceptable, EPA maintains that commenters who apply the MIR to entire populations are improperly characterizing population risks as well as the MIR.

Comment: Several commenters said that if levels of exposure are within the bounds of variation in ambient background levels, the activity should not be regulated. In addition, an annual dose of 10 mrem/y ede is probably within the normal variations seen in natural background; therefore, a cumulative dose of this magnitude from all man-made sources and pathways appears to be acceptable when considering risks if the ALARA principal is followed and enforced.

Response: The EPA believes that comparison of estimated MIR levels to natural background risk levels is irrelevant. What EPA considers important is the incremental risk associated with a particular activity. Reference to natural background risk levels is only acceptable in deciding what benchmark society deems acceptable.

4. *Ample Margin of Safety Decision:* Some commenters expressed opinions on what factors should be considered in the decision on what level of regulation provides an "ample margin of safety" as required by section 112 of the CAA and the *Vinyl Chloride* decision. Some commenters argued for strong consideration of health effects and uncertainties, while others emphasized consideration of economic impacts or a balancing of multiple factors.

Comment: Several commenters suggested that in the ample margin of safety decision, EPA should give greater consideration to health effects, noncancer effects, alternative exposure pathways, co-emitted pollutant risks, nonquantified health effects, interactions among pollutants, and uncertainties not taken into account in the EPA's risk estimates. It was also suggested that an "ample margin of safety" means no less than elimination of all avoidable risks.

Some commenters identified additional economic factors that they thought should be considered and that would lead to more stringent regulatory decisions. For instance, there are many costs to society associated with the deaths and illnesses associated with pollution, such as emotional costs to families, medical costs of treatment and institutionalization, and weakening of the gene pool.

Response: EPA disagrees with the comment that an "ample margin of safety" requires the elimination of all avoidable risks. The *Vinyl Chloride* decision does not require this degree of stringency. EPA did consider non-fatal cancers and genetic effects in developing this rule; additional health and economic information was considered to the extent that it exists in the rulemaking record. EPA will continue to endeavor to consider fully all relevant factors in the selection of final standards under section 112.

5. *Risk Assessment and Treatment of Uncertainty:* The response to the EPA's solicitation of comment regarding the treatment of uncertainty varied from approval of the EPA's position to suggestions that uncertainty should force stricter standards, or conversely, prohibit restrictive standards. One group of commenters stated that EPA had shown a good appreciation of the uncertainty associated with the scientific evaluation of health data and the exposure data used in estimating risk. Commenters also provided recommendations on which step of the decision process was the appropriate place for the consideration of uncertainty.

Comment: Some commenters favored consideration of uncertainties in the acceptable risk step of the decision process, while others felt it is more appropriate to consider uncertainties only in the ample margin of safety step, and still others advocated consideration during both steps. Some stated that questions of uncertainty and conservatism cannot be separated or deferred from the determination of acceptable risk, while others felt that consideration of uncertainty should be deferred until the ample margin of safety

step. Most of these latter commenters believed that the MIR should be the sole criterion for making the acceptable risk decision, and that uncertainties and other factors are best considered in the ample margin of safety step. In so doing, some added that these uncertainties should not be addressed by incorporating unscientific, over-conservative assumptions into the risk assessments.

Response: The EPA believes that it is essential to consider the quality of the information it uses to make decisions when the decisions are being made. Thus, EPA agrees with commenters that stated that it would be inappropriate to evaluate the "safe" level and the "margin of safety" without taking the uncertainties (both scientific and technological) into account. Because EPA has concluded that many factors should be considered in making the acceptable risk decision, the EPA disagrees with commenters who believed that MIR should be the sole criterion for making the acceptable risk decision and that uncertainties and other factors are best considered in the ample margin of safety step.

Comment: When estimates are imprecise, accurate quantified statements of uncertainty are essential; these factors must be actively involved in the decision-making process both for regulations and site-specific permitting decisions.

Response: The EPA has initiated a substantial effort to quantify the uncertainty in its radiation risk estimates. However, until quantitative uncertainty estimates are available, the Agency must base its decisions on the current measures of uncertainty at its disposal.

Comment: It would be inconsistent with the EPA's distinction between risk assessment and risk management for the Agency to deal with bona fide scientific questions at the stage of deciding what probability of contracting cancer is "acceptable." Risk considerations alone should be dealt with in this first step. Moreover, an adequate data base must be established for technical, scientific, and economic considerations before these can be balanced with acceptable risks.

Response: The EPA disagrees that bona fide scientific questions are inappropriate at the risk management step. The EPA's risk assessments are based on what it considers the best available scientific evidence, with conservative but reasonable assumptions made when necessary. At the risk management step, the decisionmakers need to know the uncertainties associated with the risk estimates and the range of scientific opinion regarding the assumptions that have been included in the assessment.

Comment: Some commenters suggested that the proposed rules are improperly based on incomplete technical analyses.

Response: The final rules are the result of extensive research and technical analysis conducted over a period of several years, and, thus, the record underlying the rules is reasonably complete and accurate. Commenters' technical comments, as well as those of other commenters, are incorporated into the record to the extent they proved pertinent. In arriving at the acceptable risk decisions under CAA section 112 for these rules, costs and technological feasibility were not considered. Such were considered along with the health-related factors, however, in determining whether more stringent rules were needed in arriving at the statutorily required ample margin of safety.

Comment: Several commenters have asserted that EPA's risk assessments are not realistic but are worst case estimates. Some commenters objected to EPA's assumption that people living in the vicinity of radionuclide sources were exposed continuously, for a 24 hours per day 70-year lifetime, to predicted long-term ambient radionuclide levels. Commenters maintained that the average lifetime of an industrial facility is considerably less than 70 years, and that few individuals would be expected to live in the same location for their entire lives.

Response: The EPA recognizes that the assumption of 70 years of continuous exposure constitutes a simplification of actual conditions and represents, in part, a policy judgment by EPA, but feels that this assumption is preferable to other alternatives. Although emissions of radionuclides from industrial sources would reasonably be expected to change over time, such changes cannot be predicted with any certainty. In lieu of closing, plants may elect to replace or even expand their operations and subsequently increase their emissions. The 70-year exposure duration represents a steady-state emissions assumption that is consistent with the way in which the measure of carcinogenic strength is expressed (i.e., as the probability of contracting cancer based upon a lifetime [70 year] exposure to a unit concentration). Constraining the analysis to an "average" plant lifetime carries the implication that no one could be exposed for a period longer than the average. Since by definition, some plants would be expected to emit longer than the average, this assumption would tend to underestimate the possible MIR. The EPA agrees that the U.S. population is highly mobile. However, adjusting the exposure assumptions to constrain the possibility of exposure to emissions implies that exposure during the periods away from the residence are zero. In addition, a less-than-lifetime assumption would also have a proportional impact on the estimated MIR, suggesting that no individual could be exposed for 70 years. On balance, EPA believes that the present assumption of continuous exposure is consistent with the steady-state nature of the analysis and with the stated purpose of making plausible, if conservative, estimates of the potential health risks. It is the EPA's opinion that this assumption, while representing in part a policy judgment by EPA, continues to be preferable to adopting a shorter lifetime figure, both in view of the shortcomings of such alternatives and in the absence of compelling evidence to the contrary.

Comment: The EPA should measure the gain in risk reduction made against the costs to reach such gain and compare the benefits against the increased risk borne by workers.

Response: The EPA does consider both the incremental reduction in risk and the costs at the ample margin of safety step. The EPA is unaware of any increase in worker exposure that will be caused by the promulgated NESHAPs.

6. Scope of the Regulations

Comment: Several commenters stated that NESHAPS should be developed for other sources or categories of radionuclide emissions including that from Naturally Occurring Radioactive Materials (NORM) contamination of oil and gas production equipment and in construction materials, and also from naturally occurring radon in the soil that underly residences, schools, businesses and offices. They questioned whether emanation rates of radon (222 and 220) from coal stockpiles, boilers, fly ash, and bottom ash significant for regulation under the NESHAP program.

Response: The EPA believes that the source categories evaluated in this rulemaking represent the sources with the greatest potential for causing unacceptable risks from radionuclide emissions to ambient air. The Agency has examined the potential problem of radon in natural gas provided to homes and found that the transit times allow for the decay of the radon to acceptable levels. Emissions of radon from coal piles and coal ash piles has also been examined, as part of the CERCLA rulemaking on Reportable Quantities,

with similar results. EPA will continue to look at these and other potential sources to see if they are appropriate sources for regulation under section 112. Finally, it must be noted that EPA's authority under CAA Section 112 is limited to the regulation of source categories of toxics to ambient air and, thus, lacks authority to regulate or control naturally ocurring radon in soils that underly homes or businesses under this code section.

Comment: Consideration should be given to the problems presented by overlapping sources, any increase in the number of facilities within each category over time, and the goal of controlling the total incremental pollution for all radionuclide emissions from all source points in all twelve source categories.

Response: The Agency agrees and its policies on acceptable risk levels are based, in part, on assuring that risks caused by overlapping and multiple sources do not result in individuals receiving an unacceptable level of exposure and risk. Explicitly accounting for overlapping and multiple sources of exposure greatly complicates the calculation of exposures and risks. Since concentrations of radionuclides decline rapidly with distance from a source, however, it is highly unlikely that any individual could be the most exposed individual for more than one source. In most cases, members of the public will receive risks less than 1×10^{-6} from more than one source.

Comment: The standards should address cumulative health impacts resulting from exposures to multiple radiological and nonradiological pollutants emitted by the same or multiple sources located in relative proximity to one another.

Response: Although EPA has been unable to quantify cumulative and synergistic health impacts for multiple hazardous materials and sources have not been accurately qualified, it is our judgment that if such effects could be accurately quantified, they would not substantially alter EPA's conclusions in this rulemaking.

Comment: The standards consider only fatal cancers and fail to take into account the entire range of chronic debilitating and incapacitating diseases that may result from radionuclide emissions.

Response: EPA has taken into account the entire range of chronic debilitating and incapacitating diseases that may result from radionuclide emissions.

Comment: Proposed standards are based on what the EPA perceives as achievable rather than a safe level of airborne radioactivity emissions; this is not an appropriate basis for setting air emission standards under the Act.

Response: The EPA believes that its standards ensure an acceptable level of risk to public health with an ample margin of safety as required by the Clean Air Act and the decision in *Vinyl Chloride*. The Agency has established a threshold presumption that lifetime fatal cancer risks to individuals of approximately 1×10^{-4} are acceptable under the *Vinyl Chloride* decision, and has attempted to assure that as many persons as possible do not receive lifetime risks greater than 1×10^{-6}.

Comment: The potential effect of the proposed rule on Federal preemption in the area of regulation of facilities needs to be carefully considered. Nuclear facilities are unique and complex, and consistent regulation is in the best interest of the public. Congress determined that national regulation of nuclear power plants is appropriate in establishing the Atomic Energy Act.

Response: The Agency agrees that consistent regulation is in the interest of the public and has promulgated national emissions standards that apply to nuclear power plants. However, the Clean Air Act does not preempt state standards that are at least as stringent as those set by the Federal Government.

Comment: The consistency of these standards with other existing and proposed radiation standards, for air pathways and other pathways, should be discussed.

Response: As noted in the March 7, 1989 Federal Register notice for the proposed standards, the statutory requirements of CAA section 112 differ from the requirements of other authorities under which the EPA and other regulatory bodies set radiation standards. Therefore, the first priority for EPA is to assure that the regulations promulgated are in accordance with its statutory mandate.

Comment: All facilities that emit similar radionuclides should be held to the same emission standards; a remote facility should not be allowed higher emission rates than an urban facility, nor should a government or municipal facility be allowed higher emission rates than a private or industrial facility.

Response: The EPA's decisionmaking approach in setting final rules assures that all members of the public are adequately protected, regardless of the source of their exposure or their choice of residence in an urban, suburban, rural, or remote area of the country. The EPA believes that different source categories may be treated differently even if they emit similar pollutants, so long as the final standard protects public health with an ample margin of safety.

Comment: The Clean Air Act does not allow for dose standards.

Response: We disagree with those commenters stating that Congress in directing the Agency to set emission standards did not authorize that those standards be set in terms of dose to an individual. CAA section 302(k) defines the term "emission standard" to include limits on the quantity, rate, or concentration of an air pollutant and the Agency views dose standards fully consistent with that definition. In many cases, because there are over two hundred known radionuclides, numerous different ones are emitted from an individual source. In addition, the risk due to each is a further function of many factors such as particle size and exact chemical state. An emission standard for radionuclides based on quantity at the stack would often be complex to the point of impracticality. A dose standard provides a better approach to protecting the public since it allows the establishment of a uniform limit based on consideration of all of the factors related to the particular mix of radionuclides emitted from each source. Moreover, this approach is supported by radiation protection experts and the regulated community.

Comment: Some commenters posit that Clean Air Act Section 112 does not, or should not, authorize EPA to regulate radionuclide air emissions from those sources, or categories of sources, that are already regulated pursuant to the Uranium Mill Tailings Radiation Control Act of 1978, Pub. L. No. 95-604, 92 Stat. 3021 (codified in scattered sections of 42 U.S.C.) ("UMTRCA"). These commenters reason that because UMTRCA was promulgated subsequent to the last comprehensive revisions to the Clean Air Act, and, because UMTRCA's statutory scheme is more specifically focused upon the sources to which it applies than is the Clean Air Act, EPA's authority under CAA Section 112 is, in effect, preempted.

Response: EPA disagrees that it lacks authority to regulate, under CAA Section 112, the radionuclide air emissions of sources also regulated under UMTRCA. Indeed, UMTRCA itself resolves this issue by quite explicitly stating that "[n]othing in this chapter applicable to byproduct material * * * shall affect the authority of the [EPA] under the Clean Air Act of 1970, as amended * * * " 42 U.S.C. section 2022(e). The legislative history is similar: "Authorities of the EPA under other laws would not be abridged by the new requirements." H. Rep. No. 1480,

95th Cong., 2d Sess. 6, reprinted in, 1978 U.S. Code Cong. & Admin. News 7433, 7444. In other words, there is no indication that Congress intended UMTRCA to preempt EPA's regulatory authority under the Clean Air Act; rather Congress expressly contemplated EPA authority to simultaneously regulate under both legislative schemes.

7. Procedural

Comment: Many commenters felt that the affected parties familiar with the proposed standards have not had adequate time to thoroughly review available documents, and many stated that many supporting documents were not available until mid-April. In addition, several stated that the material contained significant errors.

Response: The EPA made every effort to notify affected parties of the rulemaking action, and it timely prepared and distributed the background materials supporting the proposed rules. However, the court order under which this rulemaking has been conducted necessitated strict adherence to the schedule for public comments and hearings. The Agency is not aware of any significant errors in the risk assessment. Where additional or new information was provided or developed during the comment period, it has been incorporated into the Final Environmental Impact Statement (FEIS), also referred to as the Background Information Document (BID).

Comment: The Proposed Rulemaking Notice, published in the **Federal Register** on March 7, 1989, does not identify those who participated in its preparation. The authors of the Draft Environmental Impact Statement (DEIS) do not appear to represent the kinds of knowledge, experience, and expertise necessary for the task.

Response: The DEIS does identify the ORP staff members who contributed to the development of the background material and indicates that S. Cohen and Associates, Inc., the Office's Technical Support Contractor, provided considerable technical support and analysis. The Agency disagrees strongly that the participants in this effort lack the necessary knowledge, experience, and expertise to prepare the proposal or final rulemaking packages.

Comment: The conclusion of the Regulatory Flexibility Act analysis that this rule will have little or no impact on small businesses because virtually all small businesses regulated under this rule already comply with the proposed standards is unsupported.

Response: The final rule for NRC-Licensed and Non-DOE Federal facilities is the only NESHAP with the potential to affect small businesses. That standard is a baseline standard, which indicates that EPA is unaware of any particular facility that does not comply with the final rule. In doing its risk assessment, EPA looked at model facilities with relatively large emissions for that class of facility to ensure that the risk was not underestimated. Therefore, EPA believes that it is highly unlikely that any small business would have emissions which would exceed the standard.

Comment: An international panel of recognized health professionals and epidemiologist should review and comment on the health effects of these very low levels of proposed radiation protection standards.

Response: The Agency invited comments from all interested parties during the public comment period. Further, it has reviewed and considered the findings and recommendations of the NCRP, the ICRP, UNSCEAR, and the NAS in developing its risk coefficients. Finally, the risk coefficients used in this risk assessment were reviewed and approved by the Agency's Science Advisory Board.

Comment: Even among the various sources proposed for regulation in this rulemaking there does not appear to be an even handed application of the EPA's own analysis. The different regulatory standards proposed by the EPA for the various sources are irrational.

Response: The EPA disagrees. The proposed regulations were developed on a consistent basis for each of the four approaches. For the final rule, the EPA used a single approach to determine the level of each standard it set. The EPA believes that consistency among the standards has been achieved.

Comment: The EPA should defer final action in this rulemaking to permit public comment on the Science Advisory Board's Review of EPA's proposal.

Response: The court imposed schedule for this rulemaking does not permit the Agency to extend the public comment period.

Comment: The EPA should propose its enforcement policy for public review and comment.

Response: The EPA does not plan at this time to create a specific enforcement policy for these rules, but instead currently intends to enforce them in the same manner that it enforces other Clean Air Act standards.

8. Decision to List Under Section 112

The FR notice requested comments on the appropriateness of listing radionuclides as hazardous air pollutants under section 112 of the Act. Comments on this issue ranged from unequivocal support for listing to questions as to the justification for listing under this section of the Act. Many, while not necessarily opposing listing, stated that their particular source or source category should not be regulated under the Act due to the insignificant risks to public health presented, or, in light of the existence of other regulations.

Comment: Several commenters stated that the listing under section 112 is appropriate because a hazardous air pollutant includes those substances that may result in an increase in mortality or an increase in serious irreversible or incapacitating reversible illness. The EPA should apply the same risk assessment criteria to radionuclides that are applied to other toxic air pollutants regulated under section 112. Such an approach is the only way that the health protection goals will be achieved.

Response: The EPA agrees that listing under section 112 is appropriate, and it does apply the same approach and criteria to all risk assessments and standard setting under section 112. However, differences in our knowledge about different hazardous materials, differences in the modes of exposure (pathways), and differences in the assessment of exposure lead to different risk assessment methods.

Comment: Many oppose the listing of radionuclides for three main reasons: (1) Radionuclide emissions from all source categories constitute only 1/30th of natural background, which is an insignificant amount; (2) concentrations released into the general environment as a matter of routine emissions do not constitute the degree of hazard which section 112 was meant to regulate; and (3) there is no evidence with respect to the health effects of low level radionuclide emissions.

Response: The EPA believes that its listing of radionuclides as hazardous air pollutants under section 112 is proper and is compelled by both the weight of the scientific evidence and the Administrator's statutory duties under the Act. While the EPA agrees that there is no conclusive human epidemiological data demonstrating health effects at low levels of exposure, we believe that the preponderance of the scientific evidence (both human epidemiology at higher levels of exposure and the data from non-human sources) indicates that the linear non-threshold dose response model is consistent with the available data and its utilization for regulatory purposes is appropriate. The EPA disagrees that the levels of risks posed by releases of radioactive materials into

the air are below those the Congress intended to regulate under section 112. Finally, the EPA does not consider the comparison of the risks posed by man-made sources to the risks from background to be relevant. The level of exposure corresponding to safe with an ample margin of safety, not background, is the appropriate criterion for regulation under section 112. Many risks associated with natural background radiation are relatively high and, thus, are not appropriate as a benchmark for evaluating the need for regulation.

Comment: Some commenters felt that regulation of radionuclides under section 112 is appropriate but that EPA should exempt some categories of industries that are regulated under other authorities, unless the current emissions within the source category can be shown to be unsafe.

Response: The Agency has concluded that for source categories where emissions present or potentially present unacceptable risks, it should not defer to other regulatory authorities.

9. Technological and Economic Factors

Comment: The EPA should not be concerned with availability or feasibility of controls. It should simply establish the requirement and let industry determine how it will meet it.

Response: In determining the safe level, EPA agrees. Thus, at that stage it does not consider either the availability or feasibility of controls. These are considered, however, at the second step ample margin of safety determination. Moreover, where possible, such as with the NESHAP for underground uranium mines, the regulated community is given wide latitude in selecting the combination of controls and/or work practices that will allow them to meet the mandated level of the standard.

Comment: The factors the EPA should consider before requiring control technology include: commercial vendor availability, adaptability from other uses, readily understood and applicable operating principles, costs and health benefits. Availability to U.S. industry should not be based on foreign commercialization.

Response: In general, these are the factors that the EPA considers. However, the EPA sees no reason to automatically preclude a technology solely because it has been developed and commercialized only outside of the U.S.

Comment: A technological development that has been demonstrated to reduce emissions and is in use in or outside the U.S. should be considered available and required.

Response: The EPA agrees that the availability of demonstrated control technology should be considered. However, the requirement of additional controls, at the ample margin of safety step, rests also on consideration of costs and other factors.

Comment: Because of the existing regulatory framework that forces the use of control technology pursuant to the ALARA principle, the nuclear industry is already at a very low level of emissions and further regulation is merely duplicative.

Response: The EPA agrees that the emissions from many segments of the nuclear industry are at low levels. The EPA does not anticipate that facilities with state-of-the art control systems will need additional controls to comply with the limits of the NESHAP. However, EPA does not agree that in all circumstances regulation under CAA section 112 is unnecessary and indeed has determined that final rules are needed for the radionuclide source categories identified.

Comment: The EPA should not promulgate additional radionuclide emission regulations for the uranium fuel cycle (UFC) including nuclear power plants. The industry has a proven record of protecting the public health and safety from airborne radioactive emissions. This results from the conservative design of the facilities, the careful operating philosophy employed in these facilities, and the existing framework of EPA and NRC regulations. The public already enjoys better protection from UFC radionuclide emissions than from almost any other industry's emissions.

Response: As stated in the FR notice, the Administrator has determined that regulation of potentially significant risks should not be deferred to other regulatory authorities. Based on its evaluation of the doses and risks caused by UFC facilities, the EPA does not believe that non-milling facilities will have to modify their operations to comply with the NESHAP. However, EPA has agreed to reconsider the issue of duplication of regulation as described in the discussion on subpart I.

Comment: The DOE is concerned that the EPA has proposed an outdoor radon concentration standard that is far below the level the EPA is willing to allow indoors.

Response: The authorities under which the NESHAPs and indoor radon guidance are promulgated are entirely different. The EPA does not have the authority to mandate indoor radon levels. Its guidance to homeowners is based on a single screening measurement, the protocols for which are designed not to provide an average exposure level but a maximum exposure level. Therefore, comparison with the limits established by the NESHAP is invalid.

Comment: Regulations that have the effect of forcing use of control technology are clearly inappropriate where the technology has not been shown to be currently available.

Response: CAA section 112 requires EPA to set a safe or acceptable level without regard to the availability of control technology. Nevertheless, as a practical matter, while NESHAPs allow for use of new technologies, none of the promulgated NESHAPs requires the development of new technologies.

Comment: A strong regulatory stance by the EPA in requiring pollution controls will act to stimulate innovation, reduce prices via increased sales of control technologies and processes, and reduce risk.

Response: This stimulation of innovation and price competition in the effluent control industry, while a laudable public goal, is not a requirement under section 112 of the Act. Rather, the purpose and focus of NESHAPs is to protect public health with an ample margin of safety.

Comment: EPA should include avoided costs, e.g. possible tort judgments, including punitive damages, in determining the level of the final standard at the ample margin of safety step of the decision-making process.

Response: In theory, the EPA agrees. However, as a practical matter, it is often difficult to arrive at even an approximation of avoided costs when dealing with specific source categories. They are simply too speculative, especially given that the source categories are often comprised of thousands of individual facilities.

Comment: Cost as used in the ample margin of safety discussion should include all of the costs identifiable with the decision; this would include value of the facility, economic effects on the community, and social effects of labor force dislocation.

Response: To the extent that the EPA is able to develop quantitative estimates of these costs they are considered pursuant to the decision-making process. However, as already noted, such costs are often only available, if at all, as rough, qualitative estimates.

Comment: Industry should meet the criteria irrespective of costs or technological feasibility.

Response: The EPA agrees with respect to meeting the levels determined to be "safe." The EPA disagrees with

respect to the determination of the needed ample margin of safety.

Comment: Fundamental fairness prohibits the EPA from imposing controls that cost more than some ceiling amount per estimated death prevented.

Response: Since the *Vinyl Chloride* decision precludes consideration of cost when determining what constitutes "safe," all sources must meet the standards or utilize controls to the degree necessary to bring their emissions into compliance, regardless of the cost.

Comment: EPA has not explained the basis for abandoning the existing regulatory program for uranium mill tailings disposal in favor of regulation under the CAA. The UMTRCA, passed subsequent to the CAA, provides flexibility.

Response: The Administrator has determined not to defer to other regulatory authorities when the risk merits issuance of a NESHAP under section 112 of the Act. However, the requirements of the other regulations must still be met.

Comment: If post-closure emissions are to be actively regulated under the standard, the EPA should address financial assurances for evaluation, monitoring, reporting, facility modification request, and remedial actions.

Response: Given the one-time nature of the post-closure monitoring requirements for phosphogypsum stacks and uranium mill tailings disposal sites, the EPA does not believe that the small financial burden requires specific financial assurance requirements. Details of monitoring and reporting requirements are included in the appropriate Subparts.

Comment: The proposal fails to address the occupational dose increment resulting from the installation, operation, and maintenance of the additional equipment and systems required for compliance; the collective occupational exposures required for some of these additions will be at higher individual doses and of significantly more consequence than the questionable savings in public risk.

Response: The lack of specific instances makes it impossible to fully address this concern. The EPA is not aware of any instance where a NESHAP will require emission controls that will result in a significant occupational exposure. Where controls may be required, for example at elemental phosphorus plants, they supplement or replace existing, less effective, controls. The exposure resulting from installation should be minimal since the process will be shut down, and exposures received during maintenance should be comparable.

Comment: Consideration should be given to whether public welfare would not be improved by diverting moneys from regulatory procedures with no measurable effect on human health, to research efforts, which have resulted in considerable advantages to the public health and well being. Human costs to those dependent on the industry as well as other adverse environmental repercussions caused by a shift away from nuclear power toward more polluting technologies, will far outweigh any theoretical public health benefit.

Response: The suggested cost-benefit determination is outside the purview of the Agency. However, given the concerns of the National Institutes of Health that health care may be affected, EPA has agreed to reconsider this issue.

Comment: The statement that demand for nuclear energy is on the decline due to reduced demand for nuclear generated electricity is fallacious. Also, while the analysis recognizes that these regulations will worsen the already weak position of the domestic uranium industry, it does not examine the adverse effects that will have on the national trade deficit.

Response: Imported uranium is a trivial component of the United States trade deficit.

Comment: The EPA estimates costs associated with the alternative regulatory approaches for each source category but the total fuel cycle cost will be passed through to nuclear utilities and should be assessed on that basis. This includes sources under subparts B, H, I, K, R, S, T, and W.

Response: Costs associated with the final rule are not significant compared with the total fuel cycle costs. There would be no significant impacts.

VIII. Miscellaneous

A. Docket

The docket is an organized and complete file of all information considered by EPA in the development of the standards. The docket allows interested persons to identify and locate documents so they can effectively participate in the rulemaking process. It also serves as the record for judicial review.

Transcripts of the hearings, all written statements, the Agency's response to comments, and other relevant documents have been placed in the docket and are available for inspection and copying during normal working hours.

B. General Provisions

Except where otherwise specifically stated, the general provisions of 40 CFR part 61, subpart A apply to all sources regulated by this rule.

C. Paperwork Reduction Act

The information collection requirements in this final rule have been approved by the Office of Management and Budget (OMB) under the Paperwork Reduction Act, 44 U.S.C. 3501 *et seq.* and have been assigned OMB control number 2060–0191.

D. Executive Order 12291

Under Executive Order 12291, EPA is required to judge whether this regulation is a "major rule" and therefore subject to certain requirements of the Order. The EPA has determined that regulations promulgated today will result in none of the adverse economic effects set forth in section I of the Order as grounds for finding a regulation to be a "major rule." These regulations are not major because (1) nationwide annual compliance costs do not meet the $100 million threshold; (2) the regulations do not significantly increase prices or production costs; and (3) the regulations do not cause significant adverse effects on domestic competition, employment, investment, productivity, innovation, or competition in foreign markets.

All of the final regulations presented in this notice were submitted to OMB for review as required by Executive Order 12291. Any written comments from OMB to EPA and any written EPA response to those comments has been included in the docket.

E. Regulatory Flexibility Analysis

Section 603 of the Regulatory Flexibility Act, 5 U.S.C. 603, requires EPA to prepare and make available for comment an "initial regulatory flexibility analysis" in connection with any rulemaking for which there is a statutory requirement that a general notice of proposed rulemaking be published. The "initial regulatory flexibility analysis" describes the effect of the proposed rule on small business entities.

However, section 604(b) of the Regulatory Flexibility Act provides that section 603 "shall not apply to any proposed . . . rule if the head of the Agency certifies that the rule will not, if promulgated, have a significant economic impact on a substantial number of small entities."

EPA believes that virtually all small businesses are currently in compliance with these rules. In addition, EPA has placed reporting exemptions in the rule

for NRC-licensees to limit the amount of paperwork that would be required by the smaller operators. Therefore, this rule will have little or no impact on small businesses. A small business is one that has 750 employees or fewer.

For the preceding reasons, I certify that this rule will not have significant economic impact on a substantial number of small entities.

List of Subjects in 40 CFR Part 61

Air pollution control, Arsenic, Asbestos, Beryllium, Benzene, Incorporation by reference, Mercury, Radionuclides, Vinyl chloride.

Dated: October 31, 1989.

William G. Rosenberg,

Acting Administrator.

Part 61 of chapter I of title 40 of the Code of Federal Regulations is amended as follows:

PART 61—[AMENDED]

1. The authority citation for part 61 continues to read as follows:

Authority: 42 U.S.C. 7401, 7412, 7414, 7416, 7601.

2. Part 61 is amended by revising subparts B, H, I, K and W and by adding subparts R and T to read as follows. These subparts are effective December 15, 1989. Subpart I is stayed until March 15, 1989.

Subpart B—National Emission Standards for Radon Emissions From Underground Uranium Mines

Sec.

§ 61.20 Designation of facilities.

The provisions of this subpart are applicable to the owner or operator of an active underground uranium mine which:

(a) Has mined, will mine or is designed to mine over 100,000 tons of ore during the life of the mine; or

(b) Has had or will have an annual ore production rate greater than 10,000 tons, unless it can be demonstrated to EPA that the mine will not exceed total ore production of 100,000 tons during the life of the mine.

§ 61.21 Definitions.

As used in this subpart, all terms not defined here have the meaning given them in the Clean Air Act or subpart A of part 61. The following terms shall have the following specific meanings:

(a) *Active mine* means an underground uranium mine which is being ventilated to allow workers to enter the mine for any purpose.

(b) *Effective dose equivalent* means the sum of the products of absorbed dose and appropriate factors to account for differences in biological effectiveness due to the quality of radiation and its distribution in the body of reference man. The unit of the effective dose equivalent is the rem. The method for calculating effective dose equivalent and the definition of reference man are outlined in the International Commission on Radiological Protection's Publication No. 26.

(c) *Underground uranium mine* means a man-made underground excavation made for the purpose of removing material containing uranium for the principal purpose of recovering uranium.

§ 61.22 Standard.

Emissions of radon-222 to the ambient air from an underground uranium mine shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/y.

§ 61.23 Determining compliance.

(a) Compliance with the emission standard in this subpart shall be determined and the effective dose equivalent calculated by the EPA computer code COMPLY–R. An underground uranium mine owner or operator shall calculate the source terms to be used for input into COMPLY–R by conducting testing in accordance with the procedures described in Appendix B, Method 115, or

(b) Owners or operators may demonstrate compliance with the emission standard in this subpart through the use of computer models that are equivalent to COMPLY–R provided that the model has received prior approval from EPA headquarters. EPA may approve a model in whole or in part and may limit its use to specific circumstances.

§ 61.24 Annual Reporting Requirements.

(a) The mine owner or operator shall annually calculate and report the results of the compliance calculations in section 61.23 and the input parameters used in making the calculation. Such report shall cover the emissions of a calendar year and shall be sent to EPA by March 31 of the following year. Each report shall also include the following information:

(1) The name and location of the mine.

(2) The name of the person responsible for the operation of the facility and the name of the person preparing the report (if different).

(3) The results of the emissions testing conducted and the dose calculated using the procedures in § 61.23.

(4) A list of the stacks or vents or other points where radioactive materials are released to the atmosphere, including their location, diameter, flow rate, effluent temperature and release height.

(5) A description of the effluent controls that are used on each stack, vent, or other release point and the effluent controls used inside the mine, and an estimate of the efficiency of each control method or device.

(6) Distances from the points of release to the nearest residence, school, business or office and the nearest farms producing vegetables, milk, and meat.

(7) The values used for all other user-supplied input parameters for the computer models (e.g., meteorological data) and the source of these data.

(8) Each report shall be signed and dated by a corporate officer in charge of the facility and contain the following declaration immediately above the signature line: "I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See, 18 U.S.C. 1001."

(b) If the facility is not in compliance with the emission standard of § 61.22 in the calendar year covered by the report, the facility must then commence reporting to the Administrator on a monthly basis the information listed in paragraph (a) of this section for the preceding month. These reports will start the month immediately following the submittal of the annual report for the year in noncompliance and will be due 30 days following the end of each month. This increased level of reporting will continue until the Administrator has determined that the monthly reports are no longer necessary. In addition to all the information required in paragraph (a) of this section, monthly reports shall also include the following information:

(1) All controls or other changes in operation of the facility that will be or are being installed to bring the facility into compliance.

(2) If the facility is under a judicial or administrative enforcement decree the report will describe the facilities performance under the terms of the decree.

(c) The first report will cover the emissions of calendar year 1990.

(Approved by the Office of Management and Budget under Control Number 2060–0191.)

§ 61.25 Recordkeeping requirements.

The owner or operator of a mine must maintain records documenting the source of input parameters including the results of all measurements upon which they are based, the calculations and/or analytical methods used to derive values for input parameters, and the procedure used to determine compliance. In addition, the documentation should be sufficient to allow an independent auditor to verify the accuracy of the determination made concerning the facility's compliance with the standard. These records must be kept at the mine or by the owner or operator for at least five years and upon request be made available for inspection by the Administrator, or his authorized representative.

§ 61.26 Exemption from the reporting and testing requirements of 40 CFR 61.10.

All facilities designated under this subpart are exempt from the reporting requirements of 40 CFR 61.10.

Subpart H—National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities

Sec.

§ 61.90 Designation of facilities.

The provisions of this subpart apply to operations at any facility owned or operated by the Department of Energy that emits any radionuclide other than radon-222 and radon-220 into the air, except that this subpart does not apply to disposal at facilities subject to 40 CFR part 191, subpart B or 40 CFR part 192.

§ 61.91 Definitions.

As used in this subpart, all terms not defined here have the meaning given them in the Clean Air Act or 40 CFR part 61, subpart A. The following terms shall have the following specific meanings:

(a) *Effective dose equivalent* means the sum of the products of absorbed dose and appropriate factors to account for differences in biological effectiveness due to the quality of radiation and its distribution in the body of reference man. The unit of the effective dose equivalent is the rem. For purposes of this subpart, doses caused by radon-222 and its respective decay products formed after the radon is released from the facility are not included. The method for calculating effective dose equivalent and the definition of reference man are outlined in the International Commission on Radiological Protection's Publication No. 26.

(b) *Facility* means all buildings, structures and operations on one contiguous site.

(c) *Radionuclide* means a type of atom which spontaneously undergoes radioactive decay.

(d) *Residence* means any home, house, apartment building, or other place of dwelling which is occupied during any portion of the relevant year.

§ 61.92 Standard.

Emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.

§ 61.93 Emission monitoring and test procedures.

(a) To determine compliance with the standard, radionuclide emissions shall be determined and effective dose equivalent values to members of the public calculated using EPA approved sampling procedures, computer models CAP–88 or AIRDOS–PC, or other procedures for which EPA has granted prior approval. DOE facilities for which the maximally exposed individual lives within 3 kilometers of all sources of emissions in the facility, may use EPA's COMPLY model and associated procedures for determining dose for purposes of compliance.

(b) Radionuclide emission rates from point sources (stacks or vents) shall be measured in accordance with the following requirements or other procedures for which EPA has granted prior approval:

(1) Effluent flow rate measurements shall be made using the following methods:

(i) Reference Method 2 of Appendix A to part 60 shall be used to determine velocity and volumetric flow rates for stacks and large vents.

(ii) Reference Method 2A of Appendix A to part 60 shall be used to measure flow rates through pipes and small vents.

(iii) The frequency of the flow rate measurements shall depend upon the variability of the effluent flow rate. For variable flow rates, continuous or frequent flow rate measurements shall be made. For relatively constant flow rates only periodic measurements are necessary.

(2) Radionuclides shall be directly monitored or extracted, collected and measured using the following methods:

(i) Reference Method 1 of Appendix A part 60 shall be used to select monitoring or sampling sites.

(ii) The effluent stream shall be directly monitored continuously with an in-line detector or representative samples of the effluent stream shall be withdrawn continuously from the sampling site following the guidance presented in ANSIN13.1–1969 "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities" (including the guidance presented in Appendix A of ANSIN13.1) (incorporated by reference—see § 61.18) The requirements for continuous sampling are applicable to batch processes when the unit is in operation. Periodic sampling (grab samples) may be used only with EPA's prior approval. Such approval may be granted in cases where continuous sampling is not practical and radionuclide emission rates are relatively constant. In such cases, grab samples shall be collected with sufficient frequency so as to provide a representative sample of the emissions.

(iii) Radionuclides shall be collected and measured using procedures based on the principles of measurement described in Appendix B, Method 114. Use of methods based on principles of measurement different from those described in Appendix B, Method 114 must have prior approval from the Administrator. EPA reserves the right to approve measurement procedures.

(iv) A quality assurance program shall be conducted that meets the performance requirements described in Appendix B, Method 114.

(3) When it is impractical to measure the effluent flow rate at an existing source in accordance with the requirements of paragraph (b)(1) of this section or to monitor or sample an effluent stream at an existing source in accordance with the site selection and sample extraction requirements of paragraph (b)(2) of this section, the facility owner or operator may use alternative effluent flow rate measurement procedures or site

selection and sample extraction procedures provided that:

(i) It can be shown that the requirements of paragraph (b) (1) or (2) of this section are impractical for the effluent stream.

(ii) The alternative procedure will not significantly underestimate the emissions.

(iii) The alternative procedure is fully documented.

(iv) The owner or operator has received prior approval from EPA.

(4)(i) Radionuclide emission measurements in conformance with the requirements of paragraph (b) of this section shall be made at all release points which have a potential to discharge radionuclides into the air in quantities which could cause an effective dose equivalent in excess of 1% of the standard. All radionuclides which could contribute greater than 10% of the potential effective dose equivalent for a release point shall be measured. With prior EPA approval, DOE may determine these emissions through alternative procedures. For other release points which have a potential to release radionuclides into the air, periodic confirmatory measurements shall be made to verify the low emissions.

(ii) To determine whether a release point is subject to the emission measurement requirements of paragraph (b) of this section, it is necessary to evaluate the potential for radionuclide emissions for that release point. In evaluating the potential of a release point to discharge radionuclides into the air for the purposes of this section, the estimated radionuclide release rates shall be based on the discharge of the effluent stream that would result if all pollution control equipment did not exist, but the facilities operations were otherwise normal.

(5) Environmental measurements of radionuclide air concentrations at critical receptor locations may be used as an alternative to air dispersion calculations in demonstrating compliance with the standard if the owner or operator meets the following criteria:

(i) The air at the point of measurement shall be continuously sampled for collection of radionuclides.

(ii) Those radionuclides released from the facility, which are the major contributors to the effective dose equivalent must be collected and measured as part of the environmental measurement program.

(iii) Radionuclide concentrations which would cause an effective dose equivalent of 10% of the standard shall be readily detectable and distinguishable from background.

(iv) Net measured radionuclide concentrations shall be compared to the concentration levels in Table 2 of Appendix E to determine compliance with the standard. In the case of multiple radionuclides being released from a facility, compliance shall be demonstrated if the value for all radionuclides is less than the concentration level in Table 2, and the sum of the fractions that result when each measured concentration value is divided by the value in Table 2 for each radionuclide is less than 1.

(v) A quality assurance program shall be conducted that meets the performance requirements described in Appendix B, Method 114.

(vi) Use of environmental measurements to demonstrate compliance with the standard is subject to prior approval of EPA. Applications for approval shall include a detailed description of the sampling and analytical methodology and show how the above criteria will be met.

§ 61.94 Compliance and reporting.

(a) Compliance with this standard shall be determined by calculating the highest effective dose equivalent to any member of the public at any offsite point where there is a residence, school, business or office. The owners or operators of each facility shall submit an annual report to both EPA headquarters and the appropriate regional office by June 30 which includes the results of the monitoring as recorded in DOE's Effluent Information System and the dose calculations required by § 61.93(a) for the previous calendar year.

(b) In addition to the requirements of paragraph (a) of this section, an annual report shall include the following information:

(1) The name and location of the facility.

(2) A list of the radioactive materials used at the facility.

(3) A description of the handling and processing that the radioactive materials undergo at the facility.

(4) A list of the stacks or vents or other points where radioactive materials are released to the atmosphere.

(5) A description of the effluent controls that are used on each stack, vent, or other release point and an estimate of the efficiency of each control device.

(6) Distances from the points of release to the nearest residence, school, business or office and the nearest farms producing vegetables, milk, and meat.

(7) The values used for all other user-supplied input parameters for the computer models (e.g., meteorological data) and the source of these data.

(8) A brief description of all construction and modifications which were completed in the calendar year for which the report is prepared, but for which the requirement to apply for approval to construct or modify was waived under § 61.96 and associated documentation developed by DOE to support the waiver. EPA reserves the right to require that DOE send to EPA all the information that normally would be required in an application to construct or modify, following receipt of the description and supporting documentation.

(9) Each report shall be signed and dated by a corporate officer or public official in charge of the facility and contain the following declaration immediately above the signature line: "I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See, 18 U.S.C. 1001."

(c) If the facility is not in compliance with the emission limits of § 61.92 in the calendar year covered by the report, then the facility must commence reporting to the Administrator on a monthly basis the information listed in paragraph (b) of this section, for the preceding month. These reports will start the month immediately following the submittal of the annual report for the year in noncompliance and will be due 30 days following the end of each month. This increased level of reporting will continue until the Administrator has determined that the monthly reports are no longer necessary. In addition to all the information required in paragraph (b) of this section, monthly reports shall also include the following information:

(1) All controls or other changes in operation of the facility that will be or are being installed to bring the facility into compliance.

(2) If the facility is under a judicial or administrative enforcement decree, the report will describe the facilities performance under the terms of the decree.

(d) In those instances where the information requested is classified, such information will be made available to EPA separate from the report and will be handled and controlled according to

applicable security and classification regulations and requirements.

(Approved by the Office of Management and Budget under Control Number 2060-0191.)

§ 61.95 Recordkeeping requirements.

All facilities must maintain records documenting the source of input parameters including the results of all measurements upon which they are based, the calculations and/or analytical methods used to derive values for input parameters, and the procedure used to determine effective dose equivalent. This documentation should be sufficient to allow an independent auditor to verify the accuracy of the determination made concerning the facility's compliance with the standard. These records must be kept at the site of the facility for at least five years and, upon request, be made available for inspection by the Administrator, or his authorized representative.

§ 61.96 Applications to construct or modify.

In addition to any activity that is defined as construction under 40 CFR part 61, subpart A, any fabrication, erection or installation of a new building or structure within a facility that emits radionuclides is also defined as new construction for purposes of 40 CFR part 61, subpart A.

(b) An application for approval under § 61.07 or notification of startup under § 61.09 does not need to be filed for any new construction of or modification within an existing facility if the effective dose equivalent, caused by all emissions from the new construction or modification, is less than 1% of the standard prescribed in § 61.92. For purposes of this paragraph the effective dose equivalent shall be calculated using the source term derived using Appendix D as input to the dispersion and other computer models described in § 61.93. DOE may, with prior approval from EPA, use another procedure for estimating the source term for use in this paragraph. A facility is eligible for this exemption only if, based on its last annual report, the facility is in compliance with this subpart.

(c) Conditions to approvals granted under § 61.08 will not contain requirements for post approval reporting on operating conditions beyond those specified in § 61.94.

§ 61.97 Exemption from the reporting and testing requirements of 40 CFR 61.10.

All facilities designated under this subpart are exempt from the reporting requirements of 40 CFR 61.10.

Subpart I—National Emission Standards for Radionuclide Emissions From Facilities Licensed by the Nuclear Regulatory Commission and Federal Facilities Not Covered by Subpart H

Sec.

§ 61.100 Applicability.

The provisions of this subpart apply to Nuclear Regulatory Commission-licensed facilities and to facilities owned or operated by any Federal agency other than the Department of Energy, except that this subpart does not apply to disposal at facilities regulated under 40 CFR part 191, subpart B, or to any uranium mill tailings pile after it has been disposed of under 40 CFR part 192, or to low energy accelerators, or to any NRC-licensee that possesses and uses radionuclides only in the form of sealed sources.

§ 61.101 Definitions.

As used in this subpart, all terms not defined here have the meaning given them in the Clean Air Act or subpart A of part 61. The following terms shall have the following specific meanings:

(a) *Agreement State* means a State with which the Atomic Energy Commission or the Nuclear Regulatory Commission has entered into an effective agreement under subsection 274(b) of the Atomic Energy Act of 1954, as amended.

(b) *Effective dose equivalent* means the sum of the products of absorbed dose and appropriate factors to account for differences in biological effectiveness due to the quality of radiation and its distribution in the body of reference man. The unit of the effective dose equivalent is the rem. For purposes of this subpart doses caused by radon-222 and its decay products formed after the radon is released from the facility are not included. The method for calculating effective dose equivalent and the definition of reference man are outlined in the International Commission on Radiological Protection's Publication No. 26.

(c) *Facility* means all buildings, structures and operations on one contiguous site.

(d) *Federal facility* means any facility owned or operated by any department, commission, agency, office, bureau or other unit of the government of the United States of America except for facilities owned or operated by the Department of Energy.

(e) *NRC-licensed facility* means any facility licensed by the Nuclear Regulatory Commission or any Agreement State to receive title to, receive, possess, use, transfer, or deliver any source, by-product, or special nuclear material.

(f) *Radionuclide* means a type of atom which spontaneously undergoes radioactive decay.

§ 61.102 Standard.

(a) Emissions of radionuclides, including iodine, to the ambient air from a facility regulated under this subpart shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.

(b) Emissions of iodine to the ambient air from a facility regulated under this subpart shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 3 mrem/yr.

§ 61.103 Determining compliance.

(a) Compliance with the emission standard in this subpart shall be determined through the use of either the EPA computer code COMPLY or the alternative requirements of Appendix E. Facilities emitting radionuclides not listed in COMPLY or Appendix E shall contact EPA to receive the information needed to determine dose. The source terms to be used for input into COMPLY shall be determined through the use of the measurement procedures listed in § 61.107 or the emission factors in Appendix D or through alternative procedures for which EPA has granted prior approval; or,

(b) Facilities may demonstrate compliance with the emission standard in this subpart through the use of computer models that are equivalent to COMPLY, provided that the model has received prior approval from EPA headquarters. Any facility using a model other than COMPLY must file an annual report. EPA may approve an alternative model in whole or in part and may limit its use to specific circumstances.

§ 61.104 Reporting requirements.

(a) The owner or operator of a facility subject to this subpart must submit an annual report to the EPA covering the emissions of a calendar year by March 31 of the following year.

(1) The report or application for approval to construct or modify as

required by 40 CFR part 61, subpart A and § 61.106, must provide the following information:

(i) The name of the facility.

(ii) The name of the person responsible for the operation of the facility and the name of the person preparing the report (if different).

(iii) The location of the facility, including suite and/or building number, street, city, county, state, and zip code.

(iv) The mailing address of the facility, if different from item (iii).

(v) A list of the radioactive materials used at the facility.

(vi) A description of the handling and processing that the radioactive materials undergo at the facility.

(vii) A list of the stacks or vents or other points where radioactive materials are released to the atmosphere.

(viii) A description of the effluent controls that are used on each stack, vent, or other release point and an estimate of the efficiency of each device.

(ix) Distances from the point of release to the nearest residence, school, business or office and the nearest farms producing vegetables, milk, and meat.

(x) The effective dose equivalent calculated using the compliance procedures in § 61.103.

(xi) The physical form and quantity of each radionuclide emitted from each stack, vent or other release point, and the method(s) by which these quantities were determined.

(xii) The volumetric flow, diameter, effluent temperature, and release height for each stack, vent or other release point where radioactive materials are emitted, the method(s) by which these were determined.

(xiii) The height and width of each building from which radionuclides are emitted.

(xiv) The values used for all other user-supplied input parameters (e.g., meteorological data) and the source of these data.

(xv) A brief description of all construction and modifications which were completed in the calendar year for which the report is prepared, but for which the requirement to apply for approval to construct or modify was waived under section 61.106, and associated documentation developed by the licensee to support the waiver. EPA reserves the right to require that the licensee send to EPA all the information that normally would be required in an application to construct or modify, following receipt of the description and supporting documentation.

(xvi) Each report shall be signed and dated by a corporate officer or public official in charge of the facility and contain the following declaration immediately above the signature line: "I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See, 18 U.S.C. 1001."

(b) Facilities emitting radionuclides in an amount that would cause less than 10% of the dose standard in § 61.102, as determined by the compliance procedures from § 61.103(a), are exempt from the reporting requirements of § 61.104(a). Facilities shall annually make a new determination whether they are exempt from reporting.

(c) If the facility is not in compliance with the emission limits of § 61.102 in the calendar year covered by the report, the facility must report to the Administrator on a monthly basis the information listed in paragraph (a) of this section, for the preceding month. These reports will start the month immediately following the submittal of the annual report for the year in noncompliance and will be due 30 days following the end of each month. This increased level of reporting will continue until the Administrator has determined that the monthly reports are no longer necessary. In addition to all the information required in paragraph (a) of this section, monthly reports shall also include the following information:

(1) All controls or other changes in operation of the facility that will be or are being installed to bring the facility into compliance.

(2) If the facility is under a judicial or administrative enforcement decree the report will describe the facilities performance under the terms of the decree.

(d) The first report will cover the emissions of calendar year 1990.

§ 61.105 Recordkeeping requirements.

The owner or operator of any facility must maintain records documenting the source of input parameters including the results of all measurements upon which they are based, the calculations and/or analytical methods used to derive values for input parameters, and the procedure used to determine compliance. This documentation should be sufficient to allow an independent auditor to verify the accuracy of the determination made concerning the facility's compliance with the standard, and, if claimed, qualification for exemption from reporting. These records must be kept at the site of the facility for at least five years and upon request be made available for inspection by the Administrator, or his authorized representative.

§ 61.106 Applications to construct or modify.

(a) In addition to any activity that is defined as construction under 40 CFR part 61, subpart A, any fabrication, erection or installation of a new building or structure within a facility is also defined as new construction for purposes of 40 CFR part 61, subpart A.

(b) An application under § 61.07 does not need to be filed for any new construction of or modification within an existing facility if one of the following conditions is met:

(1) The effective dose equivalent calculated by using methods described in § 61.103, that is caused by all emissions from the facility including those potentially emitted by the proposed new construction or modification, is less than 10% of the standard prescribed in § 61.102.

(2) The effective dose equivalent calculated by using methods described in § 61.103, that is caused by all emissions from the new construction or modification, is less than 1% of the limit prescribed in § 61.102. A facility is eligible for this exemption only if the facility, based on its last annual report, is in compliance with this subpart.

§ 61.107 Emission determination.

(a) Facility owners or operators may, in lieu of monitoring, estimate radionuclide emissions in accordance with Appendix D, or other procedure for which EPA has granted prior approval.

(b) Radionuclide emission rates from point sources (e.g. stacks or vents) shall be measured in accordance with the following requirements:

(1) Effluent flow rate measurements shall be made using the following methods:

(i) Reference Method 2 of Appendix A to part 60 shall be used to determine velocity and volumetric flow rates for stacks and large vents.

(ii) Reference Method 2A of Appendix A to part 60 shall be used to measure flow rates through pipes and small vents.

(iii) The frequency of the flow rate measurements shall depend upon the variability of the effluent flow rate. For variable flow rates, continuous or frequent flow rate measurements shall be made. For relatively constant flow rates only periodic measurements are necessary.

(2) Radionuclides shall be directly monitored or extracted, collected, and measured using the following methods:

(i) Reference Method 1 of Appendix A part 60 shall be used to select monitoring or sampling sites.

(ii) The effluent stream shall be directly monitored continuously using an in-line detector or representative samples of the effluent stream shall be withdrawn continuously from the sampling site following the guidance presented in ANSIN13.1–1969 "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities" (including the guidance presented in Appendix A of ANSIN13.1) (incorporated by reference—see § 61.18). The requirements for continuous sampling are applicable to batch processes when the unit is in operation. Periodic sampling (grab samples) may be used only with EPA's prior approval. Such approval may be granted in cases where continuous sampling is not practical and radionuclide emission rates are relatively constant. In such cases, grab samples shall be collected with sufficient frequency so as to provide a representative sample of the emissions.

(iii) Radionuclides shall be collected and measured using procedures based on the principles of measurement described in Appendix B, Method 114. Use of methods based on principles of measurement different from those described in Appendix B, Method 114 must have prior approval from the Administrator. EPA reserves the right to approve alternative measurement procedures in whole or in part.

(iv) A quality assurance program shall be conducted that meets the performance requirements described in Appendix B, Method 114.

(3) When it is impractical to measure the effluent flow rate at an existing source in accordance with the requirements of paragraph (b)(1) of this section or to monitor or sample an effluent stream at an existing source in accordance with the site selection and sample extraction requirements of paragraph (b)(2) of this section, the facility owner or operator may use alternative effluent flow rate measurement procedures or site selection and sample extraction procedures provided that:

(i) It can be shown that the requirements of paragraphs (b) (1) and (2) of this section are impractical for the effluent stream.

(ii) The alternative procedure will not significantly urderestimate the emissions.

(iii) The alternative procedure is fully documented

(iv) The owner or operator has received prior approval from EPA.

(4)(i) Radionuclide emission measurements in conformance with the requirements of paragraph (b) of this section shall be made at all release points which have a potential to discharge radionuclides into the air in quantities which could cause an effective dose equivalent in excess of 1% of the standard. All radionuclides which could contribute greater than 10% of the potential effective dose equivalent for a release point shall be measured. For other release points which have a potential to release radionuclides into the air, periodic confirmatory measurements should be made to verify the low emissions.

(ii) To determine whether a release point is subject to the emission measurement requirements of paragraph (b) of this section, it is necessary to evaluate the potential for radionuclide emissions for that release point. In evaluating the potential of a release point to discharge radionuclides into the air, the estimated radionuclide release rates shall be based on the discharge of the uncontrolled effluent stream into the air.

(5) Environmental measurements of radionuclide air concentrations at critical receptor locations may be used as an alternative to air dispersion calculations in demonstrating compliance with the standards if the owner or operator meets the following criteria:

(i) The air at the point of measurement shall be continuously sampled for collection of radionuclides.

(ii) Those radionuclides released from the facility, which are the major contributors to the effective dose equivalent must be collected and measured as part of the environmental measurements program.

(iii) Radionuclide concentrations which would cause an effective dose equivalent greater than or equal to 10% of the standard shall be readily detectable and distinguishable from background.

(iv) Net measured radionuclide concentrations shall be compared to the concentration levels in Table 2 of Appendix E to determine compliance with the standard. In the case of multiple radionuclides being released from a facility, compliance shall be demonstrated if the value for all radionuclides is less than the concentration level in Table 2 and the sum of the fractions that result when each measured concentration value is divided by the value in Table 2 for each radionuclide is less than 1.

(v) A quality assurance program shall be conducted that meets the performance requirements described in Appendix B, Method 114.

(vi) Use of environmental measurements to demonstrate compliance with the standard is subject to prior approval of EPA. Applications for approval shall include a detailed description of the sampling and analytical methodology and show how the above criteria will be met.

(c) The following facilities may use either the methodologies and quality assurance programs described in paragraph (b) of this section or may use the following:

(1) Nuclear power reactors may determine their radionuclide emissions in conformance with the Effluent Technical Specifications contained in their Operating License issued by the Nuclear Regulatory Commission. In addition, they may conduct a quality assurance program as described in the Nuclear Regulatory Commission's Regulatory Guide 4.15 dated February 1979.

(2) Fuel processing and fabrication plants and uranium hexafluoride plants may determine their emissions in conformance with the Nuclear Regulatory Commission's Regulatory Guide 4.16 dated December 1985. In addition, they may conduct a quality assurance program as described in the Nuclear Regulatory Commission's Regulatory Guide 4.15 dated February 1979.

(3) Uranium mills may determine their emissions in conformance with the Nuclear Regulatory Commission's Regulatory Guide 4.14 dated April 1980. In addition, they may conduct a quality assurance program as described in the Nuclear Regulatory Commission's Regulatory Guide 4.15 dated February 1979.

61.108 Exemption from the reporting and testing requirements of 40 CFR 61.10.

All facilities designated under this subpart are exempt from the reporting requirements of 40 CFR 61.10.

Subpart K—National Emission Standards for Radionuclide Emissions From Elemental Phosphorus Plants

Sec.

§ 61.120 Applicability.

The provisions of this subpart are applicable to owners or operators of calciners and nodulizing kilns at elemental phosphorus plants.

§61.121 Definitions.

(a) *Elemental phosphorus plant* or *plant* means any facility that processes phosphate rock to produce elemental phosphorus. A plant includes all buildings, structures, operations, calciners and nodulizing kilns on one contiguous site.

(b) *Calciner* or *Nodulizing kiln* means a unit in which phosphate rock is heated to high temperatures to remove organic material and/or to convert it to a nodular form. For the purpose of this subpart, calciners and nodulizing kilns are considered to be similar units.

§ 61.122 Emission standard.

Emissions of polonium-210 to the ambient air from all calciners and nodulizing kilns at an elemental phosphorus plant shall not exceed a total of 2 curies a year.

§ 61.123 Emission testing.

(a) Each owner or operator of an elemental phosphorus plant shall test emissions from the plant within 90 days of the effective date of this standard and annually thereafter. The Administrator may temporarily or permanently waive the annual testing requirement or increase the frequency of testing, if the Administrator determines that more testing is required.

(b) The Administrator shall be notified at least 30 days prior to an emission test so that EPA may, at its option, observe the test.

(c) An emission test shall be conducted at each operational calciner or nodulizing kiln. If emissions from a calciner or nodulizing kiln are discharged through more than one stack, then an emission test shall be conducted at each stack and the total emission rate from the calciner or kiln shall be the sum of the emission rates from each of the stacks.

(d) Each emission test shall consist of three sampling runs that meet the requirements of § 61.125. The phosphate rock processing rate during each run shall be recorded. An emission rate in curies per metric ton of phosphate rock processed shall be calculated for each run. The average of all three runs shall apply in computing the emission rate for the test. The annual polonium-210 emission rate from a calciner or nodulizing kiln shall be determined by multiplying the measured polonium-210 emission rate in curies per metric ton of phosphate rock processed by the annual phosphate rock processing rate in metric tons. In determining the annual phosphate rock processing rate, the values used for operating hours and operating capacity shall be values that will maximize the expected processing rate. For determining compliance with the emission standard of § 61.122, the total annual emission rate is the sum of the annual emission rates for all operating calciners and nodulizing kilns.

(e) If the owner or operator changes his operation in such a way as to increase his emissions of polonium-210, such as changing the type of rock processed, the temperature of the calciners or kilns, or increasing the annual phosphate rock processing rate, then a new emission test, meeting the requirements of this section, shall be conducted within 45 days under these conditions.

(f) Each owner or operator of an elemental phosphorus plant shall furnish the Administrator with a written report of the results of the emission test within 60 days of conducting the test. The report must provide the following information:

(1) The name and location of the facility.

(2) The name of the person responsible for the operation of the facility and the name of the person preparing the report (if different).

(3) A description of the effluent controls that are used on each stack, vent, or other release point and an estimate of the efficiency of each device.

(4) The results of the testing, including the results of each sampling run completed.

(5) The values used in calculating the emissions and the source of these data.

(6) Each report shall be signed and dated by a corporate officer in charge of the facility and contain the following declaration immediately above the signature line: "I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See, 18 U.S.C. 1001."

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§ 61.124 Recordkeeping requirements.

The owner or operator of any plant must maintain records documenting the source of input parameters including the results of all measurements upon which they are based, the calculations and/or analytical methods used to derive values for input parameters, and the procedure used in emission testing. This documentation should be sufficient to allow an independent auditor to verify the accuracy of the results of the emission testing. These records must be kept at the site of the plant for at least five years and, upon request, be made available for inspection by the Administrator, or his authorized representative.

§ 61.125 Test methods and procedures.

(a) Each owner or operator of a source required to test emissions under § 61.123, unless an equivalent or alternate method has been approved by the Administrator, shall use the following test methods:

(1) Test Method 1 of Appendix A to 40 CFR part 60 shall be used to determine sample and velocity traverses;

(2) Test Method 2 of Appendix A to 40 CFR part 60 shall be used to determine velocity and volumetric flow rate;

(3) Test Method 3 of Appendix A to 40 CFR part 60 shall be used for gas analysis;

(4) Test Method 5 of Appendix A to 40 CFR part 60 shall be used to collect particulate matter containing the polonium-210; and

(5) Test Method 111 of Appendix B to 40 CFR part 61 shall be used to determine the polonium-210 emissions.

§ 61.126 Monitoring of operations.

(a) The owner or operator of any source subject to this subpart using a wet-scrubbing emission control device shall install, calibrate, maintain, and operate a monitoring device for the continuous measurement of the pressure loss of the gas stream through the scrubber. The monitoring device must be certified by the manufacturer to be accurate within ±250 pascal (±1 inch of water). Records of these measurements shall be maintained at the source and made available for inspection by the Administrator, or his authorized representative for a minimum of 5 years.

(b) The owner or operator of any source subject to this subpart using an electrostatic precipitator control device shall install, calibrate, maintain, and operate a monitoring device for the continuous measurement of the primary and secondary current and the voltage in each electric field. Records of these measurements shall be maintained at the source and made available for inspection by the Administrator, or his authorized representative for a minimum of 5 years.

(c) For the purpose of conducting an emission test under § 61.123, the owner or operator of any source subject to the provisions of this subpart shall install, calibrate, maintain, and operate a device for measuring the phosphate rock feed to any affected calciner or nodulizing kiln. The measuring device used must be accurate to within ±5 percent of the mass rate over its operating range. Records of these measurements shall be maintained at the source and made available for inspection by the Administrator, or his authorized representative for a minimum of 5 years.

§ 61.127 Exemption from the reporting and testing requirements of 40 CFR 61.10.

All facilities designated under this subpart are exempt from the reporting requirements of 40 CFR 61.10.

Subpart Q—National Emission Standards for Radon Emissions From Department of Energy Facilities

Sec.
61.190 Designation of facilities.
61.191 Definitions.
61.192 Standard.
61.193 Exemption from the reporting and testing requirements of 40 CFR 61.10.

§ 61.190 Designation of facilities.

The provisions of this subpart apply to the design and operation of all storage and disposal facilities for radium-containing material (i.e., byproduct material as defined under section 11.e(2) of the Atomic Energy Act of 1954 (as amended)) that are owned or operated by the Department of Energy that emit radon-222 into air, including these facilities: The Feed Materials Production Center, Fernald, Ohio; the Niagara Falls Storage Site, Lewiston, New York; the Weldon Spring Site, Weldon Spring, Missouri; the Middlesex Sampling Plant, Middlesex, New Jersey; the Monticello Uranium Mill Tailings Pile, Monticello, Utah. This subpart does not apply to facilities listed in, or designated by the Secretary of Energy under Title I of the Uranium Mill Tailings Control Act of 1978.

§ 61.191 Definitions.

As used in this subpart, all terms not defined here have the meaning given them in the Clean Air Act or subpart A of part 61. The following terms shall have the following specific meanings:

(a) *Facility* means all buildings, structures and operations on one contiguous site.

(b) *Source* means any building, structure, pile, impoundment or area used for interim storage or disposal that is or contains waste material containing radium in sufficient concentration to emit radon-222 in excess of this standard prior to remedial action.

§ 61.192 Standard.

No source at a Department of Energy facility shall emit more than 20 pCi/-m^2–s of radon-222 as an average for the entire source, into the air. This requirement will be part of any Federal Facilities Agreement reached between Environmental Protection Agency and Department of Energy.

§ 61.193 Exemption from the reporting and testing requirements of 40 CFR 61.10.

All facilities designated under this subpart are exempt from the reporting requirements of 40 CFR 61.10.

Subpart R—National Emission Standards for Radon Emissions From Phosphogypsum Stacks

Sec.
61.200 Designation of facilities.
61.201 Definitions.
61.202 Standard.
61.203 Radon monitoring and compliance procedures.
61.204 Recordkeeping requirements.
61.205 Exemption from the reporting and testing requirements of 40 CFR 61.10.

§ 61.200 Designation of facilities.

The provisions of this subpart apply to the owners and operators of the phosphogypsum that is produced as a result of phosphorus fertilizer production and all that is contained in existing phosphogypsum stacks.

§ 61.201 Definitions.

As used in this subpart, all terms not defined here have the meaning given them in the Clean Air Act or subpart A of part 61. The following terms shall have the following specific meanings:

(a) *Inactive stack* means a stack to which no further routine additions of phosphogypsum will be made and which is no longer used for water management associated with the production of phosphogypsum. If a stack has not been used for either purpose for two years it is presumed to be inactive.

(b) *Phosphogypsum stacks* or *stacks* are piles of waste from phosphorus fertilizer production containing phosphogypsum. Stacks shall also include phosphate mines that are used for the disposal of phosphogypsum.

§ 61.202 Standard.

All phosphogypsum shall be disposed of in stacks or in phosphate mines which shall not emit more than 20 pCi/m^2–s of radon-222 into the air.

§ 61.203 Radon monitoring and compliance procedures.

(a) Sixty days following the date at which a stack becomes an inactive stack, or ninety days after the effective date of this rule if the stack is already inactive, the owners or operators of inactive phosphogypsum stacks shall test the stacks in accordance with the procedures described in 40 CFR part 61, Appendix B, Method 115. EPA shall be notified at least 30 days prior to an emissions test so that EPA may, at its option, observe the test. If meteorological conditions are such that a test cannot be properly conducted, then the owner or operator shall notify EPA and test as soon as conditions permit.

(b) Ninety days after the testing is required, the owner or operator shall provide EPA with a report detailing the actions taken and the results of the radon-222 flux testing. Each report shall also include the following information:

(1) The name and location of the facility,

(2) A list of the stacks at the facility including the size and dimensions of the stack,

(3) The name of the person responsible for the operation of the facility and the name of the person preparing the report (if different),

(4) A description of the control measures taken to decrease the radon flux from the source and any actions taken to insure the long term effectiveness of the control measures, and

(5) The results of the testing conducted, including the results of each measurement.

(6) Each report shall be signed and dated by a corporate officer in charge of the facility and contain the following declaration immediately above the signature line: "I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See, 18 U.S.C. 1001."

(c) If year-long measurements are made in accordance with Method 115 Appendix B to part 61 this report shall include the results of the first measurement period and provide a schedule for the measurement frequency to be used. An additional report containing all the information in

paragraph (b) of this section shall be submitted ninety days after completion of the final measurements.

(d) If at any point an owner or operator once again uses a stack for the disposal of phosphogypsum or for water management, the stack ceases to be in inactive status and the owner or operator must notify EPA in writing within 45 days. When the owner or operator ceases to use the stack it will once again become inactive and require retesting and reporting.

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§ 61.204 Recordkeeping requirements.

An owner or operator subject to this subpart must maintain records documenting the source of input parameters including the results of all measurements upon which they are based, the calculations and/or analytical methods used to derive values for input parameters, and the procedure used to determine compliance. This documentation should be sufficient to allow an independent auditor to verify the correctness of the determination made concerning the facility's compliance with the standard. These records must be kept by the owner or operator for at least five years and upon request be made available for inspection by the Administrator, or his authorized representative.

§ 61.205 Exemption from the reporting and testing requirements of 40 CFR 61.10.

All facilities designated under this subpart are exempt from the reporting requirements of 40 CFR 61.10.

Subpart T—National Emission Standards for Radon Emissions From the Disposal of Uranium Mill Tailings

Sec.
61.220 Designation of facilities.
61.221 Definitions.
61.222 Standard.
61.223 Compliance procedures.
61.224 Recordkeeping requirements.
61.225 Exemption from the reporting and testing requirements of 40 CFR 61.10.

§ 61.220 Designation of facilities.

The provisions of this subpart apply to the owners and operators of all sites that are used for the disposal of tailings, and that managed residual radioactive material or uranium byproduct materials during and following the processing of uranium ores, commonly referred to as uranium mills and their associated tailings, that are listed in, or designated by the Secretary of Energy under Title I of the Uranium Mill Tailings Control Act of 1978 or regulated under Title II of the Uranium Mill Tailings Control Act of 1978.

§ 61.221 Definitions.

As used in this subpart, all terms not defined here have the meaning given them in the Clean Air Act or subpart A of part 61. The following terms shall have the following specific meanings:

(a) *Long term stabilization* means the addition of material on a uranium mill tailings pile for purpose of ensuring compliance with the requirements of 40 CFR 192.02(a) or 192.32(b)(i). These actions shall be considered complete when the Nuclear Regulatory Commission determines that the requirements of 40 CFR 192.02(a) or 192.32(b)(i) have been met.

(b) *Operational* means a uranium mill tailings pile that is licensed to accept additional tailings, and those tailings can be added without violating subpart W or any other Federal, state or local rule or law. A pile cannot be considered operational if it is filled to capacity or the mill it accepts tailings from has been dismantled or otherwise decommissioned.

(c) *Uranium byproduct material* or *tailings* means the waste produced by the extraction or concentration of uranium from any ore processed primarily for its source material content. Ore bodies depleted by uranium solution extraction and which remain underground do not constitute byproduct material for the purposes of this subpart.

§ 61.222 Standard.

(a) Radon-222 emissions to the ambient air from uranium mill tailings pile that are no longer operational shall not exceed 20 pCi/m^2-s of radon-222.

(b) Once a uranium mill tailings pile or impoundment ceases to be operational it must be disposed of and brought into compliance with this standard within two years of the effective date or within two years of the day it ceases to be operational whichever is later. If it is not physically possible for a mill owner or operator to complete disposal within that time, EPA shall, after consultation with the mill owner or operator, establish a compliance agreement which will assure that disposal will be completed as quickly as possible.

§ 61.223 Compliance procedures.

(a) Sixty days following the completion of covering the pile to limit radon emissions but prior to the long term stabilization of the pile, the owners or operators of uranium mill tailings shall conduct testing for all piles within the facility in accordance with the procedures described in 40 CFR part 61, Appendix B, Method 115, or other procedures for which EPA has granted prior approval.

(b) Ninety days after the testing is required, each facility shall provide EPA with a report detailing the actions taken and the results of the radon-222 flux testing. EPA shall be notified at least 30 days prior to an emission test so that EPA may, at its option, observe the test. If meteorological conditions are such that a test cannot be properly conducted, then the owner or operator shall notify EPA and test as soon as conditions permit. Each report shall also include the following information:

(1) The name and location of the facility.

(2) A list of the piles at the facility.

(3) A description of the control measures taken to decrease the radon flux from the source and any actions taken to insure the long term effectiveness of the control measures.

(4) The results of the testing conducted, including the results of each measurement.

(5) Each report shall be signed and dated by a corporate officer or public official in charge of the facility and contain the following declaration immediately above the signature line: "I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See, 18 U.S.C. 1001."

(c) If year long measurements are made in accordance with Method 115 of Appendix B of part 61, this report shall include the results of the first measurement period and provide a schedule for the measurement frequency to be used. An additional report shall be submitted ninety days after completion of the final measurements.

(d) If long term stabilization has begun before the effective date of the rule then testing may be conducted at any time, up to 60 days after the long term stabilization is completed.

(e) If the testing demonstrates that the pile meets the requirement of § 61.222(a) and long term stabilization has been completed then the pile is considered disposed for purposes of this rule.

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§ 61.224 Recordkeeping requirements.

The owner or operator must maintain records documenting the source of input

parameters including the results of all measurements upon which they are based, the calculations and/or analytical methods used to derive values for input parameters, and the procedure used to determine compliance. This documentation should be sufficient to allow an independent auditor to verify the accuracy of the determination made concerning the facility's compliance with the standard. The Administrator shall be kept apprised of the location of these records and the records must be kept for at least five years and upon request be made available for inspection by the Administrator, or his authorized representative.

§ 61.225 Exemption from the reporting and testing requirements of 40 CFR 61.10.

All facilities designated under this subpart are exempt from the reporting requirements of 40 CFR 61.10.

Subpart W—National Emission Standards for Radon Emissions From Operating Mill Tailings

Sec.
61.250 Designation of facilities.
61.251 Definitions.
61.252 Standard.
61.253 Determining compliance.
61.254 Annual reporting requirements.
61.255 Recordkeeping requirements.
61.256 Exemption from the reporting and testing requirements of 40 CFR 61.10.

§ 61.250 Designation of facilities.

The provisions of this subpart apply to owners or operators of facilities licensed to manage uranium byproduct materials during and following the processing of uranium ores, commonly referred to as uranium mills and their associated tailings. This subpart does not apply to the disposal of tailings.

§ 61.251 Definitions.

As used in this subpart, all terms not defined here have the meaning given them in the Clean Air Act or 40 CFR part 61, subpart A. The following terms shall have the following specific meanings:

(a) *Area* means the vertical projection of the pile upon the earth's surface.

(b) *Continuous disposal* means a method of tailings management and disposal in which tailings are dewatered by mechanical methods immediately after generation. The dried tailings are then placed in trenches or other disposal areas and immediately covered to limit emissions consistent with applicable Federal standards.

(c) *Dewatered* means to remove the water from recently produced tailings by mechanical or evaporative methods such that the water content of the tailings does not exceed 30 percent by weight.

(d) *Existing impoundment* means any uranium mill tailings impoundment which is licensed to accept additional tailings and is in existence as of December 15, 1989.

(e) *Operation* means that an impoundment is being used for the continued placement of new tailings or is in standby status for such placement. An impoundment is in operation from the day that tailings are first placed in the impoundment until the day that final closure begins.

(f) *Phased disposal* means a method of tailings management and disposal which uses lined impoundments which are filled and then immediately dried and covered to meet all applicable Federal standards.

(g) *Uranium byproduct material or tailings* means the waste produced by the extraction or concentration of uranium from any ore processed primarily for its source material content. Ore bodies depleted by uranium solution extraction and which remain underground do not constitute byproduct material for the purposes of this subpart.

§ 61.252 Standard.

(a) Radon-222 emissions to the ambient air from an existing uranium mill tailings pile shall not exceed 20 pCi/m^2-s of radon-222.

(b) After December 15, 1989, no new tailings impoundment can be built unless it is designed, constructed and operated to meet one of the two following work practices:

(1) Phased disposal in lined tailings impoundments that are no more than 40 acres in area and meet the requirements of 40 CFR 192.32(a) as determined by the Nuclear Regulatory Commission. The owner or operator shall have no more than two impoundments, including existing impoundments, in operation at any one time.

(2) Continuous disposal of tailings such that tailings are dewatered and immediately disposed with no more than 10 acres uncovered at any time and operated in accordance with § 192.32(a) as determined by the Nuclear Regulatory Commission.

(c) All mill owners or operators shall comply with the provisions of 40 CFR 192.32(a) in the operation of tailings piles, the exemption for existing piles in 40 CFR 192.32(a) notwithstanding.

§ 61.253 Determining compliance.

Compliance with the emission standard in this subpart shall be determined annually through the use of Method 115 of Appendix B. When measurements are to be made over a one year period, EPA shall be provided with a schedule of the measurement frequency to be used. The schedule may be submitted to EPA prior to or after the first measurement period. EPA shall be notified 30 days prior to any emissions test so that EPA may, at its option, observe the test.

§ 61.254 Annual reporting requirements.

(a) The owners or operators of operating existing mill impoundments shall report the results of the compliance calculations required in § 61.253 and the input parameters used in making the calculation for each calendar year shall be sent to EPA by March 31 of the following year. Each report shall also include the following information:

(1) The name and location of the mill.

(2) The name of the person responsible for the operation of the facility and the name of the person preparing the report (if different).

(3) The results of the testing conducted, including the results of each measurement.

(4) Each report shall be signed and dated by a corporate officer in charge of the facility and contain the following declaration immediately above the signature line: "I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See, 18 U.S.C. 1001."

(b) If the facility is not in compliance with the emission limits of § 61.252 in the calendar year covered by the report, then the facility must commence reporting to the Administrator on a monthly basis the information listed in paragraph (a) of this section, for the preceding month. These reports will start the month immediately following the submittal of the annual report for the year in noncompliance and will be due 30 days following the end of each month. This increased level of reporting will continue until the Administrator has determined that the monthly reports are no longer necessary. In addition to all the information required in paragraph (a) of this section, monthly reports shall also include the following information:

(1) All controls or other changes in operation of the facility that will be or are being installed to bring the facility into compliance.

(2) If the facility is under a judicial or administrative enforcement decree, the report will describe the facilities performance under the terms of the decree.

(c) The first report will cover the emissions of calendar year 1990.

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§ 61.255 Recordkeeping requirements.

The owner or operator of the mill must maintain records documenting the source of input parameters including the results of all measurements upon which they are based, the calculations and/or analytical methods used to derive values for input parameters, and the procedure used to determine compliance. In addition, the documentation should be sufficient to allow an independent auditor to verify the accuracy of the determination made concerning the facility's compliance with the standard. These records must be kept at the mill for at least five years and upon request be made available for inspection by the Administrator, or his authorized representative.

§ 61.256 Exemption from the reporting and testing requirements of 40 CFR 61.10.

All facilities designated under this subpart are exempt from the reporting requirements of 40 CFR 61.10.

§ 61.03 [Amended]

3. By adding to the list of System International units of measure in § 61.03(a) an entry for "m^2" following "m=meter" to read as follows:

m^2=square meter

4. By adding to the list of other units of measure in § 61.03(b) an entry for "Ci" following "cc"; an entry for "pC;" following "oz"; and an entry for "mrem" following "ml" to read as follows:

Ci=curie

* * * * *

mrem=millirem=10^{-3} rem

* * * * *

pCi=picocurie=10^{-12} curie

5. Section 61.18 is amended by adding paragraph (c) to read as follows:

§ 61.18 Incorporations by reference.

* * * * *

(c) The following material is available for purchase from the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

(1) ANSI N13.1—1969, "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities." IBR approved for §§ 61.93(b)(2)(ii); 61.107(b)(2)(ii); and Method 114, par. 2.1 of Appendix B to part 61.

Appendix B to Part 61—[Amended]

6. By amending Method 111 of Appendix B as follows:

a. Section 4.1 is revised to read as follows:

4.1 Sample Preparation.

The glass fiber filter and acetone rinse from Method 5 of Appendix A to 40 CFR part 60 are combined and dissolved as described below.

4.1.1 Add polonium-209 tracer to the acetone rinse in the glass beaker from Method 5 in an amount approximately equal to the amount of polonium-210 expected in the total particulate sample. Add 16 M nitric acid to the beaker to digest and loosen the residue.

4.1.2 Transfer the residue from the glass beaker to a teflon beaker containing the glass fiber filter. Rinse the glass beaker with 16 M nitric acid. If necessary reduce the volume in the beaker by evaporation until all of the nitric acid from the glass beaker has been transferred to the teflon beaker.

4.1.3 Add 30 ml of 29 M hydrofluoric acid to the teflon beaker and evaporate to near dryness on a hot plate in a properly operating hood. Caution: Do not allow the residue to go to dryness and overheat; this will result in loss of polonium.

4.1.4 Repeat step 4.1.3 until filter is dissolved.

4.1.5 Add 100 ml of 16 M nitric acid to the residue in the teflon beaker and evaporate to near dryness. Caution: Do not allow the residue to go to dryness.

4.1.6 Add 50 ml of 16 M nitric acid and 10 ml of 12 M perchloric acid to the teflon beaker and heat until dense fumes of perchloric acid are evolved.

4.1.7 Repeat steps 4.1.3 to 4.1.6 as necessary until sample is completely dissolved.

4.1.8 Add 10 ml of 12 M hydrochloric acid and evaporate to dryness. Repeat additions and evaporations several times.

4.1.9 Transfer the sample to a 250 ml volumetric flask and dilute to volume with 3 M hydrochloric acid.

b. Section 4.4.2 is removed and sections 4.4.3 through 4.4.8 are redesignated as sections 4.4.2 through 4.4.7 respectively.

c. In section 5.1, Equation 111-3 is amended by removing "A=picocuries of polonium-210 per filter" and adding "A= picocuries of polonium-210 in the particulate sample".

d. In section 5.2, Equation 111-4 is amended by revising the entry for "A=" to read "A= picocuries of polonium-210 in the particulate sample as determined by A in Equation 111-3".

e. Section 9.1.2 is removed.

7. By adding Method 114 to the methods in Appendix B to part 61 to read as follows:

Method 114—Test Methods for Measuring Radionuclide Emissions from Stationary Sources

1. Purpose and Background

This method provides the requirements for: (1) Stack monitoring and sample collection methods appropriate for radionuclides; (2) radiochemical methods which are used in determining the amounts of radionuclides collected by the stack sampling and; (3) quality assurance methods which are conducted in conjunction with these measurements. These methods are appropriate for emissions for stationary sources. A list of references is provided.

Many different types of facilities release radionuclides into air. These radionuclides differ in the chemical and physical forms, half-lives and type of radiation emitted. The appropriate combination of sample extraction, collection and analysis for an individual radionuclide is dependent upon many interrelated factors including the mixture of other radionuclides present. Because of this wide range of conditions, no single method for monitoring or sample collection and analysis of a radionuclide is applicable to all types of facilities. Therefore, a series of methods based on "principles of measurement" are described for monitoring and sample collection and analysis which are applicable to the measurement of radionuclides found in effluent streams at stationary sources. This approach provides the user with the flexibility to choose the most appropriate combination of monitoring and sample collection and analysis methods which are applicable to the effluent stream to be measured.

2. Stack Monitoring and Sample Collection Methods

Monitoring and sample collection methods are described based on "principles of monitoring and sample collection" which are applicable to the measurement of radionuclides from effluent streams at stationary sources. Radionuclides of most elements will be in the particulate form in these effluent streams and can be readily collected using a suitable filter media. Radionuclides of hydrogen, oxygen, carbon, nitrogen, the noble gases and in some circumstances iodine will be in the gaseous form. Radionuclides of these elements will require either the use of an in-line or off-line monitor to directly measure the radionuclides, or suitable sorbers, condensers or bubblers to collect the radionuclides.

2.1 Radionuclides as Particulates. The extracted effluent stream is passed through a filter media to remove the particulates. The filter must have a high efficiency for removal of sub-micron particles. The guidance in ANSI N13.1—1969 shall be followed in using filter media to collect particulates (incorporated by reference—see § 61.18).

2.2 Radionuclides as Gases.

2.2.1 The Radionuclide Tritium (H-3). Tritium in the form of water vapor is collected from the extracted effluent sample by sorption, condensation or dissolution techniques. Appropriate collectors may include silica gel, molecular sieves, and ethylene glycol or water bubblers.

Tritium in the gaseous form may be measured directly in the sample stream using Method B–1, collected as a gas sample or may be oxidized using a metal catalyst to tritiated water and collected as described above.

2.2.2 Radionuclides of Iodine. Iodine is collected from an extracted sample by sorption or dissolution techniques. Appropriate collectors may include charcoal, impregnated charcoal, metal zeolite and caustic solutions.

2.2.3 Radionuclides of Argon, Krypton and Xenon. Radionuclides of these elements are either measured directly by an in-line or off-line monitor, or are collected from the extracted sample by low temperature sorption techniques. Appropriate sorbers may include charcoal or metal zeolite.

2.2.4 Radionuclides of Oxygen, Carbon, Nitrogen and Radon. Radionuclides of these elements are measured directly using an in-line or off-line monitor. Radionuclides of carbon in the form of carbon dioxide may be collected by dissolution in caustic solutions.

2.3 Definition of Terms

In-line monitor means a continuous measurement system in which the detector is placed directly in or adjacent to the effluent stream. This may involve either gross radioactivity measurements or specific radionuclide measurements. Gross measurements shall be made in conformance with the conditions specified in Methods A–4, B–2 and G–4.

Off-line monitor means a measurement system in which the detector is used to continuously measure an extracted sample of the effluent stream. This may involve either gross radioactivity measurements or specific radionuclide measurements. Gross measurements shall be made in conformance with the conditions specified in Methods A–4, B–2 and G–4.

Sample collection means a procedure in which the radionuclides are removed from an extracted sample of the effluent using a collection media. These collection media include filters, absorbers, bubblers and condensers. The collected sample is analyzed using the methods described in Section 3.

3. Radionuclide Analysis Methods

A series of methods based on "principles of measurement" are described which are applicable to the analysis of radionuclides collected from airborne effluent streams at stationary sources. These methods are applicable only under the conditions stated and within the limitations described. Some methods specify that only a single radionuclide be present in the sample or the chemically separated sample. This condition should be interpreted to mean that no other radionuclides are present in quantities which would interfere with the measurement.

Also identified (Table 1) are methods for a selected list of radionuclides. The listed radionuclides are those which are most commonly used and which have the greatest potential for causing dose to members of the public. Use of methods based on principles of measurement other than those described in this section must be approved in advance of use by the Administrator. For radionuclides not listed in Table 1, any of the described methods may be used provided the user can demonstrate that the applicability conditions of the method have been met.

The type of method applicable to the analysis of a radionuclide is dependent upon the type of radiation emitted, i.e., alpha, beta or gamma. Therefore, the methods described below are grouped according to principles of measurements for the analysis of alpha, beta and gamma emitting radionuclides.

3.1 Methods for Alpha Emitting Radionuclides

3.1.1 Method A–1, Radiochemistry-Alpha Spectrometry.

Principle: The element of interest is separated from other elements, and from the sample matrix using radiochemical techniques. The procedure may involve precipitation, ion exchange, or solvent extraction. Carriers (elements chemically similar to the element of interest) may be used. The element is deposited on a planchet in a very thin film by electrodeposition or by coprecipitation on a very small amount of carrier, such as lanthanum fluoride. The deposited element is then counted with an alpha spectrometer. The activity of the nuclide of interest is measured by the number of alpha counts in the appropriate energy region. A correction for chemical yield and counting efficiency is made using a standardized radioactive nuclide (tracer) of the same element. If a radioactive tracer is not available for the element of interest, a predetermined chemical yield factor may be used.

Applicability: This method is applicable for determining the activity of any alpha-emitting radionuclide, regardless of what other radionuclides are present in the sample provided the chemical separation step produces a very thin sample and removes all other radionuclides which could interfere in the spectral region of interest. APHA–605(2), ASTM–D–3972(13).

3.1.2 Method A–2, Radiochemistry-Alpha Counting.

Principle: The element of interest is separated from other elements, and from the sample matrix using radiochemistry. The procedure may involve precipitation, ion exchange, or solvent extraction. Carriers (elements chemically similar to the element of interest) may be used. The element is deposited on a planchet in a thin film and counted with a alpha counter. A correction for chemical yield (if necessary) is made. The alpha count rate measures the total activity of all emitting radionuclides of the separated element.

Applicability: This method is applicable for the measurement of any alpha-emitting radionuclide, provided no other alpha emitting radionuclide is present in the separated sample. It may also be applicable for determining compliance, when other radionuclides of the separated element are present, provided that the calculated emission rate is assigned to the radionuclide which could be present in the sample that has the highest dose conversion factor. IDO–12096(18).

3.1.3 Method A–3, Direct Alpha Spectrometry.

Principle: The sample, collected on a suitable filter, is counted directly on an alpha spectrometer. The sample must be thin enough and collected on the surface of the filter so that any absorption of alpha particle energy in the sample or the filter, which would degrade the spectrum, is minimal.

Applicability: This method is applicable to simple mixtures of alpha emitting radionuclides and only when the amount of particulates collected on the filter paper are relatively small and the alpha spectra is adequately resolved. Resolutions should be 50 keV (FWHM) or better. ASTM–D–3084(16).

3.1.4 Method A–4, Direct Alpha Counting (Gross alpha determination).

Principle: The sample, collected on a suitable filter, is counted with an alpha counter. The sample must be thin enough so that self-absorption is not significant and the filter must be of such a nature that the particles are retained on the surface.

Applicability: Gross alpha determinations may be used to measure emissions of specific radionuclides only (1) when it is known that the sample contains only a single radionuclide, or the identity and isotopic ratio of the radionuclides in the sample are well-known, and (2) measurements using either Method A–1, A–2 or A–5 have shown that this method provides a reasonably accurate measurement of the emission rate. Gross alpha measurements are applicable to unidentified mixtures of radionuclides only for the purposes and under the conditions described in section 3.7. APHA–601(3), ASTM–D–1943(10).

3.1.5 Method A–5, Chemical Determination of Uranium.

Principle: Uranium may be measured chemically by either colorimetry or fluorometry. In both procedures, the sample is dissolved, the uranium is oxidized to the hexavalent form and extracted into a suitable solvent. Impurities are removed from the solvent layer. For colorimetry, dibenzoylmethane is added, and the uranium is measured by the absorbance in a colorimeter. For fluorometry, a portion of the solution is fused with a sodium fluoride-lithium fluoride flux and the uranium is determined by the ultraviolet activated fluorescence of the fused disk in a fluorometer.

Applicability: This method is applicable to the measurements of emission rates of uranium when the isotopic ratio of the uranium radionuclides is well known. ASTM–E–318(15), ASTM–D–2907(14).

3.1.6 Method A–6, Radon-222—Continuous Gas Monitor.

Principle: Radon-222 is measured directly in a continuously extracted sample stream by passing the air stream through a calibrated scintillation cell. Prior to the scintillation cell, the air stream is treated to remove particulates and excess moisture. The alpha particles from radon-222 and its decay products strike a zinc sulfide coating on the inside of the scintillation cell producing light pulses. The light pulses are detected by a photomultiplier tube which generates electrical pulses. These pulses are processed by the system electronics and the read out is in pCi/l of radon-222.

Applicability: This method is applicable to the measurement of radon-222 in effluent

streams which do not contain significant quantities of radon-220. Users of this method should calibrate the monitor in a radon calibration chamber at least twice per year. The background of the monitor should also be checked periodically by operating the instrument in a low radon environment. EPA 520/1–89–009(24).

3.1.7 Method A–7, Radon-222-Alpha Track Detectors

Principle: Radon-222 is measured directly in the effluent stream using alpha track detectors (ATD). The alpha particles emitted by radon-222 and its decay products strike a small plastic strip and produce submicron damage tracks. The plastic strip is placed in a caustic solution that accentuates the damage tracks which are counted using a microscope or automatic counting system. The number of tracks per unit area is correlated to the radon concentration in air using a conversion factor derived from data generated in a radon calibration facility.

Applicability: Prior approval from EPA is required for use of this method. This method is only applicable to effluent streams which do not contain significant quantities of radon-220, unless special detectors are used to discriminate against radon-220. This method may be used only when ATDs have been demonstrated to produce data comparable to data obtained with Method A–6. Such data should be submitted to EPA when requesting approval for the use of this method. EPA 520/1–89–009(24).

3.2 Methods for Gaseous Beta Emitting Radionuclides.

3.2.1 Method B–1, Direct Counting in Flow-Through Ionization Chambers.

Principle: An ionization chamber containing a specific volume of gas which flows at a given flow rate through the chamber is used. The sample (effluent stream sample) acts as the counting gas for the chamber. The activity of the radionuclide is determined from the current measured in the ionization chamber.

Applicability: This method is applicable for measuring the activity of a gaseous beta-emitting radionuclide in an effluent stream that is suitable as a counting gas, when no other beta-emitting nuclides are present. DOE/EP–0096(17), NCRP–58(23).

3.2.2 Method B–2, Direct Counting With In-line or Off-line Beta Detectors.

Principle: The beta detector is placed directly in the effluent stream (in-line) or an extracted sample of the effluent stream is passed through a chamber containing a beta detector (off-line). The activities of the radionuclides present in the effluent stream are determined from the beta count rate, and a knowledge of the radionuclides present and the relationship of the gross beta count rate and the specific radionuclide concentration.

Applicability: This method is applicable only to radionuclides with maximum beta particle energies greater then 0.2 MeV. This method may be used to measure emissions of specific radionuclides only when it is known that the sample contains only a single radionuclide or the identity and isotopic ratio of the radionuclides in the effluent stream are well known. Specific radionuclide analysis of periodic grab samples may be used to identify the types and quantities of radionuclides present and to establish the relationship between specific radionuclide analyses and gross beta count rates.

This method is applicable to unidentified mixtures of gaseous radionuclides only for the purposes and under the conditions described in section 3.7.

3.3 Methods for Non-Gaseous Beta Emitting Radionuclides.

3.3.1 Method B–3, Radiochemistry-Beta-Counting.

Principle: The element of interest is separated from other elements, and from the sample matrix by radiochemistry. This may involve precipitation, distillation, ion exchange, or solvent extraction. Carriers (elements chemically similar to the element of interest) may be used. The element is deposited on a planchet, and counted with a beta counter. Corrections for chemical yield, and decay (if necessary) are made. The beta count rate determines the total activity of all radionuclides of the separated element. This method may also involve the radiochemical separation and counting of a daughter element, after a suitable period of ingrowth, in which case it is specific for the parent nuclide.

Applicability: This method is applicable for measuring the activity of any beta-emitting radionuclide, with a maximum energy greater than 0.2 MeV, provided no other radionuclide is present in the separated sample. APHA–608(5).

3.3.2 Method B–4, Direct Beta Counting (Gross beta determination).

Principle: The sample, collected on a suitable filter, is counted with a beta counter. The sample must be thin enough so that self-absorption corrections can be made.

Applicability: Gross beta measurements are applicable only to radionuclides with maximum beta particle energies greater than 0.2 MeV. Gross beta measurements may be used to measure emissions of specific radionuclides only (1) when it is known that the sample contains only a single radionuclide, and (2) measurements made using Method B–3 show reasonable agreement with the gross beta measurement. Gross beta measurements are applicable to mixtures of radionuclides only for the purposes and under the conditions described in section 3.7. APHA–602(4), ASTM–D–1890(11).

3.3.3 Method B–5, Liquid Scintillation Spectrometry.

Principle: An aliquot of a collected sample or the result of some other chemical separation or processing technique is added to a liquid scintillation "cocktail" which is viewed by photomultiplier tubes in a liquid scintillation spectrometer. The spectrometer is adjusted to establish a channel or "window" for the pulse energy appropriate to the nuclide of interest. The activity of the nuclide of interest is measured by the counting rate in the appropriate energy channel. Corrections are made for chemical yield where separations are made.

Applicability: This method is applicable to any beta-emitting nuclide when no other radionuclide is present in the sample or the separated sample provided that it can be incorporated in the scintillation cocktail. This method is also applicable for samples which contain more than one radionuclide but only when the energies of the beta particles are sufficiently separated so that they can be resolved by the spectrometer. This method is most applicable to the measurement of low-energy beta emitters such as tritium and carbon-14. APHA–609(6), EML–LV–539–17(19).

3.4 Gamma Emitting Radionuclides

3.4.1 Method G–1, High Resolution Gamma Spectrometry.

Principle: The sample is counted with a high resolution gamma detector, usually either a Ge(Li) or a high purity Ge detector, connected to a multichannel analyzer or computer. The gamma emitting radionuclides in the sample are measured from the gamma count rates in the energy regions characteristic of the individual radionuclide. Corrections are made for counts contributed by other radionuclides to the spectral regions of the radionuclides of interest. Radiochemical separations may be made prior to counting but are usually not necessary.

Applicability: This method is applicable to the measurement of any gamma emitting radionuclide with gamma energies greater than 20 keV. It can be applied to complex mixtures of radionuclides. The samples counted may be in the form of particulate filters, absorbers, liquids or gases. The method may also be applied to the analysis of gaseous gamma emitting radionuclides directly in an effluent stream by passing the stream through a chamber or cell containing the detector. ASTM–3649(9), IDO–12096(18).

3.4.2 Method G–2, Low Resolution Gamma Spectrometry.

Principle: The sample is counted with a low resolution gamma detector, a thallium activated sodium iodide crystal. The detector is coupled to a photomultiplier tube and connected to a multichannel analyzer. The gamma emitting radionuclides in the sample are measured from the gamma count rates in the energy regions characteristic of the individual radionuclides. Corrections are made for counts contributed by other radionuclides to the spectral regions of the radionuclides of interest. Radiochemical separation may be used prior to counting to obtain less complex gamma spectra if needed.

Applicability: This method is applicable to the measurement of gamma emitting radionuclides with energies greater than 100 keV. It can be applied only to relatively simple mixtures of gamma emitting radionuclides. The samples counted may be in the form of particulate filters, absorbers, liquids or gas. The method can be applied to the analysis of gaseous radionuclides directly in an effluent stream by passing the gas stream through a chamber or cell containing the detector. ASTM–D–2459(12), EMSL–LV–0539–17(19).

3.4.3 Method G–3, Single Channel Gamma Spectrometry.

Principle: The sample is counted with a thallium activated sodium iodide crystal. The detector is coupled to a photomultiplier tube connected to a single channel analyzer. The activity of a gamma emitting radionuclide is

determined from the gamma counts in the energy range for which the counter is set.

Applicability: This method is applicable to the measurement of a single gamma emitting radionuclide. It is not applicable to mixtures of radionuclides. The samples counted may be in the form of particulate filters, absorbers, liquids or gas. The method can be applied to the analysis of gaseous radionuclides directly in an effluent stream by passing the gas stream through a chamber or cell containing the detector.

3.4.4 Method G–4, Gross Gamma Counting.

Principle: The sample is counted with a gamma detector usually a thallium activated sodium iodine crystal. The detector is coupled to a photomultiplier tube and gamma rays above a specific threshold energy level are counted.

Applicability: Gross gamma measurements may be used to measure emissions of specific radionuclides only when it is known that the sample contains a single radionuclide or the identity and isotopic ratio of the radionuclides in the effluent stream are well known. When gross gamma measurements are used to determine emissions of specific radionuclides periodic measurements using Methods G–1 or G–2 should be made to demonstrate that the gross gamma measurements provide reliable emission data. This method may be applied to analysis of gaseous radionuclides directly in an effluent stream by placing the detector directly in or adjacent to the effluent stream or passing an extracted sample of the effluent stream through a chamber or cell containing the detector.

3.5 Counting Methods. All of the above methods with the exception of Method A–5 involve counting the radiation emitted by the radionuclide. Counting methods applicable to the measurement of alpha, beta and gamma radiations are listed below. The equipment needed and the counting principles involved are described in detail in ASTM–3648[8].

3.5.1 Alpha Counting:

• *Gas Flow Proportional Counters.* The alpha particles cause ionization in the counting gas and the resulting electrical pulses are counted. These counters may be windowless or have very thin windows.

• *Scintillation Counters.* The alpha particles transfer energy to a scintillator resulting in a production of light photons which strike a photomultiplier tube converting the light photons to electrical pulses which are counted. The counters may involve the use of solid scintillation materials such as zinc sulfide or liquid scintillation solutions.

• *Solid-State Counters.* Semiconductor materials, such as silicon surface-barrier p-n junctions, act as solid ionization chambers. The alpha particles interact which the detector producing electron hole pairs. The charged pair is collected by an applied electrical field and the resulting electrical pulses are counted.

• *Alpha Spectrometers.* Semiconductor detectors used in conjunction with multichannel analyzers for energy discrimination.

3.5.2 Beta Counting:

• *Ionization Chambers.* These chambers contain the beta-emitting nuclide in gaseous form. The ionization current produced is measured.

• *Geiger-Muller (GM) Counters-or Gas Flow Proportional Counters.* The beta particles cause ionization in the counting gas and the resulting electrical pulses are counted. Proportional gas flow counters which are heavily shielded by lead or other metal, and provided with an anti-coincidence shield to reject cosmic rays, are called low background beta counters.

• *Scintillation Counters.* The beta particles transfer energy to a scintillator resulting in a production of light photons, which strike a photomultiplier tube converting the light photon to electrical pulses which are counted. This may involve the use of anthracene crystals, plastic scintillator, or liquid scintillation solutions with organic phosphors.

• *Liquid Scintillation Spectrometers.* Liquid scintillation counters which use two photomultiplier tubes in coincidence to reduce background counts. This counter may also electronically discriminate among pulses of a given range of energy.

3.5.3 Gamma Counting:

• *Low-Resolution Gamma Spectrometers.* The gamma rays interact with thallium activated sodium iodide or cesium iodide crystal resulting in the release of light photons which strike a photomultiplier tube converting the light pulses to electrical pulses proportional to the energy of the gamma ray. Multi-channel analyzers are used to separate and store the pulses according to the energy absorbed in the crystal.

• *High-Resolution gamma Spectrometers.* Gamma rays interact with a lithium-drifted [Ge(Li)] or high-purity germanium [HPGe] semiconductor detectors resulting in a production of electron-hole pairs. The charged pair is collected by an applied electrical field. A very stable low noise preamplifier amplifies the pulses of electrical charge resulting from the gamma photon interactions. Multichannel analyzers or computers are used to separate and store the pulses according to the energy absorbed in the crystal.

• *Single Channel Analyzers.* Thallium activated sodium iodide crystals used with a single window analyzer. Pulses from the photomultiplier tubes are separated in a single predetermined energy range.

3.5.4 Calibration of Counters. Counters are calibrated for specific radionuclide measurements using a standard of the radionuclide under either identical or very similar conditions as the sample to be counted. For gamma spectrometers a series of standards covering the energy range of interest may be used to construct a calibration curve relating gamma energy to counting efficiency.

In those cases where a standard is not available for a radionuclide, counters may be calibrated using a standard with energy characteristics as similar as possible to the radionuclide to be measured. For gross alpha and beta measurements of the unidentified mixtures of radionuclides, alpha counters are calibrated with a natural uranium standard and beta counters with a cesium-137 standard. The standard must contain the same weight and distribution of solids as the samples, and be mounted in an identical manner. If the samples contain variable amounts of solids, calibration curves relating weight of solids present to counting efficiency are prepared. Standards other than those prescribed may be used provided it can be shown that such standards are more applicable to the radionuclide mixture measured.

3.6 Radiochemical Methods for Selected Radionuclides. Methods for a selected list of radionuclides are listed in Table 1. The radionuclides listed are those which are most commonly used and which have the greatest potential for causing doses to members of the public. For radionuclides not listed in Table 1, methods based on any of the applicable "principles of measurement" described in section 3.1 through 3.4 may be used.

3.7 Applicability of Gross Alpha and Beta Measurements to Unidentified Mixtures of Radionuclides. Gross alpha and beta measurements may be used as a screening measurement as a part of an emission measurement program to identify the need to do specific radionuclide analyses or to confirm or verify that unexpected radionuclides are not being released in significant quantities.

Gross alpha (Method A–4) or gross beta (Methods B–2 or B–4) measurements may also be used for the purpose of comparing the measured concentrations in the effluent stream with the limiting "Concentration Levels for Environmental Compliance" in Table 2 of Appendix E. For unidentified mixtures, the measured concentration value shall be compared with the lowest environmental concentration limit for any radionuclide which is not known to be absent from the effluent stream.

TABLE 1.—LIST OF APPROVED METHODS FOR SPECIFIC RADIONUCLIDES

Radionuclide	Approved methods of analysis
Am-241	A–1, A–2, A–3, A–4
Ar-41	B–1, B–2, G–1, G–2, G–3, G–4
Ba-140	G–1, G–2, G–3, G–4
Br-82	G–1, G–2, G–3, G–4
C-11	B–1, B–2, G–1, G–2, G–3, G–4
C-14	B–5
Ca-45	B–3, B–4, B–5
Ce-144	G–1, G–2, G–3, G–4
Cm-244	A–1, A–2, A–3, A–4
Co-60	G–1, G–2, G–3, G–4
Cr-51	G–1, G–2, G–3, G–4
Cs-134	G–1, G–2, G–3, G–4
Cs-137	G–1, G–2, G–3, G–4
Fe-55	B–5, G–1
Fe-59	G–1, G–2, G–3, G–4
Ga-67	G–1, G–2, G–3, G–4
H-3 (H_2O)	B–5
H-3 (gas)	B–1
I-123	G–1, G–2, G–3, G–4
I-125	G–1
I-131	G–1, G–2, G–3, G–4
In-113m	G–1, G–2, G–3, G–4
Ir-192	G–1, G–2, G–3, G–4
Kr-85	B–1, B–2, B–5, G–1, G–2, G–3, G–4
Kr-87	B–1, B–2, G–1, G–2, G–3, G–4

TABLE 1.—LIST OF APPROVED METHODS FOR SPECIFIC RADIONUCLIDES—Continued

Radionuclide	Approved methods of analysis
Kr-88	B-1, B-2, G-1, G-2, G-3, G-4
Mn-54	G-1, G-2, G-3, G-4
Mo-99	G-1, G-2, G-3, G-4
N-13	B-1, B-2, G-1, G-2, G-3, G-4
O-15	B-1, B-2, G-1, G-2, G-3, G-4
P-32	B-3, B-4, B-5
Pm-147	B-3, B-4, B-5
Po-210	A-1, A-2, A-3, A-4
Pu-238	A-1, A-2, A-3, A-4
Pu-239	A-1, A-2, A-3, A-4
Pu-240	A-1, A-2, A-3, A-4
S-35	B-5
Se-75	G-1, G-2, G-3, G-4
Sr-90	B-3, B-4, B-5
Tc-99	B-3, B-4, B-5
Te-201	G-1, G-2, G-3, G-4
Uranium (total alpha)	A-1, A-2, A-3, A-4
Uranium (isotopic)	A-1, A-3
Uranium (Natural)	A-5
Xe-133	G-1
Yb-169	G-1, G-2, G-3, G-4
Zn-65	G-1, G-2, G-3, G-4

4. Quality Assurance Methods

Each facility required to measure their radionuclide emissions shall conduct a quality assurance program in conjunction with the radionuclide emission measurements. This program shall assure that the emission measurements are representative, and are of known precision and accuracy and shall include administrative controls to assure prompt response when emission measurements indicate unexpectedly large emissions. The program shall consist of a system of policies, organizational responsibilities, written procedures, data quality specifications, audits, corrective actions and reports. This quality assurance program shall include the following program elements:

4.1 The organizational structure, functional responsibilities, levels of authority and lines of communications for all activities related to the emissions measurement program shall be identified and documented.

4.2 Administrative controls shall be prescribed to ensure prompt response in the event that emission levels increase due to unplanned operations.

4.3 The sample collection and analysis procedures used in measuring the emissions shall be described including where applicable:

4.3.1 Identification of sampling sites and number of sampling points, including the rationale for site selections.

4.3.2 A description of sampling probes and representativeness of the samples.

4.3.3 A description of any continuous monitoring system used to measure emissions, including the sensitivity of the system, calibration procedures and frequency of calibration.

4.3.4 A description of the sample collection systems for each radionuclide measured, including frequency of collection, calibration procedures and frequency of calibration.

4.3.5 A description of the laboratory analysis procedures used for each radionuclide measured, including frequency of analysis, calibration procedures and frequency of calibration.

4.3.6 A description of the sample flow rate measurement systems or procedures, including calibration procedures and frequency of calibration.

4.3.7 A description of the effluent flow rate measurement procedures, including frequency of measurements, calibration procedures and frequency of calibration.

4.4 The objectives of the quality assurance program shall be documented and shall state the required precision, accuracy and completeness of the emission measurement data including a description of the procedures used to assess these parameters. Accuracy is the degree of agreement of a measurement with a true or known value. Precision is a measure of the agreement among individual measurements of the same parameters under similar conditions. Completeness is a measure of the amount of valid data obtained compared to the amount expected under normal conditions.

4.5 A quality control program shall be established to evaluate and track the quality of the emissions measurement data against preset criteria. The program should include where applicable a system of replicates, spiked samples, split samples, blanks and control charts. The number and frequency of such quality control checks shall be identified.

4.6 A sample tracking system shall be established to provide for positive identification of samples and data through all phases of the sample collection, analysis and reporting system. Sample handling and preservation procedures shall be established to maintain the integrity of samples during collection, storage and analysis.

4.7 Periodic internal and external audits shall be performed to monitor compliance with the quality assurance program. These audits shall be performed in accordance with written procedures and conducted by personnel who do not have responsibility for performing any of the operations being audited.

4.8 A corrective action program shall be established including criteria for when corrective action is needed, what corrective actions will be taken and who is responsible for taking the corrective action.

4.9 Periodic reports to responsible management shall be prepared on the performance of the emissions measurements program. These reports should include assessment of the quality of the data, results of audits and description of corrective actions.

4.10 The quality assurance program should be documented in a quality assurance project plan which should address each of the above requirements.

5. References

(1) American National Standards Institute, "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities", ANSI-N13.1-1969, American National Standards Institute, New York, New York (1969).

(2) American Public Health Association, "Methods of Air Sampling", 2nd Edition, Method 605, "Tentative Method of Analysis for Plutonium Content of Atmospheric Particulate Matter", American Public Health Association, New York, NY (1977).

(3) Ibid, Method 601, "Tentative Method of Analysis for Gross Alpha Radioactivity Content of the Atmosphere".

(4) Ibid, Method 602, "Tentative Method of the Analysis for Gross Beta Radioactivity Content of the Atmosphere".

(5) Ibid, Method 608, "Tentative Method of Analysis for Strontium-90 Content of Atmospheric Particulate Matter".

(6) Ibid, Method 609, "Tentative Method of Analysis for Tritium Content of the Atmosphere".

(7) Ibid, Method 603, "Tentative Method of Analysis for Iodine-131 Content of the Atmosphere".

(8) American Society for Testing and Materials, 1986 Annual Book ASTM Standards, Designation D-3648-78, "Standard Practices for the Measurement of Radioactivity", American Society for Testing and Materials, Philadelphia, PA (1986).

(9) Ibid, Designation D-3649-85, "Standard Practice for High Resolution Gamma Spectrometry".

(10) Ibid, Designation D-1943-81, "Standard Test Method for Alpha Particle Radioactivity of Water".

(11) Ibid, Designation D-1890-81, "Standard Test Method for Beta Particle Radioactivity of Water".

(12) Ibid, Designation D-2459-72, "Standard Test Method for Gamma Spectrometry of Water".

(13) Ibid, Designation D-3972-82, "Standard Test Method for Isotopic Uranium in Water by Radiochemistry".

(14) Ibid, Designation D-2907-83, "Standard Test Methods for Microquantities of Uranium in Water by Fluorometry".

(15) Ibid, Designation E-318, "Standard Test Method for Uranium in Aqueous Solutions by Colorimetry".

(16) Ibid, Designation D-3084-75, "Standard Practice for Alpha Spectrometry of Water".

(17) Corley, J.P. and C.D. Corbit, "A Guide for Effluent Radiological Measurements at DOE Installations", DOE/EP-0096, Pacific Northwest Laboratories, Richland, Washington (1983).

(18) Department of Energy, "RESL Analytical Chemistry Branch Procedures Manual", IDO-12096, U.S. Department of Energy, Idaho Falls, Idaho (1982).

(19) Environmental Protection Agency, "Radiochemical Analytical Procedures for Analysis of Environmental Samples", EMSL-LV-0539-17, U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Las Vegas, Nevada (1979).

(20) Environmental Protection Agency, "Radiochemistry Procedures Manual", EPA 520/5-84-006, Eastern Environmental Radiation Facility, Montgomery, Alabama (1984).

(21) National Council on Radiation Protection and Measurements, NCRP Report

No. 50, "Environmental Radiation Measurements", National Council on Radiation Protection and Measurement, Bethesda, Maryland (1976).

(22) Ibid, Report No. 47, "Tritium Measurement Techniques", (1976).

(23) Ibid, Report No. 58 "A Handbook of Radioactivity Measurement Procedures" (1985).

(24) Environmental Protection Agency, "Indoor Radon and Radon Decay Product Measurement Protocols", EPA 520/1–89–009, U.S. Environmental Protection Agency, Washington, DC (1989).

8. By adding Method 115 to the list of methods in Appendix B to part 61 to read as follows:

Method 115—Monitoring for Radon-222 Emissions

This Appendix describes the monitoring methods which must be used in determining the radon-222 emissions from underground uranium mines, uranium mill tailings piles, phosphogypsum stacks, and other piles of waste material emitting radon.

1. Radon-222 Emissions from Underground Uranium Mine Vents

1.1 Sampling Frequency and Calculation of Emissions. Radon-222 emissions from underground uranium mine vents shall be determined using one of the following methods:

1.1.1 Continuous Measurement. These measurements shall be made and the emissions calculated as follows:

(a) The radon-222 concentration shall be continuously measured at each mine vent whenever the mine ventilation system is operational.

(b) Each mine vent exhaust flow rate shall be measured at least 4 times per year.

(c) A weekly radon-222 emission rate for the mine shall be calculated and recorded weekly as follows:

$$A_w = C_1Q_1T_1 + C_2Q_2T_2 + \ldots C_iQ_iT_i$$

Where:

A_w = Total radon-222 emitted from the mine during week (Ci)

C_i = Average radon-222 concentration in mine vent i(Ci/m³)

Q_i = Volumetric flow rate from mine vent i(m³/hr)

T_i = Hours of mine ventilation system operation during week for mine vent i(hr)

(d) The annual radon-222 emission rate is the sum of the weekly emission rates during a calendar year.

1.1.2 Periodic Measurement. This method is applicable only to mines that continuously operate their ventilation system except for extended shutdowns. Mines which start up and shut down their ventilation system frequently must use the continuous measurement method describe in Section 1.1.1 above. Emission rates determined using periodic measurements shall be measured and calculated as follows:

(a) The radon-222 shall be continuously measured at each mine vent for at least one week every three months.

(b) Each mine vent exhaust flow rate shall be measured at least once during each of the radon-222 measurement periods.

(c) A weekly radon-222 emission rate shall be calculated for each weekly period according to the method described in Section 1.1.1. In this calculation T=168 hr.

(d) The annual radon-222 emission rate from the mine should be calculated as follows:

$$A_y = \frac{52 - W_s}{n} \left(A_{w1} + A_{w2} + \ldots A_{wi}\right)$$

Where:

A_y = Annual radon-222 emission rate from the mine(Ci)

A_{wi} = Weekly radon-222 emission rate during the measurement period i (Ci)

n = Number of weekly measurement periods per year

W_s = Number of weeks during the year that the mine ventilation system is shut down in excess of 7 consecutive days, i.e. the sum of the number of weeks each shut down exceeds 7 days

1.2 Test Methods and Procedures

Each underground mine required to test its emissions, unless an equivalent or alternative method has been approved by the Administrator, shall use the following test methods:

1.2.1 Test Method 1 of Appendix A to part 60 shall be used to determine velocity traverses. The sampling point in the duct shall be either the centroid of the cross section or the point of average velocity.

1.2.2 Test Method 2 of Appendix A to part 60 shall be used to determine velocity and volumetric flow rates.

1.2.3 Test Methods A–6 or A–7 of Appendix B, Method 114 to part 61 shall be used for the analysis of radon–222. Use of Method A–7 requires prior approval of EPA based on conditions described in Appendix B.

1.2.4 A quality assurance program shall be conducted in conformance with the programs described for Continuous Radon Monitors and Alpha Track Detectors in EPA 520/1–89–009. (2)

2. Radon–222 Emissions from Uranium Mill Tailings Piles

2.1 Measurement and Calculation of Radon Flux from Uranium Mill Tailings Piles.

2.1.1 Frequency of Flux Measurement. A single set of radon flux measurements may be made, or if the owner or operator chooses, more frequent measurements may be made over a one year period. These measurements may involve quarterly, monthly or weekly intervals. All radon measurements shall be made as described in paragraphs 2.1.2 through 2.1.6 except that for measurements made over a one year period, the requirement of paragraph 2.1.4(c) shall not apply. The mean radon flux from the pile shall be the arithmetic mean of the mean radon flux for each measurement period. The weather conditions, moisture content of the tailings and area of the pile covered by water existing at the time of the measurement shall be chosen so as to provide measurements representative of the long term radon flux from the pile and shall be subject to EPA review and approval.

2.1.2 Distribution of Flux Measurements. The distribution and number of radon flux measurements required on a pile will depend on clearly defined areas of the pile (called regions) that can have significantly different radon fluxes due to surface conditions. The mean radon flux shall be determined for each individual region of the pile. Regions that shall be considered for operating mill tailings piles are:

(a) Water covered areas,

(b) Water saturated areas (beaches),

(c) Dry top surface areas, and

(d) Sides, except where earthen material is used in dam construction.

For mill tailings after disposal the pile shall be considered to consist of only one region.

2.1.3 Number of Flux Measurements. Radon flux measurements shall be made within each region on the pile, except for those areas covered with water. Measurements shall be made at regularly spaced locations across the surface of the region, realizing that surface roughness will prohibit measurements in some areas of a region. The minimum number of flux measurements considered necessary to determine a representative mean radon flux value for each type of region on an operating pile is:

(a) Water covered area—no measurements required as radon flux is assumed to be zero,

(b) Water saturated beaches—100 radon flux measurements,

(c) Loose and dry top surface—100 radon flux measurements,

(d) Sides—100 radon flux measurements, except where earthern material is used in dam construction.

For a mill tailings pile after disposal which consists of only one region a minimum of 100 measurements are required.

2.1.4 Restrictions to Radon Flux Measurements. The following restrictions are placed on making radon flux measurements:

(a) Measurements shall not be initiated within 24 hours of a rainfall.

(b) If a rainfall occurs during the 24 hour measurements period, the measurement is invalid if the seal around the lip of the collector has washed away or if the collector is surrounded by water.

(c) Measurements shall not be performed if the ambient temperature is below 35°F or if the ground is frozen.

2.1.5 Areas of Pile Regions. The approximate area of each region of the pile shall be determined in units of square meters.

2.1.6 Radon Flux Measurement. Measuring radon flux involves the adsorption of radon on activated charcoal in a large-area collector. The radon collector is placed on the surface of the pile area to be measured and allowed to collect radon for a time period of 24 hours. The radon collected on the charcoal is measured by gamma–ray spectroscopy. The detailed measurement procedure provided in Appendix A of EPA 520/5–85–0029(1) shall be used to measure the radon flux on uranium mill tailings, except the surface of the tailings shall not be penetrated by the lip of the radon collector as directed in the procedure, rather the collector shall be

carefully positioned on a flat surface with soil or tailings used to seal the edge.

2.1.7 Calculations. The mean radon flux for each region of the pile and for the total pile shall be calculated and reported as follows:

(a) The individual radon flux calculations shall be made as provided in Appendix A EPA 86 (1). The mean radon flux for each region of the pile shall be calculated by summing all individual flux measurements for the region and dividing by the total number of flux measurements for the region.

(b) The mean radon flux for the total uranium mill tailings pile shall be calculated as follows.

$$J_s = \frac{J_1A_1 + \ldots J_2A_2 \ldots J_iA_i}{A_t}$$

Where:
J_s = Mean flux for the total pile (pCi/m²-s)
J_i = Mean flux measured in region i (pCi/m²-s)
A_i = Area of region i (m²)
A_t = Total area of the pile (m²)

2.1.8 Reporting. The results of individual flux measurements, the approximate locations on the pile, and the mean radon flux for each region and the mean radon flux for the total stack shall be included in the emission test report. Any condition or unusual event that occurred during the measurements that could significantly affect the results should be reported.

3.0 Radon-222 Emissions from Phosphogypsum Stacks.

3.1 Measurement and Calculation of the Mean Radon Flux. Radon flux measurements shall be made on phosphogypsum stacks as described below:

3.1.1 Frequency of Measurements. A single set of radon flux measurements may be made after the phosphogypsum stack becomes inactive, or if the owner or operator chooses, more frequent measurements may be made over a one year period. These measurements may involve quarterly, monthly or weekly intervals. All radon measurements shall be made as described in paragraphs 3.1.2 through 3.1.6 except that for measurements made over a one year period, the requirement of paragraph 3.1.4(c) shall not apply. For measurements made over a one year period, the radon flux shall be the arithmetic mean of the mean radon flux for each measurement period.

3.1.2 Distribution and Number of Flux Measurements. The distribution and number of radon flux measurements required on a stack will depend on clearly defined areas of the stack (called regions) that can have significantly different radon fluxes due to surface conditions. The mean radon flux shall be determined for each individual region of the stack. Regions that shall be considered are:

(a) Water covered areas,
(b) Water saturated areas (beaches),
(c) Loose and dry top surface areas,
(d) Hard-packed roadways, and
(e) Sides.

3.1.3 Number of Flux Measurements. Radon flux measurements shall be made within each region on the phosphogypsum stack, except for those areas covered with water. Measurements shall be made at regularly spaced locations across the surface of the region, realizing that surface roughness will prohibit measurements in some areas of a region. The minimum number of flux measurements considered necessary to determine a representative mean radon flux value for each type of region is:

(a) Water covered area—no measurements required as radon flux is assumed to be zero,
(b) Water saturated beaches—50 radon flux measurements,
(c) Loose and dry top surface—100 radon flux measurements,
(d) Hard-packed roadways—50 radon flux measurements, and
(e) Sides—100 radon flux measurements.

A minimum of 300 measurements are required. A stack that has no water cover can be considered to consist of two regions, top and sides, and will require a minimum of only 200 measurements.

3.1.4 Restrictions to Radon Flux Measurements. The following restrictions are placed on making radon flux measurements:

(a) Measurements shall not be initiated within 24 hours of a rainfall.
(b) If a rainfall occurs during the 24 hour measurement period, the measurement is invalid if the seal around the lip of the collector has washed away or if the collector is surrounded by water.
(c) Measurements shall not be performed if the ambient temperature is below 35 °F or if the ground is frozen.

3.1.5 Areas of Stack Regions. The approximate area of each region of the stack shall be determined in units of square meters.

3.1.6 Radon Flux Measurements. Measuring radon flux involves the adsorption of radon on activated charcoal in a large-area collector. The radon collector is placed on the surface of the stack area to be measured and allowed to collect radon for a time period of 24 hours. The radon collected on the charcoal is measured by gamma-ray spectroscopy. The detailed measurement procedure provided in Appendix A of EPA 520/5–85–0029(1) shall be used to measure the radon flux on phosphogypsum stacks, except the surface of the phosphogypsum shall not be penetrated by the lip of the radon collector as directed in the procedure, rather the collector shall be carefully positioned on a flat surface with soil or phosphogypsum used to seal the edge.

3.1.7 Calculations. The mean radon flux for each region of the phosphogypsum stack and for the total stack shall be calculated and reported as follows:

(a) The individual radon flux calculations shall be made as provided in Appendix A EPA 86 (1). The mean radon flux for each region of the stack shall be calculated by summing all individual flux measurements for the region and dividing by the total number of flux measurements for the region.

(b) The mean radon flux for the total phosphogypsum stack shall be calculated as follows.

$$J_s = \frac{J_1A_1 + J_2A_2 + \ldots J_iA_i}{A_t}$$

Where:
J_s = Mean flux for the total stack (pCi/m²-s)
J_i = Mean flux measured in region i (pCi/m²-s)
A_i = Area of region i (m²)
A_t = Total area of the stack

3.1.8 Reporting. The results of individual flux measurements, the approximate locations on the stack, and the mean radon flux for each region and the mean radon flux for the total stack shall be included in the emission test report. Any condition or unusual event that occurred during the measurements that could significantly affect the results should be reported.

4.0 Quality Assurance Procedures for Measuring Rn–222 Flux

A. Sampling Procedures

Records of field activities and laboratory measurements shall be maintained. The following information shall be recorded for each charcoal canister measurement:

(a) Site
(b) Name of pile
(c) Sample location
(d) Sample ID number
(e) Date and time on
(f) Date and time off
(g) Observations of meteorological conditions and comments

Records shall include all applicable information associated with determining the sample measurement, calculations, observations, and comments.

B. Sample Custody

Custodial control of all charcoal samples exposed in the field shall be maintained in accordance with EPA chain-of-custody field procedures. A control record shall document all custody changes that occur between the field and laboratory personnel.

C. Calibration Procedures and Frequency

The radioactivity of two standard charcoal sources, each containing a carefully determined quantity of radium-226 uniformly distributed through 180g of activated charcoal, shall be measured. An efficiency factor is computed by dividing the average measured radioactivity of the two standard charcoal sources, minus the background, in cpm by the known radioactivity of the charcoal sources in dpm. The same two standard charcoal sources shall be counted at the beginning and at the end of each day's counting as a check of the radioactivity counting equipment. A background count using unexposed charcoal should also be made at the beginning and at the end of each counting day to check for inadvertent contamination of the detector or other changes affecting the background. The unexposed charcoal comprising the blank is changed with each new batch of charcoal used.

D. Internal Quality Control Checks and Frequency

The charcoal from every tenth exposed canister shall be recounted. Five percent of the samples analyzed shall be either blanks (charcoal having no radioactivity added) or

samples spiked with known quantities of radium-226.

E. Data Precision, Accuracy, and Completeness

The precision, accuracy, and completeness of measurements and analyses shall be within the following limits for samples measuring greater than 1.0 pCi/m^2—s.

(a) Precision: 10%

(b) Accuracy: ±10%

(c) Completeness: at least 85% of the measurements must yield useable results.

5.0 References

(1) Hartley, J.N. and Freeman, H.D., "Radon Flux Measurements on Gardinier and Royster Phosphogypsum Piles Near Tampa and Mulberry, Florida," U.S. Environmental Protection Agency Report, EPA 520/5–85–029, January 1986.

(2) Environmental Protection Agency, "Indoor Radon and Radon Decay Product Measurement Protocols", EPA 520/1–89–009, U.S. Environmental Protection Agency, Washington, DC. (1989).

9. By adding Appendix D to part 61 to read as follows:

Appendix D to Part 61—Methods for Estimating Radionuclide Emissions

1. Purpose and Background

Facility owners or operators may estimate radionuclide emissions to the atmosphere for dose calculations instead of measuring emissions. Particulate emissions from mill tailings piles should be estimated using the procedures listed in reference #2. All other emissions may be estimated by using the "Procedures" listed below, or using the method described in reference #1.

2. Procedure

To estimate emissions to the atmosphere:

(a) Determine the amount (in curies) used at facilities for the period under consideration. Radioactive materials in sealed packages that remain unopened, and have not leaked during the assessment period should not be included in the calculation.

(b) Multiply the amount used by the following factors which depend on the physical state of the radionuclide. They are:

(i) 1 for gases;

(ii) 10^{-3} for liquids or particulate solids; and

(iii) 10^{-6} for solids.

If any nuclide is heated to a temperature of 100 degrees Celsius or more, boils at a temperature of 100 degrees Celsius or less, or is intentionally dispersed into the environment, it must be considered to be a gas.

(c) If a control device is installed between the place of use and the point of release, multiply emissions from (b) by an adjustment factor. These are presented in Table 1.

TABLE 1.—ADJUSTMENT TO EMISSION FACTORS FOR EFFLUENT CONTROLS

Controls	Types of radionuclides controlled	Adjustment factor to emissions	Comments and conditions
HEPA filters	Particulates	0.01	Not applicable to gaseous radionuclides; periodic testing is prudent to ensure high removal efficiency.
Fabric filter	Particulates	0.1	Monitoring would be prudent to guard against tears in filter.
Sintered metal	Particulates	1	Insufficient data to make recommendation.
Activated carbon filters	Iodine gas	0.1	Efficiency is time dependent; monitoring is necessary to ensure effectiveness.
Douglas bags: Held one week or longer for decay	Xenon	0.5/wk	Based on xenon half-life of 5.3 days;
Douglas bags: Released within one week	Xenon	1	Provides no reduction of exposure to general public.
Venturi scrubbers	Particulates	0.05	Although venturis may remove gases, variability in gaseous removal efficiency dictates adjustment factor for particulates only.
	Gases	1	
Packed bed scrubbers	Gases	0.1	Not applicable to particulates.
Electrostatic precipitators	Particulates	0.05	Not applicable for gaseous radionuclides
Xenon traps	Xenon	0.1	Efficiency is time dependent; monitoring is necessary to ensure effectiveness.
Fume hoods	All	1	Provides no reduction to general public exposures.
Vent stacks	All	1	Generally provides no reduction of exposure to general public.

References

(1) Environmental Protection Agency, "A Guide for Determining Compliance with the Clean Air Act Standards for Radionuclides Emissions from NRC-Licensed and Non-DOE Federal Facilities", EPA 520/1–89–002, January 1989.

(2) Nuclear Regulatory Commission, "Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations", U.S. Nuclear Regulatory Commission Regulatory Guide 3.59, March 1987.

10. By adding Appendix E part 61 to read as follows:

Appendix E to Part 61—Compliance Procedures Methods for Determining Compliance With Subpart I

1. Purpose and Background

This Appendix provides simplified procedures to reduce the burden on Nuclear Regulatory Commission (NRC) licensees, and non-Department of Energy Federal facilities in determining compliance with 40 CFR part 61, subpart I. The procedures consist of a series of increasingly more stringent steps, depending on the facility's potential to exceed the standard.

First, a facility can be found in compliance if the quantity of radioactive material possessed during the year is less than that listed in a table of annual possession quantities. A facility will also be in compliance if the average annual radionuclide emission concentration is less than that listed in a table of air concentration levels. If the facility is not in compliance by these tables, it can establish compliance by estimating a dose using screening procedure developed by the National Council on Radiation Protection and Measurements with a radiological source term derived using EPA approved emission factors. These procedures are described in a "Guide for Determining Compliance with the Clean Air Act Standards for Radionuclide Emissions From NRC-Licenced and Non-DOE Federal Facilities."

A user-friendly computer program called COMPLY has been developed to reduce the burden on the regulated community. The Agency has also prepared a "User's Guide for the COMPLY Code" to assist the regulated community in using the code, and in handling more complex situations such as multiple release points. The basis for these compliance procedures are provided in "Background Information Document: Procedures Approved for Demonstrating Compliance with 40 CFR part 61, subpart I". The compliance model is the highest level in the COMPLY computer code and provides for the most realistic assessment of dose by allowing the use of site-specific information.

2. Table of Annual Possession Quantity

(a) Table 1 may be used for determining if facilities are in compliance with the standard. The possession table can only be used if the following conditions are met:

(i) No person lives within 10 meters of any release point; and

(ii) No milk, meat, or vegetables are produced within 100 meters of any release point.

(b) Procedures described in Reference (1) shall be used to determine compliance or exemption from reporting by use of Table 2.

TABLE 1.—ANNUAL POSSESSION QUANTITIES FOR ENVIRONMENTAL COMPLIANCE

[Annual Possession Quantities (Ci/yr)]

Radionuclide	Gaseous form*	Liquid/powder forms	Solid form*
Ac-225	9.6E−05	9.6E−02	9.6E+01
Ac-227	1.6E−07	1.6E−04	1.6E−01
Ac-228	3.4E−03	3.4E+00	3.4E+03
Ag-106	1.6E+00	1.6E+03	1.6E+06
Ag-106m	2.6E−03	2.6E+00	2.6E+03
Ag-108m	6.5E−06	6.5E−03	6.5E+00
Ag-110m	9.4E−05	9.4E−02	9.4E+01
Ag-111	6.7E−02	6.7E+01	6.7E+04
Al-26	4.0E−06	4.0E−03	4.0E+00
Am-241	2.3E−06	2.3E−03	2.3E+00
Am-242	1.8E−02	1.8E+01	1.8E+04
Am-242m	2.5E−06	2.5E−03	2.5E+00
Am-243	2.3E−06	2.3E−03	2.3E+00
Am-244	4.6E−02	4.6E+01	4.6E+04
Am-245	7.0E+00	7.0E+03	7.0E+06
Am-246	9.8E−01	9.8E+02	9.8E+05
Ar-37	1.4E+06		
Ar-41	1.4E+00		
As-72	2.9E−02	2.9E+01	2.9E+04
As-73	6.0E−02	6.0E+01	6.0E+04
As-74	4.3E−03	4.3E+00	4.3E+03
As-76	8.8E−02	8.8E+01	8.8E+04
As-77	7.9E−01	7.9E+02	7.9E+05
At-211	1.0E−02	1.0E+01	1.0E+04
Au-193	4.2E−01	4.2E+02	4.2E+05
Au-194	3.5E−02	3.5E+01	3.5E+04
Au-195	3.3E−03	3.3E+00	3.3E+03
Au-198	4.6E−02	4.6E+01	4.6E+04
Au-199	1.5E−01	1.5E+02	1.5E+05
Ba-131	1.0E−02	1.0E+01	1.0E+04
Ba-133	4.9E−05	4.9E−02	4.9E+01
Ba-133m	9.3E−02	9.3E+01	9.3E+04
Ba-135m	5.8E−01	5.8E+02	5.8E+05
Ba-139	4.7E+00	4.7E+03	4.7E+06
Ba-140	2.1E−03	2.1E+00	2.1E+03
Ba-141	1.3E+00	1.3E+03	1.3E+06
Ba-142	1.1E+00	1.1E+03	1.1E+06
Be-7	2.3E−02	2.3E+01	2.3E+04
Be-10	3.0E−03	3.0E+00	3.0E+03
Bi-206	3.1E−03	3.1E+00	3.1E+03
Bi-207	8.4E−06	8.4E−03	8.4E+00
Bi-210	4.2E−03	4.2E+00	4.2E+03
Bi-212	4.7E−02	4.7E+01	4.7E+04
Bi-213	6.0E−02	6.0E+01	6.0E+04
Bi-214	1.4E−01	1.4E+02	1.4E+05
Bk-249	7.0E−04	7.0E−01	7.0E+02
Bk-250	1.0E−01	1.0E+02	1.0E+05
Br-77	7.5E−02	7.5E+01	7.5E+04
Br-80	1.2E+01	1.2E+04	1.2E+07
Br-80m	1.5E+00	1.5E+03	1.5E+06
Br-82	1.6E−02	1.6E+01	1.6E+04
Br-83	9.9E+00	9.9E+03	9.9E+06
Br-84	5.6E−01	5.6E+02	5.6E+05
C-11	1.3E+00	1.3E+03	1.3E+06
C-14	2.9E−01	2.9E+02	2.9E+05
Ca-41	2.7E−02	2.7E+01	2.7E+04
Ca-45	5.6E−02	5.6E+01	5.6E+04
Ca-47	1.1E−02	1.1E+01	1.1E+04
Cd-109	5.0E−03	5.0E+00	5.0E+03
Cd-113	3.3E−04	3.3E−01	3.3E+02
Cd-113m	4.4E−04	4.4E−01	4.4E+02
Cd-115	5.4E−02	5.4E+01	5.4E+04
Cd-115m	1.0E−02	1.0E+01	1.0E+04
Cd-117	5.6E−02	5.6E+01	5.6E+04
Cd-117m	1.3E−01	1.3E+02	1.3E+05
Ce-139	2.6E−03	2.6E+00	2.6E+03
Ce-141	1.8E−02	1.8E+01	1.8E+04
Ce-143	1.0E−01	1.0E+02	1.0E+05
Ce-144	1.7E−03	1.7E+00	1.7E+03
Cf-248	2.0E−05	2.0E−02	2.0E+01
Cf-249	1.7E−06	1.7E−03	1.7E+00
Cf-250	4.0E−06	4.0E−03	4.0E+00
Cf-251	1.7E−06	1.7E−03	1.7E+00
Cf-252	6.4E−06	6.4E−03	6.4E+00
Cf-253	3.3E−04	3.3E−01	3.3E+02

TABLE 1.—ANNUAL POSSESSION QUANTITIES FOR ENVIRONMENTAL COMPLIANCE—Continued

[Annual Possession Quantities (Ci/yr)]

Radionuclide	Gaseous form*	Liquid/powder forms	Solid form*
Cl-254	3.6E−06	3.6E−03	3.6E+00
Cl-36	1.9E−04	1.9E−01	1.9E+02
Cl-38	6.5E−01	6.5E+02	6.5E+05
Cm-242	6.0E−05	6.0E−02	6.0E+01
Cm-243	3.3E−06	3.3E−03	3.3E+00
Cm-244	4.2E−06	4.2E−03	4.2E+00
Cm-245	2.3E−06	2.3E−03	2.3E+00
Cm-246	2.3E−06	2.3E−03	2.3E+00
Cm-247	2.3E−06	2.3E−03	2.3E+00
Cm-248	6.4E−07	6.4E−04	6.4E−01
Cm-249	4.6E+00	4.6E+03	4.6E+06
Cm-250	1.1E−07	1.1E−04	1.1E−01
Co-56	2.4E−04	2.4E−01	2.4E+02
Co-57	1.6E−03	1.6E+00	1.6E+03
Co-58	9.0E−04	9.0E−01	9.0E+02
Co-58m	1.7E−01	1.7E+02	1.7E+05
Co-60	1.6E−05	1.6E−02	1.6E+01
Co-60m	4.0E+00	4.0E+03	4.0E+06
Co-61	3.8E+00	3.8E+03	3.8E+06
Cr-49	9.0E−01	9.0E+02	9.0E+05
Cr-51	6.3E−02	6.3E+01	6.3E+04
Cs-129	1.5E−01	1.5E+02	1.5E+05
Cs-131	2.8E−01	2.8E+02	2.8E+05
Cs-132	1.3E−02	1.3E+01	1.3E+04
Cs-134	5.2E−05	5.2E−02	5.2E+01
Cs-134m	3.2E−01	3.2E+02	3.2E+05
Cs-135	2.4E−02	2.4E+01	2.4E+04
Cs-136	2.1E−03	2.1E+00	2.1E+03
Cs-137	2.3E−05	2.3E−02	2.3E+01
Cs-138	4.4E−01	4.4E+02	4.4E+05
Cu-61	4.0E−01	4.0E+02	4.0E+05
Cu-64	5.2E−01	5.2E+02	5.2E+05
Cu-67	1.5E−01	1.5E+02	1.5E+05
Dy-157	4.4E−01	4.4E+02	4.4E+05
Dy-165	5.6E+00	5.6E+03	5.6E+06
Dy-166	8.1E−02	8.1E+01	8.1E+04
Er-169	4.0E−01	4.0E+02	4.0E+05
Er-171	3.6E−01	3.6E+02	3.6E+05
Es-253	2.6E−04	2.6E−01	2.6E+02
Es-254	2.3E−05	2.3E−02	2.3E+01
Es-254m	1.8E−03	1.8E+00	1.8E+03
Eu-152	1.6E−05	1.6E−02	1.6E+01
Eu-152m	3.5E−01	3.5E+02	3.5E+05
Eu-154	2.0E−05	2.0E−02	2.0E+01
Eu-155	5.2E−04	5.2E−01	5.2E+02
Eu-156	3.2E−03	3.2E+00	3.2E+03
F-18	5.6E−01	5.6E+02	5.6E+05
Fe-52	4.9E−02	4.9E+01	4.9E+04
Fe-55	1.4E−01	1.4E+02	1.4E+05
Fe-59	1.3E−03	1.3E+00	1.3E+03
Fm-254	1.8E−02	1.8E+01	1.8E+04
Fm-255	4.0E−03	4.0E+00	4.0E+03
Fr-223	1.4E−01	1.4E+02	1.4E+05
Ga-66	5.6E−02	5.6E+01	5.6E+04
Ga-67	1.1E−01	1.1E+02	1.1E+05
Ga-68	7.6E−01	7.6E+02	7.6E+05
Ga-72	3.6E−02	3.6E+01	3.6E+04
Gd-152	4.4E−06	4.4E−03	4.4E+00
Gd-153	2.0E−03	2.0E+00	2.0E+03
Gd-159	6.8E−01	6.8E+02	6.8E+05
Ge-68	2.3E−04	2.3E−01	2.3E+02
Ge-71	2.6E+00	2.6E+03	2.6E+06
Ge-77	1.0E−01	1.0E+02	1.0E+05
H-3	1.5E+01	1.5E+04	1.5E+07
Hf-181	2.5E−03	2.5E+00	2.5E+03
Hg-193m	9.5E−02	9.5E+01	9.5E+04
Hg-197	2.4E−01	2.4E+02	2.4E+05
Hg-197m	2.5E−01	2.5E+02	2.5E+05
Hg-203	5.2E−03	5.2E+00	5.2E+03
Ho-166	2.8E−01	2.8E+02	2.8E+05
Ho-166m	6.0E−06	6.0E−03	6.0E+00
I-123	4.9E−01	4.9E+02	4.9E+05
I-124	9.3E−03	9.3E+00	9.3E+03
I-125	6.2E−03	6.2E+00	6.2E+03

TABLE 1.—ANNUAL POSSESSION QUANTITIES FOR ENVIRONMENTAL COMPLIANCE—Continued

[Annual Possession Quantities (Ci/yr)]

Radionuclide	Gaseous form*	Liquid/powder forms	Solid form*
I-126	3.7E−03	3.7E+00	3.7E+03
I-128	9.3E+00	9.3E+03	9.3E+06
I-129	2.6E−04	2.6E−01	2.6E+02
I-130	4.6E−02	4.6E+01	4.6E+04
I-131	6.7E−03	6.7E+00	6.7E+03
I-132	2.0E−01	2.0E+02	2.0E+05
I-133	6.7E−02	6.7E+01	6.7E+04
I-134	3.2E−01	3.2E+02	3.2E+05
I-135	1.2E−01	1.2E+02	1.2E+05
In-111	4.9E−02	4.9E+01	4.9E+04
In-113m	2.1E+00	2.1E+03	2.1E+06
In-114m	4.9E−03	4.9E+00	4.9E+03
In-115	2.7E−04	2.7E−01	2.7E+02
In-115m	1.4E+00	1.4E+03	1.4E+06
In-116m	3.5E−01	3.5E+02	3.5E+05
In-117	1.3E+00	1.3E+03	1.3E+06
In-117m	7.6E−02	7.6E+01	7.6E+04
Ir-190	3.5E−03	3.5E+00	3.5E+03
Ir-192	9.7E−04	9.7E−01	9.7E+02
Ir-194	2.5E−01	2.5E+02	2.5E+05
Ir-194m	1.5E−04	1.5E−01	1.5E+02
K-40	6.8E−05	6.8E−02	6.8E+01
K-42	2.9E−01	2.9E+02	2.9E+05
K-43	6.0E−02	6.0E+01	6.0E+04
K-44	4.9E−01	4.9E+02	4.9E+05
Kr-79	7.0E+00		
Kr-81	1.8E+02		
Kr-83m	2.0E+04		
Kr-85	8.4E+02		
Kr-85m	1.1E+01		
Kr-87	2.0E+00		
Kr-88	4.2E−01		
La-140	1.6E−02	1.6E+01	1.6E+04
La-141	1.1E+00	1.1E+03	1.1E+06
La-142	2.3E−01	2.3E+02	2.3E+05
Lu-177	1.4E−01	1.4E+02	1.4E+05
Lu-177m	3.5E−04	3.5E−01	3.5E+02
Mg-28	2.1E−02	2.1E+01	2.1E+04
Mn-52	3.5E−03	3.5E+00	3.5E+03
Mn-52m	5.2E−01	5.2E+02	5.2E+05
Mn-53	5.7E−02	5.7E+01	5.7E+04
Mn-54	2.5E−04	2.5E−01	2.5E+02
Mn-56	2.5E−01	2.5E+02	2.5E+05
Mo-93	1.5E−03	1.5E+00	1.5E+03
Mo-99**	5.7E−02	5.7E+01	5.7E+04
Mo-101	8.4E−01	8.4E+02	8.4E+05
Ns-22	3.2E−05	3.2E−02	3.2E+01
Na-24	2.6E−02	2.6E+01	2.6E+04
Nb-90	2.5E−02	2.5E+01	2.5E+04
Nb-93m	1.2E−02	1.2E+01	1.2E+04
Nb-94	6.0E−06	6.0E−03	6.0E+00
Nb-95	2.3E−03	2.3E+00	2.3E+03
Nb-95m	2.0E−02	2.0E+01	2.0E+04
Nb-96	2.5E−02	2.5E+01	2.5E+04
Nb-97	1.0E+00	1.0E+03	1.0E+06
Nd-147	3.0E−02	3.0E+01	3.0E+04
Nd-149	1.1E+00	1.1E+03	1.1E+06
Ni-56	2.0E−03	2.0E+00	2.0E+03
Ni-57	2.1E−02	2.1E+01	2.1E+04
Ni-59	2.2E−02	2.2E+01	2.2E+04
Ni-63	1.4E−01	1.4E+02	1.4E+05
Ni-65	7.0E−01	7.0E+02	7.0E+05
Np-235	3.0E−02	3.0E+01	3.0E+04
Np-237	1.8E−06	1.8E−03	1.8E+00
Np-238	1.9E−02	1.9E+01	1.9E+04
Np-239	1.0E−01	1.0E+02	1.0E+05
Np-240	6.5E−01	6.5E+02	6.5E+05
Np-240m	4.7E+00	4.7E+03	4.7E+06
Os-185	9.2E−04	9.2E−01	9.2E+02
Os-191m	9.0E−01	9.0E+02	9.0E+05
Os-191	3.8E−02	3.8E+01	3.8E+04
Os-193	2.9E−01	2.9E+02	2.9E+05
P-32	1.7E−02	1.7E+01	1.7E+04
P-33	1.2E−01	1.2E+02	1.2E+05

TABLE 1.—ANNUAL POSSESSION QUANTITIES FOR ENVIRONMENTAL COMPLIANCE—Continued

[Annual Possession Quantities (Ci/yr)]

Radionuclide	Gaseous form*	Liquid/powder forms	Solid form*
Pa-230	6.3E−04	6.3E−01	6.3E+02
Pa-231	8.3E−07	8.3E−04	8.3E−01
Pa-233	9.3E−03	9.3E+00	9.3E+03
Pa-234	9.3E−02	9.3E+01	9.3E+04
Pb-203	8.3E−02	8.3E+01	8.3E+04
Pb-205	1.2E−02	1.2E+01	1.2E+04
Pb-209	1.1E+01	1.1E+04	1.1E+07
Pb-210	5.5E−05	5.5E−02	5.5E+01
Pb-211	1.2E−01	1.2E+02	1.2E+05
Pb-212	6.0E−03	6.0E+00	6.0E+03
Pb-214	1.2E−01	1.2E+02	1.2E+05
Pd-103	2.1E−01	2.1E+02	2.1E+05
Pd-107	8.2E−02	8.2E+01	8.2E+04
Pd-109	9.4E−01	9.4E+02	9.4E+05
Pm-143	7.6E−04	7.6E−01	7.6E+02
Pm-144	1.1E−04	1.1E−01	1.1E+02
Pm-145	5.2E−04	5.2E−01	5.2E+02
Pm-146	4.4E−05	4.4E−02	4.4E+01
Pm-147	2.6E−02	2.6E+01	2.6E+04
Pm-148	1.7E−02	1.7E+01	1.7E+04
Pm-148m	7.6E−04	7.6E−01	7.6E+02
Pm-149	2.8E−01	2.8E+02	2.8E+05
Pm-151	1.2E−01	1.2E+02	1.2E+05
Po-210	9.3E−05	9.3E−02	9.3E+01
Pr-142	2.8E−01	2.8E+02	2.8E+05
Pr-143	1.0E−01	1.0E+02	1.0E+05
Pt-144	1.5E+01	1.5E+04	1.5E+07
Pt-191	6.4E−02	6.4E+01	6.4E+04
Pt-193	2.1E−02	2.1E+01	2.1E+04
Pt-193m	4.8E−01	4.8E+02	4.8E+05
Pt-195m	1.4E−01	1.4E+02	1.4E+05
Pt-197	1.1E+00	1.1E+03	1.1E+06
Pt-197m	3.6E+00	3.6E+03	3.6E+06
Pu-236	7.0E−06	7.0E−03	7.0E+00
Pu-237	2.3E−02	2.3E+01	2.3E+04
Pu-238	2.7E−06	2.7E−03	2.7E+00
Pu-239	2.5E−06	2.5E−03	2.5E+00
Pu-240	2.5E−06	2.5E−03	2.5E+00
Pu-241	1.3E−04	1.3E−01	1.3E+02
Pu-242	2.5E−06	2.5E−03	2.5E+00
Pu-243	3.8E+00	3.8E+03	3.8E+06
Pu-244	2.4E−06	2.4E−03	2.4E+00
Pu-245	2.1E−01	2.1E+02	2.1E+05
Pu-246	4.8E−03	4.8E+00	4.8E+03
Ra-223	1.3E−04	1.3E−01	1.3E+02
Ra-224	3.2E−04	3.2E−01	3.2E+02
Ra-225	1.3E−04	1.3E−01	1.3E+02
Ra-226	5.5E−06	5.5E−03	5.5E+00
Ra-228	1.3E−05	1.3E−02	1.3E+01
Rb-81	4.2E−01	4.2E+02	4.2E+05
Rb-83	1.4E−03	1.4E+00	1.4E+03
Rb-84	2.0E−03	2.0E+00	2.0E+03
Rb-86	1.7E−02	1.7E+01	1.7E+04
Rb-87	1.0E−02	1.0E+01	1.0E+04
Rb-88	1.7E+00	1.7E+03	1.7E+06
Rb-89	6.4E−01	6.4E+02	6.4E+05
Re−184	1.8E−03	1.8E+00	1.8E+03
Re-184m	3.6E−04	3.6E−01	3.6E+02
Re-186	1.9E−01	1.9E+02	1.9E+05
Re-187	9.3E+00	9.3E+03	9.3E+06
Re-188	3.7E−01	3.7E+02	3.7E+05
Rh-103m	1.7E+02	1.7E+05	1.7E+08
Rh-105	3.4E−01	3.4E+02	3.4E+05
Ru-97	8.3E−02	8.3E+01	8.3E+04
Ru-103	3.1E−03	3.1E+00	3.1E+03
Ru-105	2.9E−01	2.9E+02	2.9E+05
Ru-106	5.9E−04	5.9E−01	5.9E+02
S-35	7.5E−02	7.5E+01	7.5E+04
Sb-117	2.0E+00	2.0E+03	2.0E+06
Sb-122	3.9E−02	3.9E+01	3.9E+04
Sb-124	6.0E−04	6.0E−01	6.0E+02
Sb-125	1.4E−04	1.4E−01	1.4E+02
Sb-126	1.6E−03	1.6E+00	1.8E+03
Sb-126m	7.6E−01	7.6E+02	7.6E+05
Sb-127	2.0E−02	2.0E+01	2.0E+04
Sb-129	1.8E−01	1.8E+02	1.8E+05
Sc-44	1.4E−01	1.4E+02	1.4E+05
Sc-46	4.0E−04	4.0E−01	4.0E+02
Sc-47	1.1E−01	1.1E+02	1.1E+05
Sc-48	1.1E−02	1.1E+01	1.1E+04
Sc-49	1.0E+01	1.0E+04	1.0E+07
Se-73	1.6E−01	1.6E+02	1.6E+05
Se-75	1.1E−03	1.1E+00	1.1E+03
Se-79	6.9E−03	6.9E+00	6.9E+03
Si-31	4.7E+00	4.7E+03	4.7E+06
Si-32	7.2E−04	7.2E−01	7.2E+02
Sm-147	1.4E−05	1.4E−02	1.4E+01
Sm-151	3.5E−02	3.5E+01	3.5E+04
Sm-153	2.4E−01	2.4E+02	2.4E+05
Sn-113	1.9E−03	1.9E+00	1.9E+03
Sn-117m	2.3E−02	2.3E+01	2.3E+04
Sn-119m	2.8E−02	2.8E+01	2.8E+04
Sn-123	1.8E−02	1.8E+01	1.8E+04
Sn-125	7.2E−03	7.2E+00	7.2E+03
Sn-126	4.7E−06	4.7E−03	4.7E+00
Sr-82	1.9E−03	1.9E+00	1.9E+03
Sr-85	1.9E−03	1.9E+00	1.9E+03
Sr-85m	1.5E+00	1.5E+03	1.5E+06
Sr-87m	1.2E+00	1.2E+03	1.2E+06
Sr-89	2.1E−02	2.1E+01	2.1E+04
Sr-90	5.2E−04	5.2E−01	5.2E+02
Sr-91	1.2E−01	1.2E+02	1.2E+05
Sr-92	2.5E−01	2.5E+02	2.5E+05
Ta-182	4.4E−04	4.4E−01	4.4E+02
Tb-157	2.2E−03	2.2E+00	2.2E+03
Tb-160	8.4E−04	8.4E−01	8.4E+02
Tc-95	9.0E−02	9.0E+01	9.0E+04
Tc-95m	1.4E−03	1.4E+00	1.4E+03
Tc-96	5.6E−03	5.6E+00	5.6E+03
Tc-96m	7.0E−01	7.0E+02	7.0E+05
Tc-97	1.5E−03	1.5E+00	1.5E+03
Tc-97m	7.2E−02	7.2E+01	7.2E+04
Tc-98	6.4E−06	6.4E−03	6.4E+00
Tc-99	9.0E−03	9.0E+00	9.0E+03
Tc-99m	1.4E+00	1.4E+03	1.4E+06
Tc-101	3.8E+00	3.8E+03	3.8E+06
Te-121	6.0E−03	6.0E+00	6.0E+03
Te-121m	5.3E−04	5.3E−01	5.3E+02
Te-123	1.2E−03	1.2E+00	1.2E+03
Te-123m	2.7E−03	2.7E+00	2.7E+03
Te-125m	1.5E−02	1.5E+01	1.5E+04
Te-127	2.9E+00	2.9E+03	2.9E+06
Te-127m	7.3E−03	7.3E+00	7.3E+03
Te-129	6.5E+00	6.5E+03	6.5E+06
Te-129m	6.1E−03	6.1E+00	6.1E+03
Te-131	9.4E−01	9.4E+02	9.4E+05
Te-131m	1.8E−02	1.8E+01	1.8E+04
Te-132	6.2E−03	6.2E+00	6.2E+03
Te-133	1.2E+00	1.2E+03	1.2E+06
Te-133m	2.9E−01	2.9E+02	2.9E+05
Te-134	4.4E−01	4.4E+02	4.4E+05
Th-226	3.0E−02	3.0E+01	3.0E+04
Th-227	6.4E−05	6.4E−02	6.4E+01
Th-228	2.9E−06	2.9E−03	2.9E+00
Th-229	4.9E−07	4.9E−04	4.9E−01
Th-230	3.2E−06	3.2E−03	3.2E+00
Th-231	8.4E−01	8.4E+02	8.4E+05
Th-232	6.0E−07	6.0E−04	6.0E−01
Th-234	2.0E−02	2.0E+01	2.0E+04
Ti-44	5.2E−06	5.2E−03	5.2E+00
Ti-45	4.0E−01	4.0E+02	4.0E+05
Tl-200	4.4E−02	4.4E+01	4.4E+04
Tl-201	1.8E−01	1.8E+02	1.8E+05
Tl-202	1.0E−02	1.0E+01	1.0E+04
Tl-204	2.5E−02	2.5E+01	2.5E+04
Tm-170	2.4E−02	2.4E+01	2.4E+04
Tm-171	5.9E−02	5.9E+01	5.9E+04
U-230	5.0E−05	5.0E−02	5.0E+01
U-231	1.4E−01	1.4E+02	1.4E+05
U-232	1.3E−06	1.3E−03	1.3E+00
U-233	7.6E−06	7.6E−03	7.6E+00
U-234	7.6E−06	7.6E−03	7.6E+00
U-235	7.0E−06	7.0E−03	7.0E+00
U-236	8.4E−06	8.4E−03	8.4E+00
U-237	4.7E−02	4.7E+01	4.7E+04
U-238	8.6E−06	8.6E−03	8.6E+00
U-239	8.3E+00	8.3E+03	8.3E+06
U-240	1.8E−01	1.8E+02	1.8E+05
V-48	1.4E−03	1.4E+00	1.4E+03
V-49	1.3E+00	1.3E+03	1.3E+06
W-181	1.1E−02	1.1E+01	1.1E+04
W-185	1.6E−01	1.6E+02	1.6E+05
W-187	1.1E−01	1.1E+02	1.1E+05
W-188	1.0E−02	1.0E+01	1.0E+04
Xe-122	7.6E−02	7.6E+01	7.6E+04
Xe-123	1.6E+00	1.6E+03	1.6E+06
Xe-125	6.0E−01		
Xe-127	7.0E+00		
Xe-129m	7.6E+01		
Xe-131m	2.2E+02		
Xe-133	5.2E+01		
Xe-133m	6.0E+01		
Xe-135	7.6E+00		
Xe-135m	4.2E+00		
Xe-138	9.9E−01		
Y-86	2.8E−02	2.8E+01	2.8E+04
Y-87	2.3E−02	2.3E+01	2.3E+04
Y-88	2.5E−04	2.5E−01	2.5E+02
Y-90	1.1E−01	1.1E+02	1.1E+05
Y-90m	4.3E−01	4.3E+02	4.3E+05
Y-91	1.6E−02	1.8E+01	1.8E+04
Y-91m	1.6E+00	1.6E+03	1.6E+06
Y-92	7.0E−01	7.0E+02	7.0E+05
Y-93	3.8E−01	3.8E+02	3.8E+05
Yb-169	5.5E−03	5.5E+00	5.5E+03
Yb-175	2.1E−01	2.1E+02	2.1E+05
Zn-62	8.6E−02	8.6E+01	8.6E+04
Zn-65	4.4E−04	4.4E−01	4.4E+02
Zn-69	2.7E+01	2.7E+04	2.7E+07
Zn-69m	2.0E−01	2.0E+02	2.0E+05
Zr-86	2.4E−02	2.4E+01	2.4E+04
Zr-88	2.7E−04	2.7E−01	2.7E+02
Zr-89	1.6E−02	1.6E+01	1.6E+04
Zr-93	2.8E−03	2.8E+00	2.8E+03
Zr-95	6.4E−04	6.4E−01	6.4E+02
Zr-97	4.6E−02	4.6E+01	4.6E+04

*Radionuclides boiling at 100 °C or less, or exposed to a temperature of 100 °C, must be considered a gas. Capsules containing radionuclides in liquid or powder form can be considered to be solids.

**Mo-99 contained in a generator to produce Technetium-99 can be assumed to be a solid.

3. Table of Concentration Levels

(a) Table 2 may be used for determining if facilities are in compliance with the standard.

1. The concentration table as applied to emission estimates can only be used if all releases are from point sources and concentrations have been measured at the stack or vent using EPA-approved methods, and the distance between each stack or vent and the nearest resident is greater than 3 times the diameter of the stack or vent. Procedures provided in Ref. (1) shall be used to determine compliance or exemption from reporting by use of Table 2.

2. The concentration table may be used to determine compliance with the standard based on environmental measurements provided these measurements are made in conformance with the requirements of § 61.107(b)(5).

4. NCRP Screening Model

The procedures described in Reference (4) may be used to determine doses to members of the general public from emissions of radionuclides to the atmosphere. Both the total dose from all radionuclides emitted, and the dose caused by radioactive iodine must be considered in accordance with the procedures in Ref. (1).

5. The COMPLY Computer Code

The COMPLY computer code may be used to determine compliance with subpart I. The compliance model in the COMPLY computer code may be used to determine the dose to members of the general public from emissions of radionuclides to the atmosphere. The EPA may add radionuclides to all or any part of COMPLY to cover radionuclides that may be used by the regulated community.

TABLE 2.—CONCENTRATION LEVELS FOR ENVIRONMENTAL COMPLIANCE

Radionuclide	Concentration (Ci/m³)	Radionuclide	Concentration (Ci/m³)
Ac-225	9.1E−14	Bi-207	1.0E−14
Ac-227	1.6E−16	Bi-210	2.9E−13
Ac-228	3.7E−12	Bi-212	5.6E−11
Ag-106	1.9E−09	Bi-213	7.1E−11
Ag-106m	1.2E−12	Bi-214	1.4E−10
Ag-108m	7.1E−15	Bk-249	5.6E−13
Ag-110m	9.1E−14	Bk-250	9.1E−11
Ag-111	2.5E−12	Br-77	4.2E−11
Al-26	4.8E−15	Br-80	1.4E−08
Am-241	1.9E−15	Br-80m	1.8E−09
Am-242	1.5E−11	Br-82	1.2E−11
Am-242m	2.0E−15	Br-83	1.2E−08
Am-243	1.8E−15	Br-84	6.7E−10
Am-244	4.0E−11	C-11	1.5E−09
Am-245	8.3E−09	C-14	1.0E−11
Am-246	1.2E−09	Ca-41	4.2E−13
Ar-37	1.6E−03	Ca-45	1.3E−12
Ar-41	1.7E−09	Ca-47	2.4E−12
As-72	2.4E−11	Cd-109	5.9E−13
As-73	1.1E−11	Cd-113	9.1E−15
As-74	2.2E−12	Cd-113m	1.7E−14
As-76	5.0E−11	Cd-115	1.6E−11
As-77	1.6E−10	Cd-115m	8.3E−13
At-211	1.1E−11	Cd-117	6.7E−11
Au-193	3.8E−10	Cd-117m	1.6E−10
Au-194	3.2E−11	Ce-139	2.6E−12
Au-195	3.1E−12	Ce-141	6.3E−12
Au-198	2.1E−11	Ce-143	3.0E−11
Au-199	4.8E−11	Ce-144	6.2E−13
Ba-131	7.1E−12	Cf-248	1.8E−14
Ba-133	5.9E−14	Cf-249	1.4E−15
Ba-133m	5.9E−11	Cf-250	3.2E−15
Ba-135m	1.8E−10	Cf-251	1.4E−15
Ba-139	5.6E−09	Cf-252	5.6E−15
Ba-140	1.3E−12	Cf-253	3.1E−13
Ba-141	1.4E−09	Cf-254	3.0E−15
Ba-142	1.3E−09	Cl-36	2.7E−15
Be-7	2.3E−11	Cl-38	7.7E−10
Be-10	1.6E−12	Cm-242	5.3E−14
Bi-206	2.3E−12	Cm-243	2.6E−15
Cm-244	3.3E−15	Eu-156	1.9E−12
Cm-245	1.8E−15	F-18	6.7E−10
Cm-246	1.9E−15	Fe-52	5.6E−11
Cm-247	1.9E−15	Fe-55	9.1E−12
Cm-248	5.0E−16	Fe-59	6.7E−13
Cm-249	3.7E−09	Fm-254	2.0E−11
Cm-250	9.1E−17	Fm-255	4.3E−12
Co-56	1.8E−13	Fr-223	3.3E−11
Co-57	1.3E−12	Ga-66	6.2E−11
Co-58	6.7E−13	Ga-67	7.1E−11
Co-58m	1.2E−10	Ga-68	9.1E−10
Co-60	1.7E−14	Ga-72	3.8E−11
Co-60m	4.3E−09	Gd-152	5.0E−15
Co-61	4.5E−09	Gd-153	2.1E−12
Cr-49	1.1E−09	Gd-159	2.9E−10
Cr-51	3.1E−11	Ge-68	2.0E−13
Cs-129	1.4E−10	Ge-71	2.4E−10
Cs-131	3.3E−11	Ge-77	1.0E−10
Cs-132	4.8E−12	H-3	1.5E−09
Cs-134	2.7E−14	Hf-181	1.9E−12
Cs-134m	1.7E−10	Hg-193m	1.0E−10
Cs-135	4.0E−13	Hg-197	8.3E−11
Cs-136	5.3E−13	Hg-197m	1.1E−10
Cs-137	1.9E−14	Hg-203	1.0E−12
Cs-138	5.3E−10	Ho-166	7.1E−11
Cu-61	4.8E−10	Ho-166m	7.1E−15
Cu-64	5.3E−10	I-123	4.3E−10
Cu-67	5.0E−11	I-124	6.2E−13
Dy-157	5.0E−10	I-125	1.2E−13
Dy-165	6.7E−09	I-126	1.1E−13
Dy-166	1.1E−11	I-128	1.1E−08
Er-169	2.9E−11	I-129	9.1E−15
Er-171	4.0E−10	I-130	4.5E−11
Es-253	2.4E−13	I-131	2.1E−13
Es-254	2.0E−14	I-132	2.3E−10
Es-254m	1.8E−12	I-133	2.0E−11
Eu-152	2.0E−14	I-134	3.8E−10
Eu-152m	3.6E−10	I-135	1.2E−10
Eu-154	2.3E−14	In-111	3.6E−11
Eu-155	5.9E−13	In-113m	2.5E−09
In-114m	9.1E−13	Nb-95	2.2E−12
In-115	7.1E−14	Nb-95m	1.4E−11
In-115m	1.6E−09	Nb-96	2.4E−11
In-116m	4.2E−10	Nb-97	1.2E−09
In-117	1.6E−09	Nd-147	7.7E−12
In-117m	9.1E−11	Nd-149	7.1E−10
Ir-190	2.6E−12	Ni-56	1.7E−12
Ir-192	9.1E−13	Ni-57	1.8E−11
Ir-194	1.1E−10	Ni-59	1.5E−11
Ir-194m	1.7E−13	Ni-63	1.4E−11
K-40	2.7E−14	Ni-65	6.3E−10
K-42	2.6E−10	Np-235	2.5E−11
K-43	6.2E−11	Np-237	1.2E−15
K-44	5.9E−10	Np-238	1.4E−11
Kr-79	8.3E−09	Np-239	3.8E−11
Kr-81	2.1E−07	Np-240	7.7E−10
Kr-83m	2.3E−05	Np-240m	5.6E−09
Kr-85	1.0E−06	Os-185	1.0E−12
Kr-85m	1.3E−08	Os-191	2.9E−10
Kr-87	2.4E−09	Os-191m	1.1E−11
Kr-88	5.0E−10	Os-193	9.1E−11
La-140	1.2E−11	P-32	3.3E−13
La-141	7.7E−10	P-33	2.4E−12
La-142	2.7E−10	Pa-230	3.2E−13
Lu-177	2.4E−11	Pa-231	5.9E−16
Lu-177m	3.6E−13	Pa-233	4.8E−12
Mg-28	1.5E−11	Pa-234	1.1E−10
Mn-52	2.8E−12	Pb-203	6.2E−11
Mn-52m	6.2E−10	Pb-205	5.6E−12
Mn-53	1.5E−11	Pb-209	1.3E−08
Mn-54	2.8E−13	Pb-210	2.8E−15
Mn-56	2.9E−10	Pb-211	1.4E−10
Mo-93	1.1E−12	Pb-212	6.3E−12
Mo-99	1.4E−11	Pb-214	1.2E−10
Mo-101	1.0E−09	Pd-103	3.8E−11
Na-22	2.6E−14	Pd-107	3.1E−11
Na-24	2.6E−11	Pd-109	4.8E−10
Nb-90	2.6E−11	Pm-143	9.1E−13
Nb-93m	1.0E−11	Pm-144	1.3E−13
Nb-94	7.1E−15	Pm-145	6.2E−13
Pm-146	5.3E−14	Re-184m	3.7E−13
Pm-147	1.1E−11	Re-186	1.8E−11
Pm-148	5.0E−12	Re-187	2.6E−10
Pm-148m	6.7E−13	Re-188	1.7E−10
Pm-149	4.2E−11	Rh-103m	2.1E−07
Pm-151	7.1E−11	Rh-105	1.3E−10
Po-210	7.1E−15	Ru-97	6.7E−11
Pr-142	1.1E−10	Ru-103	2.6E−12
Pr-143	7.1E−12	Ru-105	2.8E−10
Pr-144	1.8E−08	Ru-106	3.4E−13
Pt-191	4.3E−11	S-35	1.3E−12
Pt-193	1.8E−11	Sb-117	2.4E−09
Pt-193m	4.8E−11	Sb-122	1.4E−11
Pt-195m	3.2E−11	Sb-124	5.3E−13
Pt-197	4.0E−10	Sb-125	1.6E−13
Pt-197m	2.6E−09	Sb-126	1.4E−12
Pu-236	5.9E−15	Sb-126m	9.1E−10
Pu-237	1.9E−11	Sb-127	7.1E−12
Pu-238	2.1E−15	Sb-129	7.7E−11
Pu-239	2.0E−15	Sc-44	1.7E−10
Pu-240	2.0E−15	Sc-46	4.2E−13
Pu-241	1.0E−13	Sc-47	3.8E−11
Pu-242	2.0E−15	Sc-48	9.1E−12
Pu-243	4.2E−09	Sc-49	1.2E−08
Pu-244	2.0E−15	Se-73	1.7E−10
Pu-245	2.1E−10	Se-75	1.7E−13
Pu-246	2.2E−12	Se-79	1.1E−13
Ra-223	4.2E−14	Si-31	5.6E−09
Ra-224	1.5E−13	Si-32	3.4E−14
Ra-225	5.0E−14	Sm-147	1.4E−14
Ra-226	3.3E−15	Sm-151	2.1E−11
Ra-228	5.9E−15	Sm-153	5.9E−11
Rb-81	5.0E−10	Sn-113	1.4E−12
Rb-83	3.4E−13	Sn-117m	5.6E−12
Rb-84	3.6E−13	Sn-119m	5.3E−12
Rb-86	5.6E−13	Sn-123	1.1E−12
Rb-87	1.6E−13	Sn-125	1.7E−12
Rb-88	2.1E−09	Sn-126	5.3E−15
Rb-89	7.1E−10	Sr-82	6.2E−13
Re-184	1.5E−12	Sr-85	1.8E−12
Sr-85m	1.6E−09	Th-232	6.2E−16
Sr-87m	1.4E−09	Th-234	2.2E−12
Sr-89	1.8E−12	Ti-44	6.2E−15

TABLE 2.—CONCENTRATION LEVELS FOR ENVIRONMENTAL COMPLIANCE—Continued

Radionuclide	Concentration (Ci/m³)	Radionuclide	Concentration (Ci/m³)
Sr-90	1.9E−14	Tl-45	4.8E−10
Sr-91	9.1E−11	Tl-200	4.5E−11
Sr-92	2.9E−10	Tl-201	1.0E−10
Ta-182	4.5E−13	Tl-202	5.0E−12
Tb-157	2.5E−12	Tl-204	1.2E−12
Tb-160	7.7E−13	Tm-170	3.3E−12
Tc-95	1.0E−10	Tm-171	2.6E−11
Tc-95m	1.4E−12	U-230	1.5E−14
Tc-96	5.6E−12	U-231	4.2E−11
Tc-96m	6.7E−10	U-232	1.3E−15
Tc-97	7.1E−13	U-233	7.1E−15
Tc-97m	7.1E−12	U-234	7.7E−15
Tc-98	6.7E−15	U-235	7.1E−15
Tc-99	1.4E−13	U-236	7.7E−15
Tc-99m	1.7E−09	U-237	1.0E−11
Tc-101	4.5E−09	U-238	8.3E−15
Te-121	1.0E−12	U-239	4.3E−09
Te-121m	1.2E−13	U-240	1.3E−10
Te-123	1.4E−13	V-48	1.0E−12
Te-123m	2.0E−13	V-49	1.6E−10
Te-125m	3.6E−13	W-181	6.7E−12
Te-127	1.0E−09	W-185	2.6E−12
Te-127m	1.5E−13	W-187	7.7E−11
Te-129	7.7E−09	W-188	5.3E−13
Te-129m	1.4E−13	Xe-122	9.1E−11

TABLE 2.—CONCENTRATION LEVELS FOR ENVIRONMENTAL COMPLIANCE—Continued

Radionuclide	Concentration (Ci/m³)	Radionuclide	Concentration (Ci/m³)
Te-131	9.1E−11	Xe-123	1.6E−09
Te-131m	1.0E−12	Xe-125	1.1E−11
Te-132	7.1E−13	Xe-127	8.3E−09
Te-133	9.1E−10	Xe-129m	9.1E−08
Te-133m	2.2E−10	Xe-131m	2.6E−07
Te-134	5.3E−10	Xe-133	6.2E−08
Th-226	3.4E−11	Xe-133m	7.1E−08
Th-227	3.8E−14	Xe-135	9.1E−09
Th-228	3.1E−15	Xe-135m	5.0E−09
Th-229	5.3E−16	Xe-138	1.2E−09
Th-230	3.4E−15	Y-86	3.0E−11
Th-231	2.9E−10	Y-87	1.7E−11
Y-88	2.7E−13	Zn-65	9.1E−14
Y-90	1.3E−11	Zn-69	3.2E−08
Y-90m	1.9E−10	Zn-69m	1.7E−10
Y-91	2.1E−12	Zr-86	2.4E−11
Y-91m	1.3E−09	Zr-88	3.1E−13
Y-92	8.3E−10	Zr-89	1.3E−11
Y-93	2.9E−10	Zr-93	2.6E−12
Yb-169	3.7E−12	Zr-95	6.7E−13
Yb-175	4.3E−11	Zr-97	3.8E−11
Zn-62	9.1E−11		

6. References

(1) Environmental Protection Agency, "A Guide for Determining Compliance with the Clean Air Act Standards for Radionuclides Emissions from NRC-Licensed and Non-DOE Federal Facilities", EPA 520/1–89–002, October 1989.

(2) Environmental Protection Agency, "User's Guide for the COMPLY Code", EPA 520/1–89–003, October 1989.

(3) Environmental Protection Agency, "Background Information Document: Procedures Approved for Demonstrating Compliance with 40 CFR part 61, subpart I", EPA 520/1–89–001, January 1989.

(4) National Council on Radiation Protection and Measurement, "Screening Techniques for Determining Compliance with Environmental Standards" NCRP Commentary No. 3, Revision of January 1989 with addendum of October, 1989.

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