United States
Environmental Protection
Agency

Air and Radiation
(6608J)

EPA 402-R-00-01
June 2000

Evaluation of EPA's Guidelines for Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM)

Report to Congress

Executive Summary

In reports accompanying the appropriations bills for the Departments of Veterans Affairs, Housing and Urban Development, and Independent Agencies for Fiscal Years 1996 and 1997, Congress requested the EPA arrange for the National Academy of Sciences (NAS) to conduct a study examining the basis for EPA's guidance on technologically enhanced naturally occurring radioactive material (TENORM). EPA was to submit the completed NAS study to Congress, along with Agency's own report on what it would do to implement the NAS's recommendations, including EPA's plans to revise its TENORM guidance documents. This report has been prepared to satisfy that requirement regarding TENORM.

In January 1999, the NAS published its report entitled, "Evaluation of Guidelines for Exposures to Technologically Enhanced Naturally Occurring Radioactive Materials." In this report, the NAS Committee found that there are differences in TENORM guidelines among federal agencies and others. The Committee found that these differences in guidelines represent differences in policies for risk management rather than differences in the technical evaluation of TENORM.

Although the NAS Committee found that most of the relevant and appropriate scientific information has already been incorporated into current TENORM guidelines, many of the Committee's recommendations point to areas where new information would be useful. For example, the Committee recommended further investigation of the varying chemical and physical forms of TENORM, and the development of better techniques to distinguish discrete TENORM levels from background radiation levels. EPA is already working in many of the areas the Committee cited for additional technical information.

EPA recognizes that there are differences in TENORM regulations and guidance documents among organizations. EPA intends to take into consideration the significance of TENORM risks to the public and the environment to determine which TENORM wastes should be addressed first and what actions, if any, should be taken in response to potential risks. EPA is working in virtually all areas of the NAS Committee's recommendations. In areas where EPA is not currently engaged, the Agency acknowledges the recommendations of the NAS. EPA will consult, as appropriate, with federal, state and other organizations involved with radiation protection issues as we progress toward TENORM solutions.

Evaluation of EPA's Guidelines on Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) Report to Congress

Introduction

Over the past 20 years, EPA and other federal as well as state government agencies, industries, and other organizations have identified an array of naturally occurring materials that, because of human activity, may present a radiation hazard to people and the environment. These materials are known generally as technologically enhanced naturally occurring radioactive materials, or TENORM.[1] In general terms, TENORM is material containing radionuclides that are present naturally in rocks, soils, water, and minerals and that have become concentrated and/or exposed to the accessible environment as a result of human activities such as manufacturing, water treatment, or mining operations. In its report,[2] the Committee on Evaluation of EPA Guidelines for Exposure to Naturally Occurring Radioactive Materials, of the National Academy of Sciences and National Academy of Engineering (the "NAS Committee" or "the Committee") defines TENORM as "*any naturally occurring material not subject to regulation under the Atomic Energy Act whose radionuclide concentrations or potential for human exposure have been increased above levels encountered in the natural state by human activities*" (p. 19). Much TENORM contains only trace amounts of radiation and is part of our everyday landscape. Some TENORM, however, contains very high concentrations of radionuclides that can produce harmful exposure levels. EPA is concerned about TENORM because of this potential for harmful exposure to humans and the environment.

In reports accompanying the appropriations bills for the Departments of Veterans Affairs, Housing and Urban Development, and Independent Agencies for Fiscal Years 1996[3] and 1997,[4] Congress requested that EPA arrange for the NAS to conduct a study examining the basis for EPA's TENORM and radon guidance. EPA was to submit the completed NAS study to Congress, along

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[1]Before 1998, the term used for these materials was "Naturally Occurring Radioactive Materials" ("NORM"). Based on more current industry and regulatory practice, the term "TENORM" now is considered more appropriate. We use "TENORM" throughout this report.

[2]Committee on Evaluation of EPA Guidelines for Exposure to Naturally Occurring Radioactive Materials, National Research Council of the National Academy of Sciences and National Academy of Engineering, "Evaluation of Guidelines for Exposures to Technologically Enhanced Naturally Occurring Radioactive Materials," 1999. Citations to this NAS Committee's report appear in parenthesis containing page citations.

[3]H.R. Rep. No. 104-384, p. 77 (1995).

[4]S. Rep. No. 104-318, p. 69 (1996).

with the Agency's own report on what it would do to implement the NAS's recommendations, including EPA's plans to revise its TENORM guidance documents. This report has been prepared to satisfy that requirement regarding TENORM. In February 1998, the NAS released the BEIR VI report entitled "Health Effects of Exposure to Radon." This new report is the most definitive accumulation of scientific data on indoor radon. The Agency is in the process of reviewing whether the BEIR VI findings warrant any changes in EPA's radon policy and will be issuing a separate Report to Congress on this issue.

Background

TENORM is found in a wide variety of waste materials, some raw mineral ores, and in trace amounts in some consumer products where molecules of radionuclides may be bound to specific minerals used in the manufacturing process (zircon, for example, contains minute quantities of uranium and thorium and used widely as a glaze for ceramics and metal molds). The radionuclide Radium-226, a decay product of uranium and thorium with a radiation decay half-life of 1600years, commonly is found in TENORM materials and wastes and is the principal source of radiation doses to humans for natural surroundings. While normally occurring in soils of the United States[5] at concentrations ranging from less than 1 to slightly more than 4 picocuries per gram (pCi/g, where picocuries are a measure of radiation content in a material), Radium-226 in TENORM materials can occur in concentrations ranging from undetectable amounts to as much as several hundred thousand pCi/g. In comparison, EPA has issued guidance[6] that recommends that radioactively contaminated soils should be cleaned up so remnant radium concentrations are 5 pCi/g or less. Uranium, thorium and potassium radionuclides and their daughter products are also commonly found in TENORM wastes.

Total amounts of TENORM wastes produced in the Untied States annually may be in excess of 1 billion tons.[7] Nuclear Regulatory Commission (NRC) staff calculations show that the disposal the

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[5]Myrick, T., Berven, B., and Haywood, "Determination of Concentrations of Selected Radionuclides in Surface Soil in the U.S.," in Health Physics Journal, Vol. 45, no.3, pp. 631-642, 1983.

[6]U.S. EPA, 1998, Memorandum on Use of Soil Cleanup Criteria in 40CFR Part 192 as Remediation Goals for CERCLA Sites, Signed by Stephen T. Luftig, Director, Office of Emergency and Remedial Response, and Larry Weinstock, Acting Director, Office of Radiation and Indoor Air. Directive No. 92000.4-25, February 12, 1998.

[7]S. Cohen and Associates, Inc., 1993, Preliminary Risk Assessment of Diffuse NORM Wastes, Prepared for U.S. EPA under contract No. 68D20155, May 1993. (EPA will not be finalizing this report. Instead, the Agency will be issuing a series of technical reports on a waste-specific basis. These reports will include the most current information on the waste.)

annual production of TENORM in industrial landfills could easily exceed $100 billion.[8] In many cases, relatively low levels of radiation occur in large volumes of material that contain the TENORM. This situation causes a dilemma because of the high cost of disposing of radioactive waste in comparison with (in many cases) the relatively low value per ton of the product from which the TENORM is separated. In addition, relatively few landfills or other licensed disposal locations can accept radioactive waste. However, TENORM materials exempt from NRC regulation are routinely disposed of without being labeled "radioactive material." Also, large quantities of TENORM are currently undisposed and may be found in many of the thousands of abandoned mine sites around the nation.[9]

Table 1, in Appendix A, provides a range of reported concentrations, and average concentration measurement in some cases, of TENORM in various wastes and materials. This table is not a comprehensive list, as TENORM radiation is known to occur in many other materials; however, it should provide a relative sense of the hazards posed by these particular radioactive substances.

NAS Committee's Report

In the conference report accompanying H.R. 2099, the FY 1996 appropriations bill for the Department of Veterans Affairs and Housing and Urban Development, and Independent Agencies, the conferees included the following language:

> The conferees direct EPA to enter into and arrangement with the National Academy of Sciences to investigate and report on the scientific basis for EPA's recommendations relative to indoor radon and other naturally occurring radioactive materials (NORM). The Academy is to examine EPA's guidelines in light of the recommendations of the National Council of Radiation Protection and Measurements and other peer-reviewed research by the National Cancer Institute, the Centers for Disease Control, and others. The Academy shall summarize the principal areas of agreement and disagreement among these bodies and shall evaluate the scientific and technical basis for any differences that exist. EPA is to submit this report to the appropriate committees of the Congress with 18 months of the date of the enactment of this act, and state its views on the need to revise the guidelines for radon and NORM in light of the Academy's evaluation. The agency also shall explain the technical and policy basis for such views.[10]

EPA entered into an agreement with the NAS on March 31, 1997, to respond to the

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[8] New Jersey Department of Environment Protection, Commission on Radiation Protection, Soil Remediation for Radioactive Materials Proposed New Rules: N.J.A.C. 7:28-12, DEP Docket Number 11-99-06-697.

[9] S. Cohen and Associates, Inc. 1989, Radiological Monitoring at Inactive Surface Mines, report prepared for the U.S. Environmental Protection Agency, February, 1989.

[10] H.R. Rep. No. 104-384, at 77 (1995).

congressional requirement and reported the signing of the agreement to the Appropriations Committee as requested in 1997. The NAS Committee published its study in January 1999. EPA's transmittal to Congress of the NAS Committee study, along with this report by EPA, fulfills the legislative requirements discussed above.[11]

The purpose of the NAS Committee's study was to investigate the scientific and technical bases for EPA's TENORM guidelines. Congress instructed that, as part of its investigation and report, the NAS Committee "summarize the principal areas of agreement and disagreement among [EPA and other organizations] and ...evaluate the scientific and technical basis for any differences that exist."[12]

The NAS Committee's charge included examining the following issues:

1) ***Whether the differences in the guidelines for TENORM developed by EPA and other organizations are based upon scientific and technical information, or on policy decisions related to risk management.***

2) ***If the guidelines developed by EPA and other organizations differ in their scientific and technical bases, what are the relative merits of the different scientific and technical assumptions?***

3) ***Whether there is relevant and appropriate scientific information that has not been used in the development of contemporary risk analysis for NORM.***

The NAS examined and compared the existing guidelines for TENORM developed by EPA and other organizations concerned with radiation protection. These other organizations include the Department of Energy, the Nuclear Regulatory Commission, the National Council on Radiation Protection and Measurements, the International Commission on Radiological Protection, the International Atomic Energy Agency, the Commission of European Communities, and the Health Physics Society. The NAS also reviewed guidelines published by the individual states.

NAS Committee's Conclusions

The NAS Committee made the following conclusions in response to the charge elements:

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[11] The NAS report also presents an evaluation of the guidelines for indoor radon. The Committee found that this evaluation was relatively straightforward because the guidelines for the indoor radon exposure situation are well defined and the primary task for the Committee was to evaluate whether the differences among the various guidelines have a scientific and technical basis. This report does not address indoor radon guidelines because we are in the process of reviewing the NAS BEIR VI report and plan to send a report to Congress indicating whether the BEIR VI findings warrant any changes in EPA's policy on radon.

[12] H.R. Rep. No. 104-384,p. 77 (1995).

sources combined does not, by itself, provide acceptable radiation protection of the public, because doses should be reduced as far below the primary dose limit as practicable" (p. 93).

In spite of the differences in risk management approaches, and the consequent substantial differences in implied risk associated with the different guidelines (implied health risks vary over several orders of magnitude), the Committee concluded that "*[t]he principle that exposures should be maintained ALARA, economic and social factors being taken into account, appears to be the most important factor in determining risks actually experienced for any controllable exposure situation*" (p. 247). Therefore, to the extent that the ALARA objective is applied consistently to all exposure situations, all guidelines would be consistent with regard to the risks actually achieved, even though the risks that are ALARA can depend significantly on the particular exposure situation. The Committee also noted that, using the ALARA process, "*[t]here is not a priori reason to expect risks judged reasonably achievable for one exposure situation (such as releases from operating nuclear facilities) to be consistent with risks judged reasonably achievable for a different situation (such as radioactive waste disposal)*." (p.148) Finally, the Committee concluded that the current differences in approach for radiation risk management, though confusing, do not result in important differences in public health protection. However, "*continued attention to the factors that affect radiation dose and risk for specific TENORM situations is crucial for consistently protective, cost-effective radiation control*." (p.247)

Although there are significant differences in radiation protection standards developed by the Federal agencies, the NAS Committee concluded that these differences do not result in important differences in public health protection; it is also important to note that in some cases the differences are for legitimate reasons. For example, NRC regulates its licensees under the ADA, for the most part on a site-by-site basis under the "umbrella" of an upper-bound dose limit, which is based on international and national recommendations from the ICRP and NCRP. The limit is coupled with the required application for procedures and engineering controls to reduce the potential public doses to levels that are ALARA. EPA, in its primary role as a standards-settings agency, regulates under the authority of both the AEA and environmental statues. EPA regulates by class of facility or source, pollutant, or environmental medium. In setting its standards, EPA generally establishes a goal, often mandated by legislation, and considers technological feasibility, costs, and other factors in determining levels to be achieved in practice. Although not required, EPA aims for consistent regulatory policy concerning standards for radionuclides and chemicals.

Transfer of Existing Guidelines

The Committee found that another important factor in the development of standards or guidelines for TENORM is an organization's judgement about transferability of existing standards/guidelines to other exposure situations. As the NAS stated. "*[t]he committee strongly cautions against generalizing numerical guidance derived for a specific situation to another situation without sufficient thought as to the applicability to the new circumstance*." "*[Because] many sources of TENORM have mineralogical characteristics and processing histories,...and*

therefore, have different radon-emanation coefficients, leachability, and bioavailability." (p. 246) The NAS recommended that organizations limit the transfer of standards or guidelines by the degree to which the physical and chemical properties and projected exposure pathways of the TENORM are substantially similar to those considered for existing guidelines. Exemption levels should consider the physical characteristics of a site, the extent of the TENORM source, and the projected land use.

Regulations and Guidelines

The NAS Committee noted that EPA has developed standards under several different environmental laws for the regulation of TENORM, including the Clean Air Act (CAA), the Clean Water Act (CWA), the Safe Drinking Water Act (SDWA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Committee found, however, that "*neither EPA, which has primary responsibility for setting federal radiation standards, nor any other federal agency with responsibility for regulating radiation exposures has developed standards applicable to all exposure situations that involve TENORM. Instead, federal regulation of TENORM is fragmentary, and many potentially important sources of public exposure to TENORM are not regulated by any federal agency*" (p. 246).

Recommendations on Additional Research Needs

The NAS identified a number of areas in which it recommends that EPA conduct additional research and study regarding TENORM. A discussion of these recommendations, and EPA's responses, follows.

Recommendation: EPA'S ASSESSMENTS OF RISKS FROM TENORM SHOULD INCLUDE ASSESSMENTS OF EXISTING BACKGROUND RADIATION LEVELS

EPA's Response:

The NAS Committee emphasized the importance of considering exposure to TENORM in the context of natural background radiation levels (p. 248). The Committee concluded that background radiation levels are highly relevant to TENORM regulation because the radionuclides in TENORM are identical to the radionuclides in nature. The NAS Committee urged EPA to include in our assessment of TENORM-related risks an assessment of existing background radiation and the risks that this radiation contributes to overall risks from radiation exposure. It noted that "*[a]rguments concerning small differences in the target regulatory level at small fractions of the natural background tend to pale into insignificance in comparison with natural background levels and their local and regional variations*" (p. 248). The Committee also stated that, "*[a]s a practical matter, the implications of [the] existing levels and [the] variability of natural radionuclide concentrations and doses received by humans should receive careful consideration in the*

regulation of TENORM" (p.248).

EPA agrees that the levels of background radiation need to be considered in the assessment of TENORM. EPA's radiation regulations limit the amount of radiation above background because the radiation is controllable or was placed there by man and should be controllable, unlike radioactive materials not generated by man. There are numerous studies of background exposure dose and risk (e.g., NCRP Report 94, "Exposure of Populations in the US and Canada from Natural Background Radiation" and the National Research Council's, "Risk Assessment of Radon in Drinking Water").

Guidance has also been developed to help in the process of demonstrating compliance when background radioactivity is present and is variable. An example of this guidance is the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) which is used to characterize contaminated sites. EPA will continue to take into account these important background and radioactivity studies in developing TENORM guidance and regulations.

Recommendations: EPA SHOULD DEVELOP BETTER TOOLS FOR DISTINGUISHING DISCRETE TENORM FROM BACKGROUND

EPA Response:

Because of the importance that the NAS Committee placed on the role of background radiation in the regulation of TENORM, it recommended that EPA develop better tools for distinguishing discrete TENORM from background radiation levels. Because TENORM radionuclides are ubiquitous in the environment, the NAS Committee expressed concern that the inability to distinguish TENORM from background radiation levels could result in unnecessary or over-broad regulation. The Committee argued, and EPA agrees, that it makes little or no sense to require cleanup of TENORM to levels below those that would exist naturally at a particular location (p.95). This issue is especially important in regards to mining sites because these sites often have background radiation levels that are higher than non-mining sites (p.95).

Data from the National Uranium Resource Evaluation (NURE), state geological surveys, and nuclear power plants databases provide reliable estimates of background radiation for the United States. EPA is incorporating information on background levels of radiation into all aspects of its evaluation of TENORM risks and potential disposal solutions. EPA will include discussions of background radiation in the comprehensive source-specific reports that it will develop for TENORM wastes and products.

A number of private entities, are working to develop detection equipment that can provide more accurate instantaneous field radiation level measurements, on the order of what the NAS Committee recommended, than can the equipment currently available. Regardless of the tools developed for measuring these low levels of radiation, however, EPA's principal concern is still the control of man-made and TENORM sources of radiation.

Recommendation: **EPA SHOULD EXAMINE FURTHER THE CHEMICAL FORMS AND PHYSICAL STRUCTURES OF TENORM AND SHOULD DEVELOP A MORE COMPREHENSIVE SYSTEM TO DOCUMENT THE VARIOUS USES AND DISPERSAL OF TENORM**

EPA Response:

The NAS Committee noted that, *"TENORM present[s] unique problems because of their large volumes and widespread occurrence in industrial products, byproducts, and wastes. The physical, chemical, and radiological properties of TENORM vary widely.*" (p.74)

EPA agrees with the Committee's conclusions about the complexity of TENORM, and for this reason EPA already is working to establish a comprehensive means of documenting significant aspects of TENORM associated with various waste streams or products. EPA will conduct this documentation in cooperation with interested stakeholders, including representatives of state and local governments, industries and non-governmental and other entities. As previously mentioned, these reports will compile the most relevant information on the amount and location of waste, the associated risks, the varying physical structures and chemical forms, current disposal techniques, and applicable guidelines and regulations. The reports will build on efforts conducted across the Agency on specific industries, wastes and products.

For example, through EPA's ongoing field projects, the Agency is gathering new information about TENORM wastes in uranium overburden and in-situ leach operations. EPA also is fostering relationships with the organizations at the forefront of these issues. Through this network of organizations, EPA will be able to continue to build on its comprehensive documentation of TENORM data issues. Once EPA releases a technical report on a particular type of TENORM, the Agency intends to invite a variety of stakeholders to review the report and provide input. At meetings with these stakeholders, EPA expects to gather information on the most appropriate approaches to dealings with the waste hazards, risks, and disposal issues.

Recommendation: **EPA'S EXPOSURE ASSESSMENTS SHOULD CONSIDER TENORM'S BIOAVAILABILITY, LEACHABILITY, AND RADON EMANATION RATES**

EPA Response:

The NAS Committee suggested that EPA consider TENORM's bioavailability, leachability, and radon emanation rates in our assessments of the effects of exposure to TENORM (p.245). The NAS noted the potential importance of these factors in developing TENORM guidelines, and urged us to study them further in order to understand them better (p.245). The Agency is considering these factors, and many others, in our field studies and risk assessment modeling discussed above. EPA will also take them into account its future efforts in to determine how best to address that risks associated with TENORM.