Abstract. The regulation of naturally occurring radioactive material in the United States presents unique regulatory challenges. Except for those isotopes considered to be byproduct, source or special nuclear material, naturally occurring radioactive material (NORM) is not included in the U.S. Nuclear Regulatory Commission’s authority under the Atomic Energy Act. Although the United States Environmental Protection Agency has the authority to set standards involving exposure to NORM, that federal agency has not implemented regulations specific to this material. As a result, the possession and use of both discrete sources and diffuse material containing those isotopes has been left up to the individual states for regulation. Industrial processes, such as mining, oil and gas production, and drinking water treatment systems, that result in the concentration of NORM above concentrations that warrant regulatory attention vary widely in locale, degree of regulatory control needed, and options for disposal. Several states in which these industries have created NORM contamination problems or legal issues have adopted rules to address their specific situations. As a result, a patchwork of non-uniform rules for NORM has been developed in states across the country. The Conference of Radiation Control Program Directors, Inc. (CRCPD), an organization made up primarily of staff from state radiation control programs in the United States, has developed a suggested state regulation for NORM that radiation control programs in the states can use as a model. The model regulations provide a uniform dose basis for exemptions and decontamination, contamination criteria, and recycling of equipment, and disposal options. They also provide for flexibility in implementation by individual states in the regulation of unique processes and situations involving enhanced concentrations of NORM.

1. Introduction

Radiation control programs in the United States have been aware of radioactive contamination and waste problems associated with industrial processes that create diffuse technologically enhanced naturally occurring radioactive material, otherwise known as NORM or TENORM, for over twenty years. The need for an appropriate and uniform regulatory position regarding the use, decontamination and disposal of residues and wastes containing enhanced levels of naturally occurring radionuclides (above those levels found in nature) as a result of human activity was brought to the attention of the states by requests from companies for authorization to use the materials. Various groups and organizations have attempted to both quantify the scope of materials involved and to determine mechanisms by which new standards could be applied to industries that had not previously come under the auspices of radiation regulation in the past.

Diffuse NORM appears in a wide variety of human practices and, depending on the industrial activity, geography, and geology of a region, can vary widely in concentration, chemical characteristics, and physical properties. Some examples of the types of processes that may concentrate NORM above levels of regulatory concern and the primary locations associated with them in the United States include:

(a) Oil and gas production—In this industry, scales and sludge containing primarily radium can accumulate in equipment and can cause contamination of production and equipment-handling areas. Studies have shown that the plating of radium-bearing scales in tubulars and equipment is most associated with produced water from oil production formations. Although the average concentration found in scale is about 3,700 Bq/kg radium, some have been found to contain over 3.7 mBq/kg. External gamma readings on oil tubulars have been found up to 50 to 100 µSv/hr, and the beta activity from lead 210 and other radon daughters in gas production and petrochemical industry equipment are even higher. Soil has been found contaminated with radium up to 370 kBq/kg; this creates land transfer and liability issues. Produced water associated with oil production can contain concentrations of radium up to 104 kBq/L.
Sludge in tanks and other equipment may contain up to 74kBq/kg radium. Most NORM associated with this industry is found in the oil-producing states of Texas, Oklahoma, Louisiana, Arkansas, and Mississippi, and to a lesser extent in other states. [1,2]

(b) Phosphate fertilizer production and phosphogypsum—This industry is of primary concern in Florida, although some production takes place to a lesser degree in Texas and other states. Millions of tons of phosphogypsum tailings are created, containing an average concentration of Ra-226 of about 1.1 kBq/kg.

(c) Water treatment facilities—In areas where radium is found in drinking water supplies, the radium may concentrate in resins and sludge as the water is treated. Depending on local geology, this type of NORM may appear at locations throughout the country and vary widely in concentration. As new radium standards promulgated by the U.S. Environmental Protection Agency (EPA) are implemented, this source of NORM will become more prevalent, and the need for worker protection standards and waste disposal options will rise.

The existing regulatory framework did not facilitate incorporation of these materials into national uniform standards. Except for those isotopes considered to be byproduct, source or special nuclear material, NORM is not included in the U.S. Nuclear Regulatory Commission’s (NRC) authority under the Atomic Energy Act. Although EPA has the authority to set standards involving exposure to NORM, that federal agency has not implemented regulations specific to this material. As a result, the possession and use of both discrete sources and diffuse material containing those isotopes has been left up to the individual states for regulation. Additionally, federal and state rules for licensing and use of radioactive material were based on those radioactive materials that are possessed and used for their radioactive properties, not as an incidental waste product of another process. For the most part, radioactive materials regulated under the U.S. Atomic Energy Act, either by NRC or under an Agreement with NRC by Agreement States, and discrete sources of naturally occurring and accelerator produced radioactive material (NARM) regulated by states only are controlled in similar fashion. For these materials, the regulatory structure involves a process of exemptions for low concentrations and certain items, general licensure (permit by rule), and specific licensure (upon application and approval by a regulatory agency), followed by criteria and provisions for safe handling and cleanup and disposal of waste. Because diffuse NORM can create similar radiation hazards and waste concerns, state regulatory programs concluded that facilities and equipment contaminated by activities that produce NORM should be treated in a similar regulatory manner as those regulated under the Atomic Energy Act and existing state NARM rules.

The industrial processes described above and others, such as mining, mineral extraction, and burning of coal for electricity production, that result in the concentration of NORM above concentrations that warrant regulatory attention vary widely in locale, degree of regulatory control needed, and options for disposal. Several states in which these industries have created NORM-related contamination problems and/or legal issues have either proceeded with rulemaking on their own or in coordination with other states. To date, only eleven states have adopted regulations that specifically address NORM. As a result, a patchwork of non-uniform rules for NORM has been developed in states across the country.

2. Development of Model State Regulations

The Conference of Radiation Control Program Directors, Inc. (CRCPD), an organization made up primarily of staff from state radiation control programs in the United States, recognized the need for some uniformity and consistency in NORM regulations in the mid-1980’s and began development of model, or suggested, state regulations. The development of model regulations by CRCPD, with involvement of professionals from federal agencies, international radiation protection agencies, regulated industries, and public interest groups, is a key function of the organization, and is consistent with its goals of working toward uniformity in laws and regulations governing radiation, promoting radiological health, and encouraging cooperation between agencies. The need for a uniform regulatory framework for NORM throughout the country was based on several issues, including:
— Interstate trans-boundary issues due to requests to introduce some of the material, such as coal ash and phosphogypsum into interstate commerce and scrap for release and recycling crossing state lines;
— Waste disposal options consistent with materials under existing regulation such as uranium mill tailings; and
— Variation in exemption levels causing public perception problems and confusion.

The CRCPD set up several committees over the next decade to identify the technical issues and regulatory gaps, provide waste options, and develop model regulations and implementation guidance. The development of a uniform standard has been a complex process in defining the scope of regulated activities, establishing exemption and cleanup criteria, and allowing flexibility in implementation for those states with unique situations involving NORM. Complicating factors of variable risks posed by different types of NORM, depending upon chemical and physical properties, potential exposure pathways, and the mixtures of radionuclides of concern, were important considerations in establishing exemptions from regulatory control.

As a result of the coordinated efforts of state and federal regulatory staff and the involvement of affected industries, such as scrap recycling, petroleum, phosphate fertilizer production, and water treatment, the CRCPD has developed a model regulation that states can use to adopt and implement in individual state radiation control agencies.[3] This will promote better uniformity while providing flexibility to state programs for addressing specific industrial processes unique to their region or in considering other factors involved. Numerous drafts of the regulations have been through peer review by state and federal agencies, and the latest revision was also reviewed by the National Academy of Science. The Board of Directors of CRCPD has approved the suggested state regulations and, pending final concurrence from the federal agencies involved in radiation protection in partnership with CRCPD, the model regulations will be made available for states to use in the development of consistent NORM regulations in state agencies having regulatory authority for NORM.

3. Features of the Model Regulations for NORM

The basic regulatory framework for CRCPD’s suggested state regulations for NORM includes similar sections as those for other radioactive material regulation and licensing standards. The rules contain prospective, remedial and operational aspects for TENORM. The model regulations contain several areas where flexibility is given to states for implementation based on local issues and risk evaluations. [4] The sections and the unique features addressed by the model standards as they apply to NORM are as follows.

3.1. Scope

This regulation is limited to only TENORM, that is naturally occurring radioactive material whose radionuclide concentrations are increased by or as a result of past or present human practices, and does not include background radiation, natural radioactivity of rocks and soils, or that radioactive material defined as source, special nuclear, or byproduct material under the U.S. Atomic Energy Act. In addition to addressing the routine possession, use and disposal of TENORM, the scope also notes the applicability of the rules to situations in which TENORM is introduced into products without adding any beneficial effect and/or the manufacture or distribution of products containing similar material.

3.2. Definitions

This section includes definitions of terms unique to NORM, such as “TENORM” as described above, “residual radioactivity” as it applies to NORM, and “consumer or retail product.” The definitions are meant to clarify the meaning of the model regulations.
3.3. Exemptions

The exemption is, for the most part, dose based in relying upon an agency’s determination that a specific material that the reasonably maximally exposed individual will not receive a public dose with a total effective dose equivalent (TEDE) of more than 1 mSv. However, some of the exemptions also rely upon years of experience in dealing with uranium mill tailings and their associated risks. The exemptions of specific materials, such as zircon and zirconia, and specific activities, such as application of water treatment plant sludge containing radium concentrations below 370 bq/kg to farmland are provided as optional language. The purposeful dilution of TENORM in order to exempt it from regulatory control is prohibited without specific agency approval.

3.4. Basic Radiation Protection Standards

The standards for occupational exposure, 0.05 Sv annual TEDE, and exposure limits to the public, 1 mSv annual TEDE are equivalent to those applied to other uses of radioactive material and are consistent with those established by NRC. These limits do not include doses from indoor radon and short half-life progeny.

Both dose-based criteria of 0.25 mSv annual TEDE to the average member of the critical group near a facility and radium concentration limits in soil of 185 bq/kg above background in any 15 cm layer. These are consistent with decommissioning criteria for other types of facilities involving radioactive material. Equipment or facilities meeting agency-established screening levels may also be released for unrestricted release. Provisions for conditional release of metal for recycle are unique to the NORM rules.

3.5. Licensing Provisions

The model regulations establish a system of both general and specific licensing. The purpose of the general license provision is to apply basic requirements to activities that involve concentrations above those exempted, but do not involve activities for which a specific license and a complex application process is warranted. Regulations under the general license include provision for basic radiation protection standards and waste disposal. Certain other activities involving TENORM tend to pose a greater radiation hazard than those provided for under the general license. These activities, including manufacture and distribution of consumer products, decontamination operations and disposal of wastes from other persons, require submission and agency approval of a specific license for their conduct. Manufactured consumer products must meet established safety criteria for distribution to exempt consumers. Other basic radiation protection and waste disposal standards apply, as well as financial security arrangements for decommissioning.

3.6. Disposal Options

All persons under general or specific licensure are provided several options under which to manage non-exempt TENORM waste. The options include:
— transfer for storage or disposal at a specifically-licensed facility authorized to take such waste;
— transfer to a permitted solid or hazardous waste disposal facility, if such NORM is not prohibited by permit or law from receiving the material;
— disposal by injection wells permitted under federal or state regulations; and
— limited disposal by land application or other alternate methods permitted by the agency.

3.7. Implementation Guidance

In conjunction with the model regulations, the CRCPD is developing implementation guidance that will provide tools for using the dose-based standards. The guidance document contains environmental exposure pathways and scenarios, suggested computer assessment programs, and
appropriate instrumentation and methodology for conducting, documenting and analysing radiation measurements. This document follows the model regulations and simplifies methods for assuring compliance.

4. Conclusion

In addressing the need for uniform standards for NORM in the United States, The CRCPD has developed a set of model regulations and implementation guidance that are both consistent and flexible. Since NORM is not regulated at the federal level, it is even more important that state radiation control programs work cooperatively to address the unique regulatory issues regarding NORM throughout the country.

REFERENCES