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Issues Related to Setting Exemption

Levels for Oil and Gas NORM*

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ABSTRACT

In the absence of any federal regulations that specifically address the handling and disposal of wastes containing naturally occurring radioactive material (NORM), individual states have taken responsibility for developing their own regulatory programs for NORM. A key issue in developing NORM rules is defining exemption levels – specific levels or concentrations that determine which waste materials are subject to controlled management. In general, states have drawn upon existing standards and guidelines for similar waste types in establishing exemption levels for NORM. Simply adopting these standards may not be appropriate for oil and gas NORM for several reasons. The Interstate Oil and Gas Compact Commission's NORM Subcommittee has summarized the issues involved in setting exemption levels in a report titled *Naturally Occurring Radioactive Materials (NORM): Issues from the Oil and Gas Point of View*. The committee has also recommended a set of exemption levels for controlled practices and for remediation activities on the basis of the issues discussed.

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INTRODUCTION

The Interstate Oil and Gas Compact Commission (IOGCC) recognizes that the regulation of petroleum industry wastes containing naturally occurring radioactive material (NORM) has created additional expenses for oil and gas production and processing operations. The IOGCC's Environmental and Safety Committee created a NORM Subcommittee to evaluate issues facing the petroleum industry and its regulators with respect to NORM. One objective shared by the industry and regulators is the development of NORM regulations that adequately protect human health and the environment while minimizing the associated economic burden on the industry.

To assist state agencies that regulate oil and gas operations, the IOGCC's NORM Subcommittee has developed a set of discussion papers that address many aspects of NORM regulations, from defining appropriate exemption levels to identifying safe disposal or recycle options. (1) One of these discussion papers focuses on developing exemption levels for oil and gas NORM. That paper is presented here in its entirety.

BACKGROUND

Exemption levels are specific levels or concentrations of NORM that determine which waste materials are subject to controlled management. In the absence of any federal regulation of NORM, many states have promulgated their own NORM regulations. To date, a total of six major oil and gas producing states have regulations or guidelines in place that provide NORM exemption levels for release of land and equipment for unrestricted use. (2) Exemption levels are provided as exposure levels (in units of $\mu\text{R/h}$); radionuclide activity concentrations (in units of pCi/g); surface contamination levels (in units of disintegrations per minute/ 100 cm^2); and radon flux (in units of $\text{pCi/m}^2\text{-s}$). Release criteria and exemption levels from existing NORM regulations and guidelines are summarized in Table 1.

In general, states have drawn from existing standards and guidelines for similar waste types in establishing release criteria and exemption levels for NORM. Several states have adopted an activity level of 5 pCi/g radium in the top 15 cm of soil as the exemption level for unrestricted release of land. A level of 15 pCi/g has also been adopted by most states as a standard for subsurface soil (i.e., soil at a depth greater than 15 cm). These same levels initially were promulgated by the U.S. Environmental Protection Agency (EPA) for disposal and cleanup of uranium and thorium mill tailing sites (Title 40, Code of Federal Regulations, Part 192 [40 CFR 192]). The criterion of 5 pCi/g for surface soil is a health-based standard that was established to limit exposure to gamma radiation. The subsurface criterion of 15 pCi/g was derived on the basis of the cost and feasibility of detecting discrete caches of high-activity material. Several states have established dual exemption levels for release of land dependent upon radon flux rates. Typically, the standard is 5 pCi/g of radium if the radon flux is $20\text{ pCi/m}^2\text{-s}$ or higher and 30 pCi/g if the radon flux is below this level. This level was based on the standard for radon established by the National Emission Standards for Hazardous Air Pollutants (contained in 40 CFR 192 and 40 CFR 61), a set of standards promulgated pursuant to the Clean Air Act and its amendments. Characterization of NORM waste (e.g., scale) generated by the oil and gas industry has indicated that the radon emanation

fraction is on the order of a factor of 10 lower than the emanation rate from typical soil or mill tailings and would typically be well below the 20 pCi/m²/s limit. (3) As a result, in states that have established the dual exemption levels, the 30 pCi/g standard would be applied at almost all sites affected by petroleum industry NORM.

With respect to exemption levels for loose wastes containing NORM (e.g., scale, sludge, and soil), states have established exemption levels ranging from 5 to 30 pCi/g of radium. In about half of the states, the standard is either 5 pCi/g or 30 pCi/g, depending upon the radon flux rate; in one state, the standard is 30 pCi/g, and in the remaining states, the standard is 5 pCi/g. With respect to exemption levels for equipment with NORM residue, most states have established a screening level based on external exposure levels. Typically this level is 50 μ R/h including background; in one state (Mississippi) the standard is 25 μ R/h above background. A few states have established an exemption level for contaminated equipment on the basis of surface activity levels. These levels vary from state to state, but are similar to guidelines provided in Nuclear Regulatory Commission Guideline 1.86 (4) and U.S. Department of Energy Order 5400.5. (5) For these states, equipment is exempt only if a swipe sample is less than the designated count rate collected from a 100-cm² area (i.e., dpm/100 cm²).

In April 1999, the Conference of Radiation Control Program Directors (CRCPD) released their final report, *Part N, Regulation and Licensing of Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM)*. (6) Exemption levels for any combination of Ra-226 and Ra-228 are set at 5 pCi/g on the basis of experience with hazards associated with uranium mill tailings. Further, the CRCPD does not consider it appropriate to perform purposeful dilution in order to meet the exemption limit. The NORM Subcommittee, on the other hand, believes that in some cases dilution is both the least expensive and the safest way to obtain concentrations below exemption limits.

ISSUES

Exemption Levels for NORM-Contaminated Equipment

In most of the states, an upper gamma exposure rate of 50 μ R/h, including background, is designated for release of contaminated pipe and equipment. In addition, surface activity levels for release of contaminated equipment and property have been put in place by some states, but the IOGCC believes that they are not necessary because gamma exposure criteria are sufficient for the oil and gas industry's releases. Surface activity levels are difficult and expensive to determine, provide little information regarding the potential for human exposure, and may be in conflict with the gamma exposure criteria. Additionally, many types of NORM-contaminated material may not be suitable for collection of a 100-cm² swipe sample. Gamma exposure measurements are inexpensive and easy to perform, thereby simplifying the release procedure for pipe and equipment.

Dose Limits and Health Risk

The upper limit for radiation dose to the public is an important consideration in regulating NORM. The National Council on Radiation Protection and Measurements (NCRP) (7) and the International Commission on Radiation Protection (ICRP) (8) recommend an upper limit on exposure to members of the public from man-made radiation sources of 1 millisievert (1 mSv) (100 millirem [100 mrem])/year. This upper limit is designed to restrict exposure of members of the public to reasonable levels of risk, comparable with risks associated with other common sources. Both the NCRP and ICRP advocate application of the as low as reasonably achievable (ALARA) philosophy. By applying ALARA, this upper limit should never be reached; expected doses would be much less than the limit.

The CRCPD Part N report states (Section N.5) that operations with and use or transfer of TENORM should be conducted in a manner such that a member of the public will not receive an annual total effective dose in excess of 1 mSv/yr from all licensed sources, including TENORM. (6) The calculated dose should not include doses from indoor radon. Release of TENORM for unrestricted use is also limited to a dose limit of 1 mSv/yr (or some fraction of), excluding natural background.

The NCRP has recommended remedial action levels for intervention at previously contaminated NORM sites. In Section 16 of Report 116, the NCRP stated that for exposures from natural radiation sources, "It is recommended that remedial action be undertaken when continuous exposures from natural sources, excluding radon, are expected to exceed five times the average background, or 5 mSv (500 millirem)/year. Remedial action for radon should be undertaken when the total exposure to radon decay products for an individual exceeds an annual average of 2 working level months (WLM)." (8) The NCRP also cautions "Actions to reduce exposure should not be limited by or to the remedial action level and, following the ALARA principle, levels substantially below the remedial action level may be obtainable and appropriate."

The ICRP states that the dose limit, 1 mSv/y (100 mrem/yr), does not apply in the case of intervention (i.e., remedial measures). (8) Furthermore, the ICRP states "The need for and the extent of remedial action has to be judged by comparing the benefit to the reduction in dose with the detriment of the remedial work, including that due to the doses incurred in the remedial work." On the basis of these statements, the NORM Subcommittee recommends that NORM regulations have different standards for controlled practices and remedial activities.

Estimation of health risk from radiation doses is a controversial issue. The widely accepted model used to quantify risk from radiation exposure is the linear-no-threshold model. The underlying assumption of this model is that any radiation dose, regardless of the magnitude, will result in some adverse human health effect. The extent of health impact is linear with increasing dose, and no threshold dose exists below which health effects do not occur. However, this assumption is not supported by the available data, which indicate that health effects have only been observed in humans at doses above 10 rem delivered at high dose rates. In January 1996, the Health Physics Society issued a position statement entitled "Radiation Risk in Perspective." (9) The society states that there is substantial scientific evidence that the linear-no-threshold model is an oversimplification of the dose-response relationship and results in misrepresentation of

the health risks in the low dose range. Below 10 rem, health effects are either too small to be observed or are nonexistent.

ASSESSMENT STUDIES

Several dose assessment studies have been conducted to evaluate the potential human health impacts from handling and disposing of petroleum industry NORM. A list of relevant studies is provided in Table 2. The extent of health impacts from exposure to NORM-contaminated materials depends on several factors, including final disposition of the waste, applicable routes of exposure, and exposure time. Higher potential doses have been estimated for disposal options that provide only a small degree of isolation of the NORM (e.g., landspreading). Using information from available assessments, one could conclude that an exemption level of 10 pCi/g would be conservative (i.e., protective of the maximum exposed individual under the most restrictive end use scenario) with respect to the 100 mrem/yr dose limit. Similarly, a level of 30 pCi/g would be adequately protective with respect to the 500 mrem/yr dose limit and the limit of 2 WLM for radon exposures. These estimates are focused on protecting the hypothetical "maximally exposed individual," the concept of which may, in many cases, not be realistic. For many foreseeable future scenarios, higher activity concentrations would still result in negligible impacts to human health. In many of the scenarios analyzed in the studies conducted to date, a level of 15 pCi/g would be protective.

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this issue paper is to provide state regulators with an overview of relevant information so they can make appropriate, informed management decisions regarding regulation of NORM. The NORM Subcommittee believes that management of NORM wastes should be based on the recommendations of the NCRP. The cost of over-regulation would place a tremendous burden on the industry, in particular on small producers. Most small producers in the industry already are operating on a tight budget, and many would not be able to bear the costs of regulating at the levels mandated for other industries.

On the basis of the issues discussed herein and NCRP Report 116, the NORM Subcommittee believes that establishment of different standards for controlled (or licensed) practices and for remediation activities is warranted. For controlled, licensed practices, a screening level for release of contaminated pipe and equipment is appropriate. A screening level of 50 μ R/h is consistent with the standard set by several major oil and gas producing states. This level is readily determinable in the field.

For loose waste materials (e.g., scale and sludge) involved in controlled practices, an exemption level of 15 pCi/g is reasonable. NORM waste generated by the oil and gas industry has been shown to have a much lower radon flux rate than waste generated by the uranium milling industry. Higher activity limits can be justified on a case-by-case basis, particularly when it can be demonstrated that the wastes will be managed in a manner that provides a high degree of isolation from humans and the environment.

For remedial activities, the NORM Subcommittee recommends an exemption limit of 30 pCi/g. Lower levels may be justified for some sites, and the need for remediation must be determined on a case-by-case basis. Consistent with the ALARA philosophy, the need for remediation should be justified on the basis of net benefit gained from the action as compared with the detriment incurred by the remedial action.

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Table 1. Summary of Existing Oil and Gas Producing States' NORM Regulations and Guidelines

State	Exemption Levels/ Release Criteria
Arkansas	
Equipment Property	<p>≤50 μR/h including background at any accessible point; and surface contamination below the following limits (dpm/100 cm²):</p> <p>For U-nat., U-235, U-238, and associated products (including Po-210) except Ra-226, Th-230, Ac-227, and Pa-231: average of 5,000; maximum of 15,000; and removable of 1,000</p> <p>For Ra-226, Ra-228, Th-230, Th-228, Pa-231, and Ac-227: average of 100; maximum of 300; and removable of 20</p> <p>For beta-gamma emitters: average of 5,000; maximum of 15,000; removable of 1,000</p>
Soil Material	<p><5 pCi/g Ra-226 and/or Ra-228, and</p> <p><150 pCi/g of any other NORM radionuclide</p>
Unrestricted Transfer of Land	<p>≤5 pCi/g Ra-226 or Ra-228 above background averaged over the first 15 cm of soil below surface, averaged over 100 m², and</p> <p>≤15 pCi/g averaged over subsequent 15 cm soil intervals</p>
Louisiana	
Equipment Property	≤50 μR/h at any accessible point
Soil Material	<p>≤5 pCi/g Ra-226 or Ra-228 above background, and</p> <p>≤150 pCi/g of any other NORM radionuclide</p>
Unrestricted Transfer of Land	<p>≤5 pCi/g Ra-226 or Ra-228 above background averaged over the first 15 cm of soil below surface, averaged over 100 m², and</p> <p><15 pCi/g averaged over subsequent 15 cm soil intervals; or</p> <p>≤30 pCi/g of Ra-226 or Ra-228 averaged over 15 cm depth increments, provided the total effective dose to individual members of the public does not exceed 100 mrem/yr</p>
Michigan (Guidelines)	
Equipment Property	<p>≤10 μR/h above background; and surface contamination below the following limits (dpm/100 cm²):</p> <p>For alpha radiation: average of 100; maximum of 300; and removable of 20</p> <p>For beta-gamma radiation: average of 5,000; maximum of 15,000; removable of 1,000</p>
Soil Material	≤5 pCi/g Ra-226 above background
Unrestricted Transfer of Land	<p>≤5 pCi/g Ra-226 above background averaged over the top 15 cm soil layer, averaged over 100 m², and ≤15 pCi/g averaged over succeeding 15 cm thick soil layers</p>

Table 1. Continued

State	Exemption Levels/ Release Criteria
Mississippi	
Equipment Property	<p>≤ 25 $\mu\text{R/h}$ above background at any accessible point; and surface contamination below the following limits ($\text{dpm}/100\text{ cm}^2$):</p> <p>For U-nat., U-235, U-238, and associated products (including Po-210) except Ra-226, Th-230, Ac-227, and Pa-231: average of 5,000; maximum of 15,000; and removable of 1,000</p> <p>For Ra-226, Ra-228, Th-230, Th-228, Pa-231, and Ac-227: average of 100; maximum of 300; and removable of 20</p> <p>For Beta-gamma emitters: average of 5,000; maximum of 15,000; removable of 1,000</p>
Soil Material	<p>< 5 pCi/g Ra-226 or Ra-228 above background, or < 30 pCi/g, averaged over any 100 m^2, provided the radon emanation rate is ≤ 20 $\text{pCi/m}^2/\text{s}$; and</p> <p>≤ 150 pCi/g of any other NORM radionuclide</p>
Unrestricted Transfer of Land	<p>≤ 30 pCi/g Ra-226 or Ra-228 averaged over a maximum depth of 15 cm of soil below the surface, averaged over 100 m^2, provided the radon emanation rate is < 20 $\text{pCi/m}^2/\text{s}$; or</p> <p>If the radon emanation rate is ≥ 20 $\text{pCi/m}^2/\text{s}$, ≤ 5 pCi/g Ra-226 or Ra-228 averaged over the first 15 cm of soil below the surface and ≤ 15 pCi/g averaged over subsequent 15 cm soil intervals, averaged over 100 m^2</p>
New Mexico	
Equipment Property	≤ 50 $\mu\text{R/h}$ including background; and removable surface contamination must be $\leq 1,000$ $\text{dpm}/100\text{ cm}^2$
Soil Material	<p>≤ 30 pCi/g Ra-226 above background, and</p> <p>≤ 150 pCi/g of any other NORM radionuclide above background</p>
Unrestricted Transfer of Land	≤ 30 pCi/g Ra-226 above background in soil in 15 cm layers, averaged over 100 m^2
Texas	
Equipment Property	≤ 50 $\mu\text{R/h}$ including background at any accessible point; and surface contamination below the following limits ($\text{dpm}/100\text{ cm}^2$): average of 5,000, maximum of 15,000, and removable of 1,000
Soil Material	<p>≤ 30 pCi/g Ra-226 or Ra-228, and</p> <p>≤ 150 pCi/g of any other NORM radionuclide</p>
Unrestricted Transfer of Land	≤ 30 pCi/g Ra-226 or Ra-228 averaged over the first 15 cm of soil, averaged over 100 m^2

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