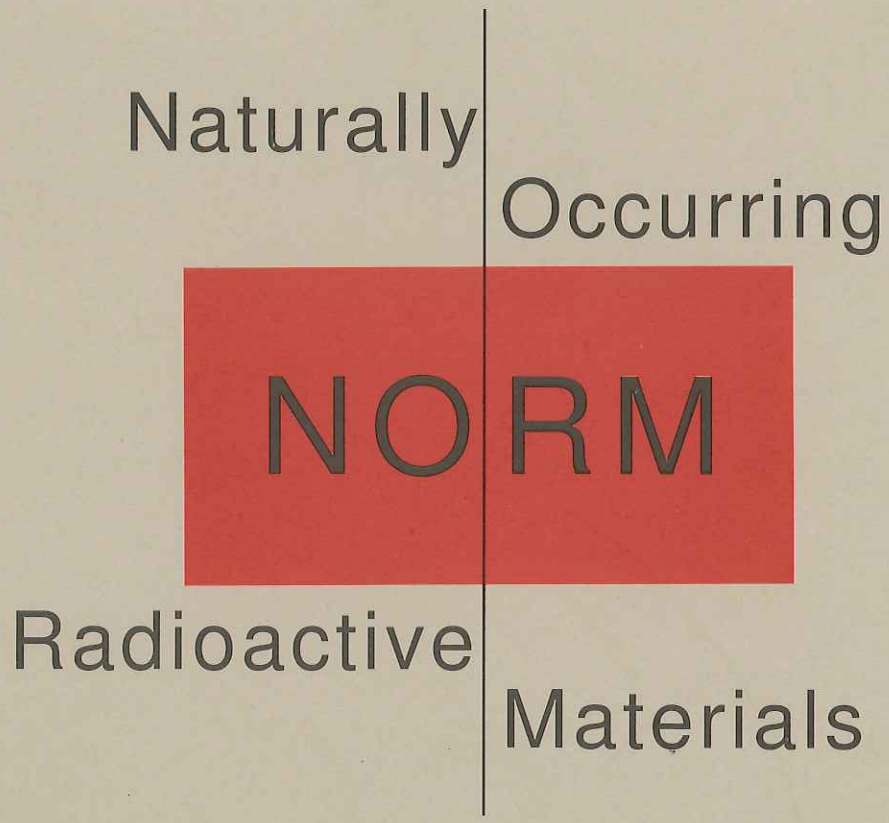

Guidance Document and

Summary of State Regulations for NORM in Oil and Gas

Interstate Oil and Gas Compact Commission

NORM Subcommittee of the Environmental and Safety Committee

TABLE of CONTENTS

Page

PREFACE

This is the final report on the work of a subcommittee of the IOGCC, on NORM oilfield. The industry problem, however, is not really addressed by the report. The report provides thoughtful and feasible solutions; but these solutions are based upon what radiation protection authorities (whomever they are) have institutionalized as an irrational fear that any level of Ionizing radiation is dangerous. Their radiation protection policy is derived from high-dose radiation health effects data (i.e., from Hiroshima and Nagasaki atomic bomb survivors, and from medical therapies). To apply this data to low-dose radiation protection where studies find no adverse health effects, administratively presumes health effects to be linearly proportional to radiation dose down to zero dose. No lower limit is acknowledged below which radiation effects are negligible.

There is no scientific evidence for adverse health effects at the low dose rates experienced in oil field NORM. Most low-dose laboratory and population studies are inadequate to show effects at low levels. However, many show bio-positive or adaptive response at low dose rates.

At present, regulatory levels to manage oil field waste contaminated with NORM costs about $2000 per ton. On occasion it can be significantly higher. This management cost does find its way into the price of gasoline and heating oil. Oilfield NORM is a very minor issue lumped in with all other forms of NORM contaminated waste. It is even less significant when the entire range of ionizing radiation sources are considered. But what is the cost of all these regulated wastes? Using today's standards, each human life hypothetically saved in a Western industrial society by their implementation through protection regulations is estimated to cost about $2.5 billion. The total cost of maintaining these absurdly low and unscientific relationships for radiological doses defies reason. It takes public funds away from other more realistic health risks and desperate public health problems. The cost of immunization against measles, diphtheria, polio and a host of other childhood killers that plague "below the poverty line" children throughout the world would run no more than $100 per vaccination. Are Westerners worth 25 million times as much as a child in Africa, or even a Native American baby on a reservation in New Mexico?

Radiation health effects' research on low doses has been constrained by radiation science policy, along with scientific knowledge about radiation and human health, and the potential application of radiation in biology, agriculture, and human and non-human health and nutrition. Around the world, radiation medicine and other nuclear applications and benefits are constrained and made uneconomic, and caused preventable adverse health effects, while imposing enormous public costs for "radiation protection" that provide no health benefits. Data exists at the doses and populations to establish that no adverse effects exist. New molecular and cellular biology data demonstrate that cellular control of massive natural DNA damage rates contradicts the biological plausibility of the present standards.

We need to push for a practical threshold; one based upon epidemiological data that presently exists and is ignored. The new paradigm must include data from exposure in medical procedures, the nuclear industry, the data from Three-mile Island, Chernobyl, military exposed during atmospheric testing and, yes, even people who live in regions of high natural radiation. Consider the data that demonstrates thresholds and does not use the irrational extrapolation downward from high dose effects. Let us define a practical threshold, below which we would not expect to find detectable radiologenic cancers or genetic effects. Below this practical threshold no regulation would be necessary, and it would most likely eliminate most oilfield NORM.

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INTRODUCTION

It is well known in the oil and gas industry that naturally occurring radioactive materials (NORM) are present in the brines that surface during oil and gas production. NORM is found in scale, sludge, produced water, and production and processing equipment.

The regulations of NORM and its restricted handling and disposal have created additional expenses for production and processing operations. This "cost of regulation" falls the hardest on marginal production and during the close out of production facilities.

The oil and gas industry understands that chronic exposure to significant levels of ionizing radiation from any source can be hazardous to the public; however, for the most part, petroleum industry NORM is not characterized by significant levels of radiation. To mitigate any potential risk, the industry, working with state regulatory agencies, is developing and implementing NORM guidelines and management tools that will meet two goals:

- Protection of the health of the general public
- Minimization of the cost of NORM management.

In support of these goals, the NORM Subcommittee of the Environmental and Safety Committee of the Interstate Oil and Gas Compact Commission (IOGCC) compiled a report complete with reference material. The IOGCC hopes the document will assist states in the development of NORM management criteria.

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I
BACKGROUND

Although the existence of naturally occurring radioactive material (NORM) has been known for quite some time, NORM waste and especially its management is an emerging environmental issue. The methods for treating, processing and disposing of NORM waste are rapidly evolving.[1]

Oilfield NORM is a byproduct of production brines and occurs primarily in the form of radium-226 (Ra-226) with associated levels of radium-228 (Ra-228), which are the daughter products of uranium-238 (U-238) and thorium-232 (Th-232). The radionuclides U-238 and Th-232 are naturally present in many of the subsurface formations containing oil and gas producing reservoirs. Both U-238 and Th-232 are relatively insoluble and remain in place in the subsurface formations. However, their radioactive progeny are slightly soluble in the subsurface and can mobilize in the subsurface liquid environment. Ra-226, polonium-210 (Po-210) and lead-210 (Pb-210) are the principal radionuclides of concern based on their dominant concentrations and relative health concerns.

NORM accumulates in the oil production stream when the dissolved radium (Ra-226 and Ra-228) is carried to the surface in the produced brine water. Formation fluid chemistry determines whether radium dissolution or precipitation occurs. Radium solubility increases in water that has a high saline (total dissolved solids) content and either low or high pH values. Radium is chemically analogous to the alkaline earth element barium and calcium that are typically found dissolved in formation fluids. Chloride and sulfate salts also are typically found in the formation fluids. If conditions are conducive to precipitation, radium will co-precipitate with the alkaline earth elements to form complex sulfates, carbonates and silicates. These precipitates are deposited in oil production equipment in the form of scale, sediment and sludge. Generally, higher water production results in increased NORM deposition.

The primary waste streams of concern are radium bearing scales and sludges, as well as equipment and soils impacted by NORM wastes. Selection of the most appropriate waste management alternatives needs to take into account the physical/chemical characteristics of the impacted materials.

Characterization of Oilfield NORM

A significant amount of data characterizing oilfield NORM is available. Although the concentration of NORM in soil, scale and equipment is site specific, there are common characteristics associated with oilfield NORM.

The primary radionuclides of concern in petroleum industry NORM are Ra-226 and Ra-228. Total radium concentrations (i.e., Ra-226 plus Ra-228) in scales and sludges are quite variable. For scales, radium concentrations can range from undetectable levels to several thousand pCi/g.[2] For sludges, they can range from undetectable levels to several hundred pCi/g.[2] For both waste streams, extremely high concentrations (on the order of several hundreds of thousands of pCi/g) have been reported; however, such values do not appear to be statistically representative of petroleum industry NORM. [3,4]

Radium (Ra-226 and Ra-228), especially in the chemical form $Ra/BaSO_4$, present in oilfield NORM, is extremely insoluble. The EPA Toxicity Characteristic Leaching Procedure (TCLP) method has been used to determine the potential for leaching of radionuclides from solid material under simulated worst-case physical and chemical conditions. In real terms, these worst-case physical and chemical conditions could not occur at a NORM-impacted site and, therefore, are overly conservative for determining leaching potential. Nevertheless, results of the TCLP analysis of representative soil and scale samples demonstrate the highly insoluble nature of oilfield NORM.[5,6] Furthermore, these data indicate that default solubility values provided in standard radiation dose assessment codes are not appropriate, because they would tend to grossly overestimate the resulting potential radiation dose from water-dependent pathways.

Lead-210 (Pb-210) and polonium-210 (Po-210) are decay products of Ra-226. In the absence of site-specific data for oil production waste, it should be assumed that they are present at equilibrium concentration with Ra-226. However, in gas operations, Rn-222 is the predominate parent product from which elevated levels of Po-210 and Pb-210 may be present. Pb-210 is a beta emitter and Po-210 is an alpha emitter. Potential inhalation or ingestion of these radionuclides should be considered in any dose assessment or evaluation of waste management alternatives.

Rn-222 is the progeny of Ra-226 and a naturally occurring radioactive gas that is generated within the material matrix. The transport and release of radon from the material into the air is limited by the tightly bound crystalline lattice structure of the scale. Actual measurements of airborne concentrations of radon in NORM-impacted sites have shown that in areas having elevated concentrations of Ra-226, radon

concentrations are often indistinguishable from natural background radon concentrations.[7,8] Additional studies measuring radon emanation rates from NORM-impacted scales, soils, and sediments that were collected from several different sites have found values ranging from 0.02 to 0.22.[9,10] These values are relatively small when compared to the emanation fraction for a typical soil (e.g., 0.25).

Potential Health Impacts from Exposure to NORM

The health risk associated with radiation from NORM is similar to that presented by exposure to any ionizing radiation source. The risk depends upon many factors; among them are the length of exposure, the level of radiation, the general health of the exposed person, and whether exposure is internal or external. Implementation of basic industrial hygiene practices in oil field operations typically will reduce the potential for inadvertent exposure to NORM. In general, the greatest risks associated with petroleum industry NORM are related to potential long-term exposures to members of the general public associated with disposal of these materials. However, numerous studies have indicated that, in most circumstances, these risks, as well as those to workers, are negligible.

In the discussion papers that follow, references are made to specific studies evaluating potential radiological doses and risks associated with petroleum industry NORM. These references summarize the major conclusions of each study, as they are relevant to the discussion and provide a citation so that the reader might obtain a copy of the full report, if necessary. More detailed discussions of each study are beyond the scope of this report. It is strongly advised that in-depth reviews of these studies are warranted to support specific regulatory positions.

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II
EXEMPTION LEVELS OF OIL AND GAS NORM

Background

Exemption levels are specific levels or concentrations 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 which provide exemption levels for release of land and equipment for unrestricted use.[1] Exemption levels are provided as: (1) exposure levels (in units of μR/h); (2) radionuclide activity concentration (in units of pCi/g); (3) surface contamination level (in units of disintegration per minute/ 100 cm^2); and (4) radon flux (in units of $pCi/m^2/s$). A summary of release criteria and exemption levels from existing NORM regulations and guidelines are shown in the attached Table.

In general, states have drawn upon existing standards and guidelines for similar waste-types in establishing release criteria and exemption levels for NORM. Several states have adopted a 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 for disposal and cleanup of uranium and thorium mill tailing sites in 40 CFR 192. The criterion of 5 pCi/g for surface soil is a health-based standard, established to limit exposure to gamma radiation. The subsurface criterion of 15 pCi/g was derived on the basis of 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 $pCi/m^2/s$ or higher and 30 pCi/g if the radon flux is below this level. This standard 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 ten lower than the emanation rate from typical soil or mill tailings and would typically be well below the 20 $pCi/m^2/s$ limit.[2] As a result, in states that have established the dual exemption levels, the 30 pCi/g standard would be applied at almost all sites impacted by petroleum industry NORM.

With respect to exemption levels for loose wastes impacted by NORM (e.g., scale, sludge, and soil), states have established 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 two states, the standard is 30 pCi/g, and in the remaining states, the standard is 5 pCi/g. With respect to exemption levels for NORM-impacted equipment, most states have established a screening level based on external exposure levels. Typically this level is 50 μR/h including background; in one state (Mississippi) the standard is 25 μR/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[3] and U.S. Department of Energy Order 5400.5.[4] For these states, equipment is exempt only if a swipe sample is less than the designated count rate collected from a 100-cm^2 area (i.e., dpm/100 cm^2).

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)".[5] 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 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-Impacted Equipment

In most of the states, an upper gamma exposure rate of 50 μR/h, including background is designated for release of contaminated pipe and equipment. Surface

activity levels for release of contaminated equipment and property have been put in place by some states, but the NORM Subcommittee 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-cm^2 swipe sample. Gamma exposure measurements are inexpensive and easy to perform, thereby simplifying the release procedure for pipe and equipment.

Exposure 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)[6] and the International Conference on Radiation Protection (ICRP) [7] recommend an upper limit on exposure to members of the public from man-made radiation sources of 1 millisievert (100 millirem)/year. This limit is an upper limit, designed to limit 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 limit should never be exceeded; expected doses would be much less than the limit.

The CRCPD Part N report states in Section N.5 that operations, use, or transfer of TENORM should be conducted in a manner such that a member of the public will not receive in excess of an annual total effective dose of 1 mSv/yr from all licensed sources, including TENORM. 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)."[6] 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).[7] 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 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 below which health effects are observed exists. However, this assumption is not supported by the available data collected which has shown 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."[8] 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 oversimplification of the health risks in the low dose range. Below 10 rem, health effects are either too small to be observed or are non-existent.

Assessment Studies

Several dose assessment studies have been conducted to evaluate the potential human health impacts from handling and disposal of petroleum industry NORM. A list of relevant studies is provided in the attached List of Relevant Risk Assessment Studies. The extent of health impacts from exposure to NORM-contaminated materials is

dependent 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 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 based on protecting the maximally exposed individual who in many cases may 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 in order for them to make appropriate management decisions for NORM. The subcommittee believes that management of NORM wastes should be based on the recommendations of the NCRP. The cost of over-regulation would bear a tremendous burden on the industry, in-particular, small producers. Small producers in the industry are operating on a tight budget and many would not be able to absorb the costs of regulating at the levels mandated for other industries.

On the basis of the issues discussed herein and NCRP Report 116, the 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 μR/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 from 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 remediation 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 to the detriment incurred by the remedial action.

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

State	Exemption Levels/ Release Criteria
Arkansas	**Equipment/Property:** ≤50 µR/h including background at any accessible point; and surface contamination below the following limits (dpm/100 cm^2): for U-nat., U-235, U-238, and associated products (including Po-210) except Ra-226, Th-230, Ac-277, and Pa-231: average of 5,000; maximum of 15,000; and removable of 1,000. for Ra-226, Ra-228, Th-230, Th-228, Pa-231, and Ac-227: average of 100; maximum of 300; and removable of 20. for beta-gamma emitters: average of 5,000; maximum of 15,000; removable of 1,000. **Soil/Material:** <5 pCi/g Ra-226 and/or Ra-228, and <150 pCi/g of any other NORM radionuclide. **Unrestricted Transfer of Land:** ≤5 pCi/g Ra-226 or Ra-228 above background averaged over the first 15 cm of soil below surface, averaged over 100 m^2, and ≤15 pCi/g averaged over subsequent 15 cm soil intervals.
Louisiana	**Equipment/Property:** ≤50 µR/h at any accessible point. **Soil/Material:** ≤5 pCi/g Ra-226 or Ra-228 above background, and ≤150 pCi/g of any other NORM radionuclide. **Unrestricted Transfer of Land:** ≤5 pCi/g Ra-226 or Ra-228 above background averaged over the first 15 cm of soil below surface, averaged over 100 m^2, and <15 pCi/g averaged over subsequent 15 cm soil intervals; or ≤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.
Michigan (Guidelines)	**Equipment/Property:** ≤10 µR/h above background; and surface contamination below the following limits (dpm/100 cm^2): for alpha radiation: average of 100; maximum of 300; and removable of 20. for beta-gamma radiation: average of 5,000; maximum of 15,000; removable of 1,000. **Soil/Material:** ≤5 pCi/g Ra-226 above background **Unrestricted Transfer of Land:** ≤5 pCi/g Ra-226 above background averaged over the top 15 cm soil layer, averaged over 100 m^2, and ≤15 pCi/g averaged over succeeding 15 cm thick soil layers.

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

State	Exemption Levels/ Release Criteria
Mississippi	**Equipment/Property:** ≤25 µR/h above background at any accessible point; and ≤2000 dpm/100cm2 from accessible internal and external surfaces. **Soil/Material:** ≤50 microR/hr above background. **Unrestricted Transfer of Land:** ≤50 microR/hr above background at any discrete point; and ≤200 microR/hr including background at every 0.15 meter interval in five boreholes per acre or at least 3 boreholes per site location, one meter deep.
New Mexico	**Equipment/Property:** ≤50 µR/h including background; and removable surface contamination must be ≤1,000 dpm/100 cm^2. **Soil/Material:** ≤30 pCi/g Ra-226 above background, and ≤150 pCi/g of any other NORM radionuclide above background. **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 µR/h including background at any accessible point; and surface contamination below the following limits (dpm/100 cm^2): average of 5,000, maximum of 15,000, and removable of 1,000. **Soil/Material:** ≤30 pCi/g Ra-226 or Ra-228, and ≤150 pCi/g of any other NORM radionuclide. **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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III

DISPOSAL OF NORM BY UNDERGROUND INJECTION

Background

Disposal of exploration and production (E&P) waste liquids, such as produced water and used drilling fluids, by injection into strata that are isolated from underground sources of drinking water, is a common practice. These wells are regulated as Class II wells under the Underground Injection Control (UIC) program of the federal Safe Drinking Water Act. Underground Injection Control regulations do not preclude the injection of oil and gas wastes that contain NORM. Since NORM is known to be a component of produced water, injection has always included NORM as a component of E&P waste.

Oil and gas waste disposal wells are either converted production wells that have been recompleted in a formation that does not contain oil or gas or are drilled and completed specifically for disposal. Wells that inject E&P liquids are operated at pressures below the fracture pressure of the formation and force liquids into the formation matrix. Although NORM wastes are typically solids and occur as scale, sand, silt, sludge and contaminated soil, solids can be crushed, ground and otherwise processed and treated and then entrained with liquid wastes to an injectable slurry that will not plug the formation.

To inject NORM wastes that contain a relatively high concentration of solids, wells must be operated at pressures that cause the formation to fracture. Depending on the depth and geology, fractures can be horizontal or vertical. "Fracture injection" to dispose of wastes is not common and is not authorized by many regulatory agencies. Adverse environmental impact is a concern should the waste not be confined to the disposal interval. However, studies have shown that fracture azimuth and length can be predicted and monitored to ensure waste containment,[1] and that repeated injections could be carried out that allows the injection of large volumes of waste.[2]

Although disposal wells are numerous in all oil and gas producing states, few states have allowed disposal by injection of E&P NORM waste.[3] For example, Texas, which had 8,099 active disposal wells as of December 1998, has permitted only seven wells for the disposal of NORM wastes since 1995. Additionally, Louisiana has permitted only one disposal well for E&P NORM waste disposal, and the well is reserved for noncommercial purpose only.[4]

NORM disposal by injection has the potential to dispose of more than 100,000 barrels of waste in a single well, depending on the geologic characteristics of the

formation. When a well is abandoned, it may be plugged under the standards for disposal wells with no special requirements necessary as a result of NORM injection.

According to one study, the cost to dispose of E&P NORM waste varied greatly.[5] The cost of NORM injection is increased significantly above the cost of other E&P wastes due to treatment and processing, handling and decontaminating containers, and laboratory analyses. Nevertheless, the report indicates that NORM injection is cost competitive with other NORM disposal alternatives.

Issues

Public Notice

The disposal of E&P wastes by injection requires notice under the Underground Injection Control regulations. The actual notice requirements vary from state to state due to the flexibility allowed for state-delegated programs for Class II (oil and gas related) injection wells. Because NORM-impacted material is a component of E&P wastes, it could be problematic whether or not notice should be specifically required for E&P NORM waste because of public concerns regarding radioactive materials.

Nevertheless, the injection of NORM wastes, particularly at commercial disposal wells, is a continuous activity that includes the handling and management of large volumes of NORM waste. In fact, two large commercial NORM injection facilities have operated for years without incident nor have their operations generated significant public concern. Notice requirements, if any, should be consistent with existing state law.

Fracture Injection

Disposal at pressures that cause formation fracturing might be prohibited by some state regulatory programs due to environmental concerns although offshore and pilot projects indicate that controlled fracturing and fracture monitoring is possible. The regulatory posture toward fracture injection is an issue that is still subject to debate and will need to be considered if the disposal technology will be applied to NORM waste.

Risk Associated with the Disposal of NORM by Injection

One report concluded that the estimated doses associated with injection appear to be so low that the risk to the public is negligible.[6] A groundwater flow and contaminant transport model were used to model injection of NORM. Using conservative assumption doses from ingestion of groundwater, that related to injection

well failures at various calculated depths. In the base-case scenario in which the casing failure occurred near the bottom of the aquifer, the model predicted a dose equivalent to 0.01 mrem/yr when the receptor water well was 0.3 km downgradient from the injection well.

In the model, no attempt was made to determine the well types, injection pressures or rates. A volume of 100,000 barrels of NORM with a concentration of 2,000 pCi/L was assumed to have exited the well casing at various depths in geologic layers. Therefore, the model is applicable to both matrix and fracture injection.

A related study of the injection of NORM into salt caverns also concluded that this disposal option presented negligible risk to the public.[5] Even in the worst-case scenario, in which the cavern roof failed and the NORM was released into a shallow drinking water aquifer, the potential lifetime dose to the receptor was only 1×10^{-8} mrem.

Conclusions

Injection of slurries or solids containing NORM-impacted materials presents a low risk disposal alternative for oilfield wastes that occur as particles or have been treated and processed to injectable size. Injection wells are capable of disposing of large volumes of such waste at costs that are comparable to other disposal alternatives. Regulatory controls are in place through underground injection control programs to accommodate the disposal of E&P NORM wastes into conventional disposal wells. Public notification specific to NORM injection activities should be considered. Review of regulatory requirements for fracture injection and cavern disposal of NORM waste is warranted.

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IV
DISPOSAL OF NORM IN ABANDONED WELLS

Background

An oil or gas field well that is being plugged and abandoned could provide a repository for NORM-contaminated tubulars or other material. NORM-contaminated equipment that is deteriorated to the degree that it is no longer usable has no value as scrap or is not accepted as scrap, or cannot be easily decontaminated, also could be disposed of in an abandoned well if allowed by state regulations. Abandoned wells also could host NORM-contaminated solids such as tank bottoms or contaminated soils. Louisiana, Michigan, Mississippi, New Mexico and Texas have regulations for the encapsulation of NORM in plugged and abandoned wells.[1]

Historically, in response to favorable economic conditions or technical developments, plugged and abandoned oil wells have been reopened and returned to production or recompleted in a different zone in response to a new oil or gas discovery. Abandoned wells that encapsulate NORM negate such opportunities.

A limiting factor is the small capacity of a wellbore. Ordinarily, well production casings are 4 ½ or 5 ½ inches in diameter and can accommodate only a single string of tubing and only a few hundred cubic feet of NORM solids.

The expense of placing NORM into a well during plugging operations substantially raises costs. In part, increased costs are caused by increased rig time. Costs also involve preparing the material for disposal and regulatory compliance. One study found that the cost of NORM disposal by plugging and abandonment tended to be higher than for other options.[1]

The cost might limit this disposal alternative. A survey by the Railroad Commission of Texas in 1996 found that very few requests for NORM plugging and abandonment were received. The Louisiana Office of Conservation also observed a decline in request for NORM plugging and abandonment in the year 1996.

Issues

Type of NORM Material

Although the disposal of NORM by encapsulation in a plugged well is more conducive to the disposal of NORM contaminated tubulars and other small pieces of equipment, the placement of other wastes such as tank bottoms and soils inside

tubulars or mixed with drilling mud and placed between cement plugs is a possibility and is allowed by some states (e.g. Texas).

Public Notice

Disposal of NORM into a plugged well is a one-time, volume-limited operation, which should be weighed when considering public notices. If all of the waste was generated on the same tract where the disposal will occur, then notice might be unnecessary. In any event, notice requirements should be consistent with state law and landowner consent.

Well Identification/Recordation

The encapsulation of NORM in a plugged well is assumed to be permanent; however, the possibility of intrusion and inadvertent exposure must be minimized by institutional controls. These should include red-dyed cement in the surface plug; a three-bladed radiation symbol welded to the top casing plate; notation on the plugging record; and deed recording.

Risk Associated with Placement of NORM in a Plugged and Abandoned Well

A Department of Energy (DOE) study concluded that the estimated doses associated with downhole encapsulation appear to be so low that the risk to the public is negligible.[2] To model the risk related to downhole encapsulation, it was assumed that a casing failure occurred and a 100,000-barrel volume of 2,000 pCi/L radium dissolved instantaneously. It then moved horizontally into a porous formation or vertically along the wellbore. The model, which was also used to estimate the dose risk related to injection, overstates the volume by a factor of 100 for a typical well, assumes the material will be fluid, and is capable of migrating from the wellbore. Even in the worst-case scenario when a casing failure occurred at the same depth as the receptor, a water supply well located 0.3 km downgradient, the equivalent dose concentration to the person who ingested the water was approximately 1 mrem/yr. In realistic scenarios, the risk to the public certainly appears negligible, being several orders of magnitude lower than the worst-case scenario.

Conclusions

Encapsulation of NORM materials in a well that is being plugged and abandoned presents a low risk to the environment, particularly for oilfield tubulars that are no longer usable due to deterioration and have little or no value as scrap metal. To a lesser degree, other small pieces of equipment and very small volumes of sand and sludge can be placed in plugged wells. Volume limitations and cost are limiting factors, along with deed restrictions.

Appropriate regulatory controls for NORM encapsulation could be effected in conjunction with the plugging and abandonment rules of the regulatory agency.

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V
LANDSPREADING

Background

Landspreading is a long-standing method used to dispose of a wide variety of nonhazardous E&P wastes* containing hydrocarbons, including drill cuttings, produced solids, tank bottoms, pit bottoms, waste crude, pipeline scales and sludge, and pigging wastes. In general, landspreading represents one of the least expensive methods for disposing of hydrocarbon-bearing wastes. It also is used frequently for *in situ* remediation of soils contaminated by spilled hydrocarbons

Landspreading is a relatively simple process that depends on the availability of oxygen, water and bacteria naturally present in the soil to break down the hydrocarbon components of a waste stream. Sometimes the practice entails nothing more than spreading the waste over a tract of land using standard earth-moving equipment. Tilling the waste into the soil and adding water and/or fertilizers (e.g., nitrogen-rich manure) will accelerate the biodegradation process.

Most often, landspreading occurs on lease sites at or near the point of waste generation, but wastes also are transported to centralized, noncommercial landspreading or to commercial landspreading facilities. Regulations governing landspreading vary from state to state with respect to permit requirements, application restrictions, siting restrictions and final treatment levels. Often, landowner notification or permission also is required. The intent of these regulations is to limit the potential for environmental contamination and to minimize the impact to the landowner.

Texas and New Mexico allow the landspreading of NORM on-site. In Texas, an application for a commercial landspreading facility can be permitted by the Railroad Commission under specific conditions. In both states, landspreading of NORM-impacted wastes is allowed provided that, after landspreading, the state's respective radium exemption level is met (5 pCi/g radium-226 and radium-228 above background in Texas and 30 pCi/g Ra-226 above background in New Mexico).

In Texas, landspreading of NORM waste is allowed without a permit on the lease site where the waste was generated, provided the resultant radium-226 and radum-228 concentration in the soil is ≤5 pCi/g above background levels [16 TAC 3.94(e)(2)(A)].

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* Nonhazardous E&P wastes include wastes that are exempt from regulation as hazardous waste under the Resource Conservation and Recovery Act (RCRA) and related state statutes and nonexempt wastes that are not listed as hazardous and do not exhibit any hazardous characteristics.

Off-site surface disposal of NORM is allowed in Texas provided the same concentration standards are met and a permit is obtained [16 TAC 3.94(g)].

In New Mexico, in accordance with requirements contained in the NORM regulations promulgated by the Environment Department [Title 20, *New Mexico Administrative Code (NMAC)*, Chapter 3, Part 1, Subpart 14, Section 1407(A)], on-site surface disposal of NORM-contaminated soils is allowed provided a license and a Subpart 13 permit are obtained, and the operator complies with the requirements of Oil Conservation Division (OCD) Rule 711 that govern surface waste management facilities. Under this regulation, licensees may blend or disk NORM-contaminated soil in place, provided the soils at the site were contaminated with NORM prior to promulgation of the regulation (i.e., August 3, 1995) and provided the exemption standard for Ra-226 in soil of 30 pCi/g above background is not exceeded. Under 19 NMAC 15.I.714(c)(1), the NORM disposal rules promulgated by the OCD, disposal is allowed at centralized surface waste management facilities, provided it is disposed of in a manner that is protective of the environment, public health and fresh waters. The OCD further requires that the facility must operate under a Rule 711 permit.

Risk Assessment Results

Potential doses associated with landspreading of NORM-impacted wastes have been assessed for both workers and the public.[1-3] Although these studies use different methodologies and draw different conclusions about specific analyses, they indicate that landspreading presents negligible risk to workers and the public under many circumstances. The two primary factors, which determine the level of potential exposure, are radium concentrations in the soil after landspreading and future use of the land (i.e., whether the property will be used for recreational, agricultural, industrial or residential purposes). Potential exposures do not appear to be of concern for workers or future recreational or agricultural users of the property even when the resultant radium concentrations after landspreading are quite high (i.e., several hundred pCi/g).[3] One study[3] indicated that for future industrial or residential users, potential exposures are variable depending on radium concentration, construction practices (e.g., degree of re-grading or excavation of surface soils), and on-site erosion rates.

Conclusions

Landspreading can be a disposal option if appropriate regulatory controls are established. One risk assessment[3] indicates that for certain circumstances, landspreading of NORM can result in elevated radiation doses to future residential inhabitants. State agencies could consider authorizing on-site landspreading provided the radium concentration after landspreading does not exceed the state's NORM exemption level and land owner permission is obtained. For any off-site NORM landspreading, public notice of a NORM disposal application would be appropriate.

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VI
LANDFILL DISPOSAL

Background

The design and operation of all permitted solid waste landfills are governed by requirements contained in the Resource Conservation and Recovery Act (RCRA). Under RCRA, solid waste includes any discarded, abandoned, recycled or inherently waste-like material. Hazardous wastes include solid wastes that are listed as hazardous by either the EPA or a corresponding state agency and wastes that exhibit any of four hazardous characteristics (i.e., ignitability, corrosivity, reactivity, and toxicity). Nonhazardous wastes are solid wastes that are not listed, do not exhibit a hazardous characteristic or are not otherwise exempted. Radioactivity in solid wastes is not regulated as hazardous under RCRA. Solid waste landfills generally are divided into hazardous and nonhazardous categories referred to as Subtitle C and Subtitle D landfills, respectively, after the classification established in RCRA. Subtitle C of RCRA (in 40 CFR, Part 264) contains requirements for the management and operation of hazardous waste landfills and Subtitle D (in 40 CFR, Parts 257 and 258) contains requirements for the management and operation of nonhazardous waste landfills.

The U.S. Environmental Protection Agency (EPA) established these federal regulations as standards for states to adopt in their solid waste management programs. They address the location, design, construction, operation, monitoring and closure of solid waste landfills. Individual states that have been granted authority to operate Subtitle C or Subtitle D permitting programs may adopt the federal regulations by reference, or they may promulgate their own regulations. State regulations must be at least as stringent as the federal regulations before the EPA will grant permit program approval. Classification schemes for nonhazardous waste landfills vary from state to state and often establish more distinctions between types of landfills than are included in the federal rules.

Regulations Governing Disposal of NORM in Landfills

Under existing state regulations, provisions for disposing of NORM-impacted wastes in commercial landfills are limited. Exempt E&P wastes refer those exempted by the EPA and most state agencies from regulation as hazardous.[1] While most states allow the disposal of exempt E&P wastes in commercial landfills, only a few explicitly allow or prohibit the disposal of NORM-impacted wastes in landfills. Michigan has issued guidelines for the disposal of materials containing up to 50 pCi/g of Ra-226,

including petroleum industry NORM, in municipal nonhazardous waste landfills. Most of the wastes going to municipal landfills are from households, although small quantities of other types, including hazardous wastes, also may be disposed of in a municipal landfill. Standards specific to municipal landfills are contained in 40 CFR 258; under federal rules, these standards are more stringent than the standards for other types of nonhazardous landfills. In Louisiana, E&P wastes containing up to 30 pCi/g Ra-226 or Ra-228 may be disposed of in permitted nonhazardous oilfield waste facilities. Other states may allow the disposal of petroleum industry NORM in Subtitle C or D landfills; however, such disposal may require special approval and is likely to be evaluated on a case-by-case basis.

State approval for the disposal of radium-bearing wastes in landfills has some precedent at the federal level. In June 1994, the EPA issued its *Suggested Guidelines for the Disposal of Drinking Water Treatment Wastes Containing Radioactivity.*[2] Although these guidelines are not applicable to petroleum industry NORM wastes, the radionuclides addressed by the guidelines include Ra-226 and Ra-228, and some of the water treatment NORM wastes are similar in generation and concentration levels to the petroleum industry's NORM wastes. As a result, the risk-based disposal guidelines for radium-bearing wastes have some relevance to disposal issues facing the petroleum industry.

Colorado, which does not have a NORM regulatory program, has adopted regulations governing the disposal of drinking water treatment wastes containing NORM. Water treatment sludge containing up to 40 pCi/g total alpha activity may be disposed of at a nonhazardous, solid waste disposal facility, provided there are no free liquids present in the sludge, its pH is $\geq$6, and the landfill meets specific operating and monitoring requirements (6 CCR 1007-2, Section 12). Under Colorado regulations it is possible that other wastes falling below this 40 pCi/g threshold, including petroleum industry NORM, also are disposed of in nonhazardous landfills. No other states appear to have adopted similar regulations.

Under the suggested EPA guidelines, NORM-impacted wastes containing between 3 and 50 pCi/g of total radium could be disposed of in both nonhazardous and hazardous landfills. Specifically, the EPA recommends disposal methods that "...provide reasonable assurance that people will be protected from radon releases from the undisturbed waste and that the waste will be isolated to reduce the risk of disturbance or misuse." The EPA further recommends that construction of a building on a disposal site containing Ra-226 wastes be avoided or, at least, any such buildings should not be used for residential or commercial purposes. Although the guidelines do

not specify the measures needed to achieve these goals, they indicate that the disposal facility should be in compliance with RCRA Parts 257 and 258, (i.e., the regulations governing design, construction, operation and monitoring of nonhazardous landfills) and that requirements for hazardous waste facilities (such as those contained in RCRA Part 264) be considered to ensure adequate groundwater protection. For wastes containing between 50 and 2,000 pCi/g of total radium, the EPA recommends that disposal decisions be made on an individual basis. At a minimum, the EPA recommends disposal of these wastes in a RCRA hazardous waste unit. The EPA also recommends that wastes within this concentration range be considered for disposal at a licensed NORM or low-level radioactive waste disposal facility. When the concentration exceeds 2,000 pCi/g of total radium, the EPA recommends disposal in accordance with the provisions of the Atomic Energy Act for source materials.

Risk Assessment Results

Assessments of risks relating to disposal of petroleum industry NORM in Subtitle D landfills (i.e., landfills permitted to receive primarily nonhazardous wastes) have been conducted.[3,4] These studies evaluated potential doses to workers and the public associated with the disposal of solid wastes containing 50 pCi/g of Ra-226. Different assumptions were made regarding the volume of NORM waste being disposed of, the size of the landfill, the placement of the NORM waste within the landfill and landfill design and performance. Both studies conclude that potential doses to workers associated with landfill NORM wastes are negligible. Estimates of doses to residents living near the landfill during the disposal action also are negligible.[4] Similarly, for most future land use scenarios (i.e., residential, industrial, recreational and agricultural), potential doses to the public are well below 100 mrem/year, even when it is assumed that landfill liners and covers are breached. Under a few circumstances, potential doses to the public could be of concern; however, states can control these circumstances to prevent any public exposures. These controls might need to address the total volume of Ra-226 placed in any single landfill and/or cell, the depth of the NORM wastes with respect to the landfill cap and institutional controls protecting the integrity of the landfill cap and liner.

Conclusions

State-level NORM oil and gas regulatory programs should consider the disposal of nonhazardous solid wastes containing up to 50 pCi/g Ra-226 in either nonhazardous or hazardous landfills. In addition, states should consider the landfill disposal of waste streams containing higher concentrations, up to 2,000 pCi/g Ra-226, in hazardous waste landfills. State agencies promulgating NORM rules would need to coordinate the acceptance of these types of disposal with the agency that regulates solid waste disposal.

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VII
DISPOSAL OF NORM BY RE-MELTING

Background

Although NORM-impacted scrap metal generated by the petroleum industry currently is not disposed of by re-melting, this form of recycling could represent a viable disposition option for this waste stream. However, the scrap metal recycling industry faces a myriad of issues making it difficult to accept NORM-impacted materials at its facilities. Until these issues can be resolved, re-melting of the petroleum industry's NORM-impacted scrap metal is unlikely to become a widespread practice.

Scrap metal recycling is an important industry in the United States, providing a significant portion of supply of all types of metal.[1] While domestic steel consumption has declined over the last two decades, the scrap metal share of the iron and steel market has increased.[2] In 1997, scrap metal processors handled about 66 million to 70 million metric tons of scrap iron and steel,[3,4] of which approximately 46% was comprised of obsolete scrap (i.e., worn out, broken and discarded objects).[4] Recycled ferrous scrap made up approximately 72% of the country's raw steel production in 1997,[4] up from around 33% in 1980.[2] The international market for scrap metal recycling also is significant, with industrialized nations exporting scrap metal to developing nations as demand and business conditions dictate. In 1997, the U.S. exported approximately 8.9 million metric tons of ferrous scrap, having an estimated value of about $1.3 billion.[4]

These statistics reflect the fact that iron and steel scrap are vital raw materials for the production of new steel and cast iron products.[4] Recycling of scrap metal has become increasingly significant for several reasons. From an environmental perspective, recycling of scrap metal has become important because re-melting scrap (1) requires much less energy than the production of iron or steel products from iron ore; (2) reduces the burden on landfill disposal facilities; (3) prevents the accumulation of abandoned steel products in the environment; and (4) avoids environmental damage resulting from replacement of the scrap metal through raw material production.[1,4] Because recycling scrap reduces the need to mine and process raw iron ore, health risks associated with mining and refining the metal (i.e., occupational injuries) also would be reduced.[1] From a technological perspective, recycling of scrap metal has become more significant with the proliferation of electric arc furnaces (EAFs), particularly through growth of the "mini-mills" that target specific markets.[5] EAFs use nearly 100% scrap iron and steel for the furnace charge, as opposed to basic oxygen furnaces (BOFs), which use approximately 30% scrap, and open-hearth furnaces, which

use around 50% scrap.[1] In the first half of 1998, EAFs consumed almost 70% of all recycled ferrous scrap,[6] up from only 37% in 1990.[1]

The scrap metal recycling industry generally will not accept any scrap metal that is radioactive. A specialized metal recycling segment of the radioactive waste handling industry does recycle radioactive scrap metal, generated by the U.S. Department of Energy and the nuclear power industry. While thousands of tons of this metal have been recycled within these sectors, very little has been smelted and recycled for public use.[1] These facilities have the capacity to handle a portion of the potential inventory of NORM-impacted scrap generated by a variety of industries, including the petroleum industry.

The reasoning behind the scrap metal recycling industry's reluctance to process radioactive scrap is understandable. In the past, there have been instances in which facilities have been contaminated by inadvertent re-melting of radioactive sources.[4,7,8] Most of these incidents appear to have involved sealed radioactive sources, such as Cs-137 level gauges, Co-60 therapy devices, and radium devices. Losses resulting from decontamination, waste disposal and lower profits reportedly have ranged from $7 million to $23 million per incident. To protect themselves from such losses, most metal recyclers have installed radiation detection systems to screen radioactive scrap. Usually, shipments found to contain radioactive material at any level are rejected and returned to the supplier. If possible, when a sealed source is involved, it is confiscated.

None of these documented incidents of facility contamination has involved scrap metal containing NORM; nonetheless, NORM-impacted scrap frequently is rejected by radiation detection systems and returned to the supplier.[7,8] According to estimates by the American Petroleum Industry (API), approximately 600,000 tons of NORM-impacted scrap are generated annually by the oil and gas industry, 75% of which would be rejected by the scrap recycling industry based on the use of radiation detection systems.[9,10] Prior to the installation of these systems in the late 1980s, NORM-impacted scrap was routinely processed by the metal recycling industry.

Radiological Risk Associated with Re-Melting NORM-Impacted Scrap

Several studies[11,12] have indicated that re-melting of equipment containing radium-bearing materials presents minimal risk to the public, and that risk to workers can be controlled. Bench-scale tests funded by the Petroleum Environmental Research Forum (PERF)[11] indicated that during the re-melting process, approximately 98% of the Ra-226, Ra-228 and Th-228 was recovered in the slag generated during re-melting. The

partitioning of Ra-226 to the offgas was calculated to be 0.0004%. Partitioning of Pb-210 and Po-210 were inconclusive.

On the basis of these measurements, estimated potential radiological doses to the public from airborne emissions, exposure to recycled metal or exposure to recycled slag are negligible.[12] Potential radiological doses to workers involved in the transportation, loading and unloading, re-melting and fabrication of the NORM-impacted scrap and resultant metal also are negligible if the NORM level of the feed is controlled.[12]

Recycling Industry Concerns

While re-melting of NORM-impacted scrap is technically feasible and presents little risk to human health and safety, there are several issues that must be addressed before metal recyclers will accept NORM-impacted scrap on a widespread basis. These issues are tied to either regulatory or economic constraints, or both. For the most part, economic constraints have not been quantified; however, the recycling industry can predict some degree of cost impact.

There are five primary areas of concern.[13] One relates to segregation of the inbound feed material. Using the fixed load detectors currently installed at most facilities, it is not possible to identify specific types of radioactive contamination (i.e., a Cs-137 sealed source versus Ra-226 in pipe scale). Portable multi-channel analyzers could be used to identify specific radionuclides; however, recyclers would not be able to distinguish between discrete NORM (e.g., Ra-226 sealed source) and diffuse NORM (e.g., Ra-226 in pipe scale) without taking numerous individual measurements from each shipment that trip the detector's alarm. These limitations might make it difficult for the industry to cost-effectively segregate out larger sources of radiation from scrap containing NORM.

A second concern is that in order to process radioactive materials, a recycling facility might be required to obtain a license under Nuclear Regulatory Commission (NRC) and state regulations, unless specific exemptions were granted. These licenses would require extensive radiation safety programs to ensure that feed streams and discharge effluents are within established regulatory limits. The expenses associated with obtaining a license and implementing the required radiation safety programs might be prohibitive for the scrap recycling industry. For the most part, regulators have made no exceptions to these requirements for facilities that would process NORM-impacted scrap, even though the generators of the NORM-impacted scrap are not subject to such

regulation. In Texas, a few mills have received regulatory approval to melt small quantities of NORM-impacted pipe.[5]

A third concern is the need to comply with existing, proposed or evolving volumetric standards for radioactivity in metal intended for "free release." These standards are being established to address nuclear industry materials, not petroleum industry NORM; however, the recycling industry has no regulatory guidance or other basis for making this distinction. Three countries currently have volumetric standards for total radioactivity in metal: 1) in Germany, the standard is 1 Bq/g (27 pCi/g); 2) in Sweden, the standard is 0.1 Bq/g (2.7 pCi/g); and 3) in Great Britain, the standard is 0.4 Bq/g (10.8 pCi/g).[13] In addition, the International Atomic Energy Agency has recommended an international standard of 0.3 Bq/g (8.1 pCi/g).[14] National standards for volumetric contamination of metals are being considered by a number of agencies, including the NRC, U.S. Environmental Protection Agency, Conference of Radiation Control Program Directors, and American National Standards Institute. However, proposed regulations probably are several years away. Exceeding standards of this nature could limit the potential market for re-melted steel by preventing its "free release" for unrestricted use. To ensure these standards are met, recyclers would need to accurately measure the total activity level of each batch entering the smelter and would need to know with certainty how much of the radioactivity would remain after re-melting. Given the technological constraints on characterizing inbound feed material discussed above, it is hard to predict how difficult and costly it would be to consistently meet these standards or verify compliance.

A fourth concern is the potential radioactive contamination of baghouse dust and slag, byproducts of the re-melting process that have commercial value. Scrap metal recyclers are concerned they will have fewer disposition options for the baghouse dust and slag if they have a radioactive component.

A fifth concern is that steel recyclers sell their product to consumers who have a strong phobia of and bias against radiation and radioactivity. If recyclers see a risk that they might lose market share by being labeled as a "radiation" site, they might refuse to process any material suspected of being contaminated. Given the current stigma of radiation, this scenario is quite possible.[15]

Alternative Disposal Options for NORM-Impacted Equipment

The inventory of NORM-impacted scrap metal generated by the petroleum industry each year must be handled in some fashion. Decontamination of the equipment is one option. While decontamination presents negligible risk to workers and the

public,[12] it might not be a suitable alternative for a significant portion of the scrap metal inventory. Pipe, tubing and storage vessels can be decontaminated with some effort; however, a large portion of the scrap inventory consists of small items that cannot be easily cleaned (e.g., filters, and valves). Much of the rest of the inventory includes obsolete, worn out items that have no future use; cleaning these items before final disposition could be economically prohibitive.

Disposal of NORM scrap metal as low-level radioactive waste at a licensed facility is expensive. Given that the nation's current disposal capacity for low-level radioactive wastes is limited, from a policy perspective, it may make sense to reserve this capacity for that category of wastes, particularly if alternative disposal options for NORM materials are adequately protective of human health and the environment.

If the NORM scrap inventory is not recycled, production of additional raw steel will be required. Health risks and environmental impacts associated with replacement of the metal (i.e., those associated with mining, refining and smelting iron ore)[1] are greater than those associated with re-melting NORM-impacted scrap.[12]

Conclusions

From a health risk-based perspective, re-melting of NORM-impacted equipment appears to be a viable recycling option. As a result, within their NORM regulatory programs, states should consider the re-melting of petroleum industry equipment containing NORM at a level greater than the exemption level defining regulated NORM.

However, oil and gas regulators and the petroleum industry must recognize that a myriad of issues prevents re-melting of NORM-impacted scrap metal on a widespread basis. Before this recycling option can become widely available to the petroleum industry, numerous complex regulatory and economic issues must be addressed. The debate over this topic is occurring on both a national and international level and is not likely to be resolved quickly.

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VIII
NORM SURVEY METHODOLOGIES

Purpose

This section provides general guidance for NORM survey methodologies, such as instrument selection, calibration, and specific survey techniques that may be used to measure NORM. This guidance does not represent the only correct way to survey for NORM impacted materials or equipment. New advances in instrumentation and survey methods occur continuously and state NORM rules should have sufficient flexibility to accommodate new and improved techniques as they are developed.

All of the information presented in this section, except where otherwise noted, have been derived from the API's *Bulletin on Management of Naturally Occurring Radioactive Materials (NORM) in Oil & Gas Production.*[1] Several states have developed NORM survey protocols that should be considered as additional guidelines. In addition, some examples of comprehensive survey protocol and methodology documents have been included in the references to this section.[2,3]

Types of NORM Surveys

NORM surveys in oil field operations generally involve detecting NORM deposits that have accumulated in production and processing equipment or have impacted the soil surface from a release or specific waste handling practices. The type of survey that is conducted can vary depending upon the purpose of the survey and the particular type of NORM material and radiation being measured. As an example, if all a survey is required to do is determine if some NORM material is inside a process vessel, a simple external screen with a scintillation detector will usually be sufficient. If a survey is being performed to determine if a NORM impacted piece of property (land) may be released back to the general public, a more detailed survey including soil samples may be required. Typical NORM surveys involve measurements of the following:

- Gamma levels from external equipment surfaces;
- Gamma levels from accumulations of scale and sludge;
- Gamma levels from soil and/or soil impacted by NORM;
- Alpha or beta radioactivity contamination levels on external and internal surfaces;
- NORM concentrations in media such as soil, scale and sludge, and water.
- Personnel external radiation exposures;
- Personnel internal exposure due to airborne radiation; or
- Various combinations of the above.

Gamma Surveys from External Equipment Surfaces

Survey instruments commonly used for the detection and measurement of NORM are instruments equipped with a one- or two-inch sodium iodide scintillation detectors. These usually are specific to gamma radiation, and will not detect either alpha or beta radiation.

Production equipment, particularly water-handling equipment, should be surveyed for external gamma radiation emissions. In addition, equipment being removed from service, released for maintenance work, or released for unrestricted use (e.g., sold or scrapped) should be surveyed for NORM.

Each piece of equipment should be systematically surveyed. Background gamma radiation levels should be recorded in a close-by area not impacted by NORM. This will help the surveyor detect deposits related to NORM. Typical background gamma radiation levels range from 1-2 μR/h offshore and 3-15 μR/h on land. The surveyor should pay particular attention to areas where solids may accumulate, such as pipe elbows. The meter probe should be in close proximity with the external surface of the equipment (normally not more than 1 centimeter away) and moved slowly across the equipment surfaces. Equipment NORM readings exceeding 50 μR/h, including background or other state regulatory levels, should be identified for further evaluation or marked as containing NORM.

> NOTE: The steel walls of equipment and pipe significantly attenuate the gamma radiation that may be emitted from NORM deposits, the amount of attenuation being proportional to wall thickness. Exposure rate measurements obtained in contact with the scale and sludge deposits after removal from equipment will typically be higher than would have been measured at the external surfaces of equipment before removal of the material. Equipment whose external readings measured less than 50 μR/h may contain deposits whose readings would exceed that level if removed.

Gamma Radiation from Accumulated Scale and Sludge

The same survey instruments used for surveying equipment may be used to survey accumulations of scale and sludge. Typically, when NORM scale is removed from tubulars or pipes, or NORM sludge is removed from vessels and tanks, the material is accumulated in drums. Although the NORM activity level remains essentially unchanged, gamma radiation levels may increase significantly due to the consolidation of the deposits. In some cases these levels may be high enough to trigger specific storage and handling requirements per state radiation protection regulations. In addition

to scales and sludges, workover fluids are subject to becoming NORM-impacted, by incorporation of NORM-impacted scale or sludge particles.

Gamma Radiation from Soil

Soil may become NORM-impacted as a result of various past and current production and maintenance operations, such as equipment cleanout, tubular descaling, produced water pits, and landfarming of tank bottoms.

Soil surveys should be done in a planned systematic manner to avoid unnecessary expense and ensure adequate site characterization. Soil surveys may also use the same type of survey meters used for equipment measurements. Typically the survey instrument probe should be held within a centimeter or two above the ground while conducting the surveys. The survey should be conducted over the subject land area on a delineated grid. The grid spacing should be optimized for the size of the area to be surveyed, as well as for the potential for identifying areas with elevated readings; the smaller the area to be surveyed, the smaller the grid spacing. Some regulatory agencies require that grid spacing not exceed 10 meters (~30 feet). Specific details of the grid survey such as grid size and sample location within the grid should be documented.

Areas exhibiting elevated readings may be identified for sampling and marked. To determine representative activity levels, soil samples should be collected from areas exhibiting gamma radiation levels exceeding 50 μR/h above background, or lower as dictated by some state requirements. The soil samples may either be analyzed onsite (if adequate instrumentation is available on site) or shipped to a qualified laboratory for analysis based on laboratory recommended sampling protocol. Reasons for soil sampling include, determining compliance with state exemption limits prior to release, before the sale or purchase of the lease and to characterize the existing NORM impact on a site. Background soil samples should be collected from a nearby non-NORM impacted area of the site to document the existing soil background levels for total radium.

Alpha/Beta Radioactivity Levels on External and Internal Surfaces

Survey instruments commonly used to detect alpha/beta levels in external and internal surface surveys are different than those used for gamma survey work. Usually, a count rate meter equipped with an alpha or an alpha/beta probe is used. The readings from these meters are usually recorded in units of counts per minute (cpm). These

readings are then converted by a factor depending on the meter used for comparison to a specific exemption limit. (i.e. 1000 dpm per 100 cm^2). The exemption limits are usually presented in two parts, one for fixed surface contamination and the other (lower limit) for removable surface contamination. Wiping a 100 cm^2surface with moderate pressure using a filter paper or cloth collects samples for comparison to the removable surface limit. The paper or cloth is then analyzed by appropriate survey meters. Usually wipe samples are sent to a laboratory for follow-up analysis. Because of the difficulty of obtaining and interpreting these limits many state rules choose not to apply them to NORM impacted equipment.

NORM Concentrations in Soil, Scale, Sludge and Water

Activity measurements of various NORM impacted media usually requires that samples of the impacted material be collected and sent off to a qualified laboratory for specific analysis for the isotopes of interest, usually radium-226 and radium-228. As is usual for any field sampling, specific laboratory protocols should be followed to avoid sample contamination and increase result accuracy.

Several relatively new technologies that measure radionuclide concentrations *in situ* have been developed. State regulators may accept the results of *in situ* analyses of NORM concentrations in lieu of laboratory analyses, particularly if the accuracy of the *in situ* analyses can be demonstrated through the collection and analysis of a set of control samples sent to an off-site laboratory. In general, the use of *in situ* analyses often results in reduced site characterization costs because field analytics typically are less expensive on a per sample basis than off-site laboratory analyses. Their use eliminates lengthy turn-around times and can allow one to collect the full suite of data needed to support decision-making in a single field exercise. The applicability and cost-effectiveness of *in situ* analyses has been successfully demonstrated at a petroleum industry NORM site in Michigan.[3] In this demonstration project, the use of *in situ* analyses was coupled with an adaptive decision-making process that allowed site characterization and remediation activities to be more efficiently focused to problem areas and to be bundled into one field exercise.

Personnel External Radiation Exposure

The Occupational Safety and Health Administration (OSHA) regulations permit occupationally exposed employees to receive a maximum radiation dose of 1250 millirem per calendar quarter. Typically, work area radiation levels in the general industry segment are far below this regulatory level. Therefore, routine personnel

radiation exposure surveys are not frequently done. It should be noted that OSHA regulations require the use of personnel dosimeters in areas where personnel are likely to receive greater than 312.5 millirem per calendar quarter. This equates to 600 μR/h for a 40-hour workweek. If radiation levels approach this value in routine work areas, evaluation of personnel radiation exposure should be considered.

Personnel radiation exposures may be evaluated either by having personnel wear thermoluminescent (TLD) dosimeters or film badges, which must be returned to and analyzed by the supplier. Alternatively, surveys with a shielded energy compensated Geiger Muller (GM) probe or ion chamber survey meter capable of providing a readout in millirem/hour may be conducted. When the survey method is used, work location and time information is required to estimate radiation dose.

Personnel Exposures to Airborne Radioactive Material

NORM deposits in equipment and piping do not present any airborne exposure concerns during normal operations. During maintenance or dismantling activities, airborne NORM exposure concerns are minimized by the application of typical industrial hygiene practices (such as keeping NORM deposits wet and using respiratory protective equipment). On the other hand, during grinding, cutting, chipping and sanding, and during removal of NORM scale and sludge, the NORM may become airborne. Under such conditions, it is advisable to evaluate employee exposure to ambient airborne concentrations of NORM.

Ambient (area) airborne NORM concentrations are normally evaluated by filtering a high-volume air sample and having the filter analyzed by a radiometric laboratory. The sample results are then compared to the Derived Air Concentration (DAC) limits for radium-226 or lead-210.

Personnel exposures are evaluated by the same sampling and laboratory methodology except that personnel wear lapel air samplers that operate at 2 to 5 liters per minute versus the higher flow rate ambient air pumps. In both techniques, it is essential to know the volume of air sampled along with the radiometric results in order to calculate the airborne NORM concentrations in microcuries per milliliter. To help put these exposures in perspective, the NORM decontamination industry has not found overexposures of its personnel to the DAC limits despite the fact that they work on nothing but NORM impacted equipment. It is very unlikely that significant overexposures to airborne NORM are occurring during the routine maintenance of NORM impacted equipment.

Instrument Care, Maintenance and Calibration

Portable survey meters typically used to conduct NORM surveys are, in themselves, generally quite rugged. However, the associated detectors and probes must be handled with care.

As a matter of good practice, connecting cables should not be sharply bent; frequent sharp bending of the connecting cables will break the internal cable wire. Battery contacts need to be kept clean and free of corrosion residue. In humid environments, or if instruments are used infrequently, batteries should be removed from survey meters when the survey instruments are not being used. Survey instruments should be kept clean, and detectors (probes) need to be kept free of NORM residue.

NORM survey instruments should be returned to the manufacturers (or other qualified instrument calibration agents) at least annually (semi-annually in some jurisdiction.) for general maintenance and calibration. Individual meters, detectors and connecting cables should be calibrated as discrete instruments (units): Switching components between units voids the calibration(s).

Instrument operational checks should be conducted before each use of an instrument (or after the detector has been dropped or banged against a solid object, etc.) to ensure that the instrument is functioning properly and providing representative readings. Operational checks include:

Battery Check

Switch the meter dial to the "battery" position and observe that the meter indicator moves into and remains in the accepted range, or depress the "battery" button on the meter and observe dial;

Source Check

Expose the detector (probe) to a source of radioactivity of known strength and confirm that the meter registers the proper reading. It is not adequate to merely confirm a positive response by the meter. A damaged detector may provide a positive response, but the response will be much lower than the proper reading.

Various types (and strengths) of radioactive check: sources may be purchased from most survey instrument suppliers. Operation checks of NORM survey instruments should be recorded in the survey documentation.

NOTE: There is some potential for sparking when detector cables are connected or disconnected, or when switches are turned on or off. Where explosive atmospheres may be encountered, tests for the presence of flammable gas/vapor should be made prior to the radiation survey.

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IX
ELEMENTS OF AN OIL AND GAS NORM REGULATION

These elements are from Section 7, "Naturally Occurring Radioactive Material," of the 1994 IOGCC publication, *Environmental Guidelines for State Oil and Gas Regulatory Programs*. They highlight the significant issues that should be covered in a state regulation. The 1994 document currently is undergoing revision.

7.1 Background

Naturally occurring radioactive material (NORM) is present above background levels at some oil and gas E&P facilities and oil-field service company locations. NORM found in oil-field operations originates in subsurface oil and gas formations and is typically transported to the surface in produced waters. NORM may deposit in well tubulars, surface piping, vessels, tanks, pumps, valves, and other producing or processing equipment and may be found in scales, sludges, contaminated soils, and other associated E&P wastes.

7.2 General

States should adopt an oil field NORM regulatory program that addresses identification, use, possession, transport, storage, transfer, decontamination, and disposal to protect human health and the environment. States may choose not to adopt such a program if they find, based on field monitoring data and other scientific information, that significant levels of NORM do not occur in a state's oil and gas E&P industry. States that make such a finding should periodically reevaluate the basis for that determination.

If a state determines that a regulatory program is necessary, it should tailor its program to NORM occurrence in the oil and gas E&P industry and include the elements listed in Section 7.3. Oilfield NORM should be managed in accordance with the pollution prevention and waste management hierarchy provisions of the guidelines. In addition, the other sections of the guidelines apply, where applicable, to NORM as a constituent of E&P waste.

7.3 Elements of an Oilfield NORM Program

7.3.1 Definition

States should develop a definition for NORM that is consistent with that which occurs in the oil and gas E&P industry. For purposes of the guidelines, NORM is defined as any nuclide or combination of nuclides that is radioactive in its natural physical state (i.e., it is not man-made), but does not include byproduct, source or special nuclear material.

7.3.2 Action Levels

States should establish numerical action levels above which NORM is regulated. Such action levels should also be used to regulate the transfer or release of equipment, materials, and sites.

7.3.3 Surveys

States should develop standards for survey instrumentation and procedures for identifying and documenting equipment, materials, and sites that may contain NORM above the action levels. State program requirements should specify the types of facilities to be surveyed, when surveys should be performed, when survey results should be reported to the state regulatory agency, and the required training of surveyors. State survey requirements should provide data necessary to meet the purposes described earlier in the publication, and to administer and enforce state program requirements effectively.

7.3.4 Worker Protection

State regulatory programs should include applicable state and federal standards for worker protection from exposure to radiation, including worker protection plans, and other standards necessary for the protection of workers from exposure to NORM. State regulatory programs should require the training of oilfield workers in NORM identification and radiation protection.

7.3.5 Licensing/Permitting

a. **General licensing/permitting.** Persons who possess oilfield NORM in concentrations or at exposure rates that exceed state-adopted action levels should be generally licensed or permitted.

b. **Specific licensing/permitting.** Specific licenses or individual permits should be required for commercial storage, removal, decontamination, remediation, treatment or disposal of oilfield NORM. A state may require specific licenses or individual permits for the management of oilfield NORM at centralized facilities, which are defined earlier in the book.

7.3.6 Removal/Remediation

States should establish standards and procedures for removal, decontamination and remediation that are protective of workers, the public health and the environment.

7.3.7 Storage

States should establish standards for storage of NORM that are protective of human health and the environment. NORM storage facilities should be constructed to prevent or minimize releases. Tanks used to store oilfield NORM should meet the requirements as noted in the guidelines. A state should adopt limits on the amount of time NORM exceeds action levels, which can be stored where in-state disposal alternatives have been authorized.

7.3.8 Transfer for Continued Use

State regulatory programs should allow for the transfer of land and equipment, containing NORM for continued operation in the production of crude oil and natural gas, with appropriate notification to affected parties.

7.3.9 Release of Sites, Materials and Equipment

State regulatory programs should address the levels below which, and conditions under which, equipment, materials, and sites containing NORM may be released. State regulatory programs should only authorize the release for unrestricted use of equipment, materials, and sites that exhibit NORM below action levels. Such regulations should provide for appropriate notification to affected persons.

7.3.10 Disposal

State regulatory programs should authorize disposal alternatives within the state's jurisdiction for various E&P wastes containing NORM, including contaminated equipment, and should include regulatory requirements for NORM disposal that are protective of human health and the environment. Landowner notification may be required as a condition of disposal. Commercial and centralized NORM disposal facilities should meet the criteria noted earlier in the book.

7.3.11 Interagency Coordination

State radiation programs, oil and gas programs, and waste management programs are frequently distributed among separate agencies. Therefore, in many states, multiple agencies may regulate NORM. The various agencies should coordinate their regulatory and enforcement activities under the guidance give in the guidelines.

7.3.12 Public Participation

State regulatory programs for NORM should meet public participation guidelines established in these guidelines.

7.4 Regulatory Development and Research

The Conference of Radiation Control Program Directors (CRCPD) has approved a model state regulation for TENORM, and a number of states have developed or are in the process of developing TENORM regulations. States that are developing their own NORM programs are encouraged to consult these sources for information and assistance. In addition, states should encourage and keep abreast of ongoing and future research on NORM. The term TENORM is defined in the model CRCPD regulations.

X

SUMMARY OF STATE REGULATIONS FOR NORM IN OIL AND GAS

ALABAMA

State agency: State Oil and Gas Board, 420 Hackberry Lane, P.O. Box 869999, Tuscaloosa, Alabama 35486-6999. Phone (205) 349-2852. http://www.ogb.state.al.us is the Web page. Staff e-mail addresses are: *@ogb.state.al.us (*Insert staff persons first initial and last name or insert "info" for general information).

Regulatory agency: State Board of Health, Department of Public Health, P.O. Box 303017, Montgomery, Alabama 36130-3017. Phone (334) 206-5391. Fax (334) 206-5387.

- Relevant Statute/Regulations: Alabama Rules for Control of Radiation, 420-3-26.
- Scope: These rules apply to all persons who receive, possess, use, transfer, own or acquire any source of radiation.
- Licensing: No person shall receive, possess, use, transfer, own, or acquire radioactive material except as authorized in a specific or general license or provided otherwise - 420-3-26-.02 (2).
- Cleaning Equipment: Cleaning equipment that is contaminated is a licensed activity subject to requirements of Rules 420-3-26-.02, 420-3-26-.03, and 420-3-26-.10.
- Disposal of Waste: Rules for disposal of radioactive waste are listed in Rule 420-3-26-.03.
- Subsequent Use of Equipment: Contaminated equipment is restricted in use to controlled activities.
- Subsequent Use of Materials: Depending upon levels of contamination; unrestricted use to transfer only to someone licensed to receive said materials.
- Release/Sale of NORM-Contaminated Land: 5 pCi/gm or less without restrictions; use otherwise restricted.
- Projected Volume of stored NORM in the State: No estimate available.
- Respondent: Kirksey Whatley

ALASKA

State agency: Alaska Oil and Gas Conservation Commission, 3001 Porcupine Drive, Anchorage, Alaska 99501. Phone (907) 279-1433. Fax (907) 276-7542.

Regulatory agency: Oil and Gas Conservation Commission, 3001 Porcupine Drive, Anchorage, Alaska 99501-3192. Phone (907) 279-1433. Fax (907) 276-7542.

- Relevant Statute/Regulations: Alaska does not have NORM regulations. NORM is not much of a problem here. What little we have has a low count. Industry has taken a proactive stand, cleaning tubulars, etc. NORM waste is either injected as a Class II fluid or incorporated in cement slurry.
- Respondent: David Johnston

ARIZONA

State agency: Oil & Gas Program Administrator, Arizona Geological Survey, 416 W. Congress, Suite 100, Tucson, Arizona 85701. Phone (520) 770-3500.

Regulatory agency: Arizona Radiation Regulatory Agency, 4814 S. 40th St., Phoenix, Arizona 85048. Phone (602) 255-4845, ext. 222.

- Relevant Statute/Regulations: R12-1-416(F) - Individuals may apply to other exempt levels.
- Scope: All radioactive materials.
- Licensing: It is required for possession in excess of limits.
- Disposal of Waste: Unless exempt must have approved disposal.
- Subsequent use of Equipment: Depending on levels, controls may apply.
- Subsequent use of Materials: Depending on levels, controls may apply.
- Release/sale of NORM-Contaminated Land: Depending on levels.
- Respondent: Aubrey Godwin

ARKANSAS

State agency: Arkansas Oil and Gas Commission, P. O. Box 1472, El Dorado, Arkansas 71731-1472. Phone (870) 862-4965.

Regulatory agency: Department of Health, Division of Radiation Control and Emergency Management, 4815 W. Markham Street, Little Rock, Arkansas 72205-3867. Phone (501) 661-2108.

- Relevant Statute/Regulations: Section 7 "Naturally Occurring Radioactive Material (NORM)" of the Arkansas State Board of Health Rules and Regulations for Control of Sources of Ionizing Radiation.
- Scope: Radiation protection standards for possession, use, transfer, and disposal of NORM. These regulations address NORM into products in which neither the NORM or the emitted radiation is considered to be beneficial to the products. Regulations address waste management and disposal standards.
- Licensing: General licenses are issued to mine, extract, receive, possess, own, use, process and dispose NORM. (RH-6010). Specific license for manufacturing and distribution of any NORM product for activities involving the remediation of equipment and/or facilities contaminated with NORM and the disposal of NORM waste. (RH-6020).
- Cleaning Equipment: Equipment contaminated with NORM in excess of levels listed in Appendix A, Section 7 and having maximum radiation exposure levels greater than 50 microR per hour including background shall NOT be released for unrestricted use. (RH-6010.b.).
- Disposal of Waste: RH-6013 to a licensed disposal facility or in accordance with an alternate method approved by the Department.
- Subsequent Use of Equipment: Equipment contaminated with NORM is exempt if the maximum radiation exposure level does not exceed 50 microR including background

or radioactive contamination levels do not exceed requirements of Appendix A of Section 7 (RH-6010.d.).

- Subsequent Use of Materials: RH-6023 requires that during the normal use and disposal that the radiation dose in any one year or the dose committed from intake of NORM will not exceed the doses of Column I of RH-6024.
- Release/Sale of NORM-Contaminated Land: Requires that an annotation of the deed-records to indicate the presence and quantity of NORM (RH-6010.f.1.B.).
- Projected Volume of stored NORM in the State: Unknown.
- Respondent: Jared Thompson

Regulatory agency: Arkansas Oil and Gas Commission, P.O. Box 1472, El Dorado, Arkansas 71731-1472. Phone (501) 862-4965. Fax (501) 862-8823.

- Relevant Statute/Regulations: The Oil and Gas Commission does not have regulations concerning NORM whether it be found in pipe and scale or soil and sediment.
- Scope: The Oil and Gas Commission may become involved with NORM disposal if an operator desires to dispose of the waste by well injection.
- Licensing: Not applicable - see ADH
- Cleaning Equipment: Not applicable - see ADH
- Disposal of Waste: May work jointly with ADH if applicant desires to use injection or down hole disposal.
- Subsequent Use of Equipment: Not applicable.
- Subsequent Use of Material: Not applicable.
- Release/Sale of NORM-Contaminated Land: Not applicable.
- Projected Volume of stored NORM in the State: Unknown.
- Respondent: Gary Looney

CALIFORNIA

State agency: California Department of Conservation, Division of Oil, Gas, and Geothermal Resources, 801 K Street, MS 20, Sacramento, California 95814-3530. Phone (916) 445-9686.

Regulatory agency: Department of Health Services, Radiological Health Branch, P.O. Box 942732, Sacramento, California 94234-7320. Phone (916) 322-3482. Fax (916) 324-3610.

- Relevant Statute/Regulations: California Health and Safety Code, Sections 114705-115270. California Code of Regulations, Title 17, Sections 30100-30543.
- Scope: Addresses all radioactive materials but is not specific to NORM and NORM issues in oil and gas production.
- Licensing: At the present time no decontamination, handling or disposal licenses specific to oil and gas industries and the associated NORM have been issued.
- Cleaning Equipment: Not presently licensed. No inventory or company's involved.

- Disposal of Waste: No regulations specific to oil and gas NORM disposal. If NORM sets off alarms at disposal sites or recycle facilities (including steel mills) then waste is treated as radioactive waste.
- Subsequent Use of Equipment: No specific regulations or restrictions at the present time.
- Subsequent Use of Materials: No specific regulations or restrictions at the present time.
- Release/Sale of NORM-Contaminated Land: No specific regulations or restrictions at the present time.
- Projected Volume of stored NORM in the State: Unknown, but large due to geothermal.
- Respondent: Edgar Bailey

COLORADO

State agency: Oil and Gas Conservation Commission, 1120 Lincoln St., Suite 801, Denver, Colorado 80203. Phone (303) 894-2100. Fax (303) 894-2109.

Regulatory agency: Department of Public Health and Environment (CDPHE), 4300 Cherry Creek Dr., South, Denver, CO 80246-1530. Phone (303) 692-3066. Fax (303) 759-5355.

- Relevant Statute/Regulations: Parts 3 and 4 of The Radiation Control Regulations.
- Scope: The state has broad authority to control radioactive material. NORM is evaluated on a case by case basis. Colorado has had very few instances of NORM issues in the oil and gas industry. Most of our NORM is in the sedimentary rocks associated with uranium "roll fronts."
- Licensing: Case by case evaluation.
- Disposal of Waste: Case by case evaluation.
- Subsequent Use of Equipment: Risk assessment of residual radioactivity.
- Subsequent Use of Materials: Risk assessment of residual radioactivity.
- Release/Sale or NORM-Contaminated Land: There have been no restrictions on the sale or release of land.
- Respondent: Jake Jacobi

Regulatory agency: Colorado Oil and Gas Conservation Commission, 1120 Lincoln St., Suite 801, Denver, Colorado 80203. Phone (303) 894-2100, Ext. 112. Fax (303) 894-2109.

- Relevant Statute/Regulations: None existing or proposed.
- Scope: COGCC has authority over E&P wastes but CDPHE has authority over disposal of low-level radioactive material.
- Licensing: Not in scope.
- Cleaning Equipment: Not in scope.
- Disposal of Waste: Not in scope, unknown.
- Subsequent Use of Equipment: Unknown.
- Subsequent Use of Materials: Unknown.

- Release/Sale of NORM-Contaminated Land: Unknown.
- Projected Volume of stored NORM in the State: Unknown.
- Respondent: Robin Reade

FLORIDA

State agency: Department of Environmental Protection, Division of Technical Services, Florida Geological Survey, 903 W. Tennessee St., Tallahassee, Florida 32304-7700. Phone (904) 488-4191/487-2219.

Regulatory agency: Department of Health, Bureau of Radiation Control, 1317 Winewood Blvd., Tallahassee, Florida 32399-0700. Phone (850) 487-2437. Fax (850) 921-6364.

- Relevant Statute/Regulations: Chapter 64E-5, Florida Administrative Code (soon to be reissued as chapter 64E-5, F.A.C.).
- Projected Volume of stored NORM in the State: 30 drums at 55 gallons each.
- OTHER:

  Florida's oil and gas industry is divided into two regions. In the western Panhandle to the north of Pensacola lies the Jay trend, consisting of eight fields. In south Florida, the Sunniland trend includes 14 fields located to the west and southeast of Ft. Myers. Production in south Florida began in 1943; the Panhandle fields were not discovered until 1970. Production peaked at 47.5 million barrels in 1978 and has been in general decline since then, but both regions are expected to continue operations for many more years. The Jay fields dominate, contributing around 70 percent of total production. Offshore oil production in Florida waters is currently nonexistent due to a ban on exploration and development.

  The Department of Health first investigated technologically enhanced naturally occurring radioactive materials (TENORM) contamination in Florida's oil and gas industry in the late 1980s. Exxon Company USA was the state's largest operator at time, for both the Panhandle and south Florida regions. In response to NORM regulations adopted by Louisiana and Texas, Exxon developed corporate guidelines that all of their personnel and contractors follow. The guidelines are designed to ensure compliance with the most stringent NORM regulations, regardless of whether or not the jurisdictions in which they were operating have established NORM regulations. Thus, Exxon and their contractor personnel working in Florida complied with corporate worker protection procedures, and their NORM wastes were properly disposed.

  A staff health physicist inspecting Exxon's south Florida fields in 1989 found maximum radiation levels in the 20-30μR/hr range at the fields' tank batteries. A recently completed inspection of five of the oldest fields in the same region (now operated by Calmet Florida, Inc.) served to confirm the 1989results. The highest gamma readings found was 80μR/hr in a saltwater storage tank; all other readings ranged from background (10-14μR/hr) to 40μR/hr, with most in the 20μR/hr range. The geochemistry of produced waters in the region does not appear to be conducive to radium replacement, resulting in low activity scale formation. Thirty-eight pipe scale samples were analyzed for radium content, with concentrations ranging from <0.75pCi/g.-11.5pCi/g. with an average of 2.1pCi/g.

The panhandle region was also investigated in the late 1980s, but documentation of the findings is lacking. Records indicate that in 1993, Exxon was approved to dispose of 186 barrels of NORM waste (drilling mud) downhole in a wellbore during plugging and abandonment of one of their exhausted wells. In all other cases, Exxon's NORM wastes were shipped out of state for disposal at licensed waste disposal facilities.

In 1996, staff inspectors visited the two treatment facilities operating in the region, one operated by Exxon, and the other by De Soto Oil and Gas, Inc.(now Petro Operating Co.). The highest external gamma reading (100-200μR/hr) were noted in separator tanks, but due to extremely low worker occupancy times in the elevated radiation fields, the readings were not considered an occupational hazard.

De Soto was found to be generating small quantities of NORM waste (approximately 50 drums) and storing them on site pending availability of a wellbore ready for plugging and abandonment, which they planned to use for downhole disposal of their wastes. Exxon no longer operates in the Panhandle region, having recently sold their interests to Louisiana Land Exploration (LL&E).

Due to the low occupancies for the areas where elevated gamma readings were noted, our current position is that oil and gas TENORM in Florida does not warrant increased regulatory oversight at this time. However, additional analysis of data and additional field measurements may lead us to reassess our view, particularly if an effort to promulgate comprehensive TENORM regulations is made.

- Respondent: Walter Cofer.

GEORGIA

State agency: Environmental Protection Division, Department of Natural Resources, Geologic Survey Section, Room 400, 19 Martin Luther King Dr., S. W., Atlanta, Georgia 30334. Phone (404) 656-3214. (Rules and Regulations are available from the above).

- No NORM regulations at this time.

IDAHO

State agency: Oil and Gas Conservation Commission, Idaho Department of Lands, 3780 Industrial Ave., South, Coeur d'Alene, Idaho 83815-8918. Phone (208) 769-1535.

- No NORM regulations at this time.

ILLINOIS

State agency: Department of Natural Resources, Office of Mines and Minerals, Division of Oil and Gas, 524 S. Second Street, Springfield, Illinois 62701-1787. Phone (217) 782-7756.

Regulatory agency: Department of Natural Resources, Division of Oil and Gas, 524 South Second St., Springfield, Illinois 62701-1787. E-mail: lbengal@dnrmail.state.il.us. Phone (217) 782-1689. Fax (217) 524-4819.

- Relevant Statute/Regulations: Illinois Oil and Gas Act – 225 ILCS 725/1.
- Scope: Department has authority to regulate **all** oil and gas wastes. Does not name NORM specifically, but Department interprets all to include oilfield NORM.
- Licensing: None required at this time. State Department of Nuclear Safety may purpose NORM regulations, however, current state low-level waste statutes implemented by Nuclear Safety are not clear on NORM authority.
- Cleaning Equipment: None regulated at this time except from the standpoint of worker safety, which is under the jurisdiction of the Department of Nuclear Safety.
- Disposal of Waste: Currently, only disposal of NORM in pit residues is regulated.
- Subsequent Use of Equipment: Equipment not regulated at this time.
- Subsequent Use of Materials: Use of potentially NORM contaminated materials are not regulated at this time.
- Released/Sale of NORM-Contaminated Land: Current regulations only require a notice be filled with the County Clerk stating the presence of NORM at a closed pit site.
- Projected Volume of stored NORM in the State: Unknown.
- Respondent: Lawrence Bengal

Regulatory agency: Illinois Department of Nuclear Safety, Division of Materials, 1035 Outer Park Drive, Springfield, Illinois 62704. Phone (217) 785-9935. Fax (217) 782-1328.

- Relevant Statute/Regulations: 32 Illinois Administrative Codes, but currently developing a specific TENORM rule.
- Scope: Covers all radioactive material and facilities that are not areas of exclusive federal jurisdiction.
- Licensing: Required for all that are not exempt.
- Cleaning Equipment: License required.
- Disposal of Waste: To specifically approved facilities and by specifically approved methods only.
- Subsequent Use of Equipment: Okay.
- Subsequent Use of Materials: Case-by-case evaluation needed.
- Release/Sale of NORM-Contaminated Land: Case-by-case evaluation. Decommissioning generally required.
- Projected Volume of stored NORM in the State: Unknown.
- Respondent: Steven Collins.

INDIANA

State agency: Division of Oil and Gas, 402 West Washington Street, Room 293, Indianapolis, Indiana 46204. Phone (317) 232-4055.

Regulatory agency: State Department of Health, Emergency Response and Radioactive Material Programs, Indoor and Radiologic Health, 2 North Meridian St., 5th Floor, Indianapolis, Indiana 46204-3003. Phone (317) 233-7153. Fax (317) 233-7154.

- Relevant Statute/Regulations: Proposed - No state regulations for dealing with NORM in the oil and gas industry.
- Scope: When found in scrap streams our office provides list of radiation brokers (CRCPD).
- Respondent: Rex Bowser

KANSAS

State agency: State Corporation Commission, Conservation Division, Finney State Office Building, 130 S. Market, Room 2078, Wichita, Kansas 67202. Phone (316) 337-6200.

Regulatory agency: Radiation Control Program, Bureau of Air and Radiation; Kansas Department of Health and Environment.

- Relevant Statute/Regulations: There are no existing or proposed regulations specific to NORM.
- Scope: The State of Kansas Radiation Protection Regulations apply to all persons who receive, posses, use, transfer, own or acquire any source of radiation.
- Licensing: NORM responses are evaluated to decide if radioactive materials license is required for the material.
- Cleaning Equipment: Descaling or cleaning operations would require a Radioactive Materials License if scale or sludge contains significant quantities of radioactive materials such as Radium-226.
- Disposal of Waste: There is currently no satisfactory cost-effective way of disposing of this material.
- Subsequent Use of Equipment: Release criterion of contaminated equipment would fall under the scope of Kansas Radiation Protection Regulations. Specific requirements would be addressed depending upon the scope of the licensee's proposed activities.
- Subsequent Use of materials: Release criterion of contaminated materials would fall under the scope of Kansas Radiation Protection Regulations. Specific requirements would be addressed depending upon the scope of the licensee's proposed activities.
- Release/Sale of NORM-Contaminated Land: A radioactive materials license would be required and appropriately transferred to the new owners.
- Projected Volume of stored NORM in the State: The extent of NORM contamination in oil and gas operations in Kansas has not been assessed. It has been proposed that the Department contact with a consultant to assess the extent of NORM contamination in Kansas.
- Respondent: David Whifill

KENTUCKY

State agency: Division of Oil and Gas Conservation, P. O. Box 2244, Frankfort, Kentucky 40601. Phone (502) 573-0147.

Regulatory agency: Cabinet for Health Services, 275 East Main, Frankfort, Kentucky 40601. Phone (502) 564-7130. Fax (502) 564-7573.

- Relevant Statute/Regulations: CRCPD states that "TENORM does not include the natural radioactivity of rocks, soil, or background but instead refers to materials whose radioactivity is technologically enhanced by controlled practices." Part N of CRCPD states TENORM is "radioactive material." 902 KAR 100:010(176) states "radioactive material" means a solid, liquid, or gas which emits radiation spontaneously. TENORM falls into this area as defined by the CRCPD.
- Scope: Given the above 902 KAR 100 could be considered applicable to TENORM. All the areas listed below would fall under existing regulations. If TENORM is not considered radioactive material, then Kentucky would have regulations applicable to this material
- Respondent: John Volpe.

LOUISIANA

State agency: Office of Conservation, P. O. Box 94275, Capitol Station, Baton Rouge, Louisiana 70804-9275. Phone (225) 342-5540.

Regulatory agency: Louisiana Department of Environmental Quality, Office of Air Quality and Radiation Protection, Radiation Protection Division, Licensing Section, P.O. Box 82135, Baton Rouge, Louisiana 70884-2135. Phone (504) 765-0141. Fax (504) 765-0220.

- Relevant Statute/Regulations: Louisiana Administrative Code, Title 33, Part 15, Chapter 14 Regulation and Licensing of Naturally Occurring Radioactive Material (NORM), amended January 1995.
- Scope: The regulations say: "These regulations apply to any person who engages in waste generation, extraction, mining, beneficiating, processing, possession, use, transfer, treatment, transportation, or disposal of NORM or recycling of NORM contaminated equipment in such a manner as to technologically alter the natural sources of radiation or their potential exposure pathways to humans, which could include many industries." Yet, in practice, the state of Louisiana has put NORM regulatory emphasis on the oil and gas industry. Largely, because the occurrence of NORM has predominately been found in the oil and gas industry. There are few other industries such as paper and pulp and petrochemical where the regulation of NORM has been enforced.
- Licensing: Louisiana created a general license requirement of all oil and gas operators/companies who own or operate sites where NORM contamination has been discovered. Upon discovery of the presence of NORM, an operator/company is required to notify the state of Louisiana of the site using the NORM notification form. The information is compiled into a database and each operator/company is assigned a

general license number and each site is tracked by a site-specific number. At present, the state of Louisiana has approximately 450 NORM general licenses.

For companies engaged in providing NORM decontamination, handling, disposal, and other related NORM services, the state of Louisiana requires such companies to possess a NORM specific license issued from the Division or another agreement state. At present, there are 33 companies specifically licensed through the state of Louisiana.

- Cleaning Equipment: NORM general licensees are allowed to *...perform maintenance on vessels, tanks, tubular goods, or water treatment systems, or the clearing of pipe lines to maintain oil and gas production...* under the on-site maintenance provision stated in LAC33:XV.1408.A.4., provided that written worker protection procedures are submitted to the division, and that the maximum radiation level does not exceed two millirem per hour.

  The decontamination of NORM contaminated equipment for release for unrestricted use is reserved for companies that possess a NORM specific license from the state of Louisiana or an agreement state. The handling and decontamination of NORM contaminated equipment and sites is largely performed by companies that possess a NORM specific license.
- Disposal of Waste: At present, the following are disposal option available to oil and gas operators:
  (a) Commercial treatment by method of landfarming. There are one or two commercial landfarms in Louisiana permitted for NOW disposal that accept NORM with concentration less than 30 picocuries per gram of Ra-226 or Ra-228.
  (b) Non-commercial Downhole Disposal into wellbore to be plugged and abandoned.
  (c) Non-commercial deep well injection. In July 1997, the state of Louisiana issued an oil and gas operator a license to handle and process NOW/NORM waste belonging to the operator for injection into a Class II injection well.
  (d) Commercial deep well injection. There are two commercial facilities in the state of Texas permitted and licensed to inject NOW/NORM into an injection well.
- Subsequent Use of Equipment: NORM contaminated tubular goods and pipe are often decontaminated and then, reused. That which is unusable is decontaminated and sold as scrap.
- Release/Sale of NORM-Contaminated Land: To release the site, documentation is required supporting the removal of the NORM. Included in the documentation, would be a radiation survey of the area where the NORM was present, soil sample data, and records supporting the transfer of the equipment or NORM waste for treatment, storage, or disposal. The release criteria for a site is outlined in Louisiana's NORM Implementation Manual.
- Projected Volume of stored NORM in the State: It is uncertain how much NORM is being stored in the state. In 1994 and 1995, two disposal options came available that provided an outlet for many operators to begin moving their inventory of NORM waste for disposal. One of the options existed in Louisiana through a company that operated a commercial landfarm specifically permitted/licensed to accept NOW/NORM waste. The other option existed in Texas through a company that operated a commercial injection well permitted/licensed to accept NOW/NORM waste.
- Respondent: Jason Talbot

MARYLAND

State agency: Maryland Department of the Environment, Water Management Administration, Minerals, Oil and Gas Division, 2500 Broening Highway, Baltimore, Maryland 21224.

Regulatory agency: Department of Environment, Minerals, Oil and Gas Division, 2500 Broening Highway, Baltimore, Maryland 21224. Phone (410) 631-8055.

- Relevant Statute/Regulations: No regulations or laws exist or are proposed regarding NORM in oil and gas production.
- Release/Sale of NORM-Contaminated Land: Not applicable.
- Respondent: C. Edmon Larrimore

MICHIGAN

State agency: Geological Survey Division, Department of Environmental Quality, P.O. Box 30256, Lansing, Michigan 48909. Phone (517) 334-6907. (Supervisor of Wells - same address).

Regulatory agency: Department of Environmental Quality, Geological Survey Division, Box 30256, Lansing, Michigan 48909. Phone (517) 334-6937. Fax (517) 334-6919.

- Relevant Statute/Regulations: Special Order of the Supervisor of Wells/Supervisor of Mineral Wells, Issued 11/3/1992.
- Scope: Order deals with approved method: for plugging wells in which NORM contamination exists on downhole equipment or is generated during plugging operations.
- Licensing: None required.
- Cleaning Equipment: None specified.
- Disposal of Waste: NORM-contaminated equipment may be reinserted into the wellbore from which it was taken. Soils, clothing, etc. contaminated with NORM during plugging may be disposed of by insertion into the well being plugged.
- Subsequent Use of Equipment: If NORM-contaminated equipment is not reinserted, it may be stored, reused, or recycled following applicable state and federal government regulations.
- Subsequent Use of Materials: As for equipment above.
- Release/Sale of NORM-Contaminated Land: No specific geological survey oversight of this area.
- Projected Volume of stored NORM in the State: Not applicable.
- Respondent: Ray Vugrinovich

Regulatory agency: Department of Environmental Quality, Radiological Protection Section, P.O. Box 30630, Lansing, Michigan 48909-8130. Phone (517) 335-8204. Fax (517) 335-8706.

- Relevant Statute/Regulations: Currently, the Michigan Department of Environmental Quality, pursuant to state statute (Public Code, 1978 Public Act 368, as amended), has regulatory authority over the radiological aspects of NORM. However, the

associated administrative rules (Michigan's *Ionizing Radiation Rules*) have not yet been revised to specifically address NORM concerns related to oil and gas production. A staff proposal to adopt the current version of suggested regulations from the Conference of Radiation Control Program Directors (CRCPD) (Part N of the suggested state Regulations for Control of Radiation, February 1997) is being considered.

In the interim, *Cleanup and Disposal Guidelines for Sites Contaminated with Radium-226* can be considered as applicable in Michigan to address some of the more significant concerns related to NORM.

- Disposal of Waste:
  (a) For disposal of radium-226 contaminated materials in the form of bulk waste, such as contaminated soil or contaminated debris, materials containing a radium-226 concentration not exceeding 50 picocuries per gram, averaged over any single shipment, can be accepted in a Type II solid waste landfill, as defined in Act 641, Public Acts of 1978, as amended, and permitted by the Department. The maximum radium-226 concentration within any single shipment as determined by representative sampling must not exceed 100 picocuries per gram.
  (b) For disposal of radium-226 contaminated waste materials at concentrations above 50 picocuries per gram, the wastes should be transferred to a licensed radioactive waste disposal facility.
  (c) In addition, any naturally occurring radioactive material wastes containing radium-226 at any concentration resulting from oil and gas extraction activities in Michigan may be disposed downhole during plugging and abandonment operations, subject to any additional applicable requirements of the Department.
- Release/Sale of NORM-Contaminated Land:
  (a) For release of facilities, equipment, or land for unrestricted use, the attached guidelines will be used by the department to determine acceptable levels of residual contamination during remediation of Michigan sites contaminated with radium-226.
  (b) For facilities, equipment, or land for which release under certain restrictions may be appropriate, the department will review specific site proposals for other release limits based on the methodology for dose assessment contained in NUREG/CR-5512, Vol. 1 (U.S. Nuclear Regulatory Commission, October 1992). In no case will a restricted use release be approved if the maximum individual total effect dose equivalent can exceed 100 millirem per year under conditions of a reasonable worst-case scenario. Each specific site remediation proposal involving restricted use must include an *As Low As Reasonably* Achievable analysis.
- Respondent: David Minnaar

MISSISSIPPI

State agency: State Oil and Gas Board, 500 Greymont Avenue, Suite E, Jackson, Mississippi 39202-3446. Phone (601) 354-7114.

Regulatory agency: Department of Health, Division of Radioactive Health, Radioactive Materials Branch, P.O. Box 1700, Jackson, Mississippi 39215. Phone (601) 354-6167. Fax (601) 354-6687.

- Relevant Statute/Regulations: Mississippi State Board of Health Regulations for Control of Radiation, Section N.
- Scope: Mississippi Legislature gave NORM regulatory action to the State Oil and Gas Board in 1996.
- Respondent: B. J. Smith

Regulatory agency: Mississippi State Oil and Gas Board, 500 Greymont Ave., Suite E, Jackson, Mississippi 39202. Phone (601) 354-6474. Fax (601) 354-6873.

- Relevant Statute/Regulations: Rule 68. Disposal of NORM and Rule 69. Control of NORM
- Scope: Applies to NORM derived from exploration and production activities at facilities which on or after 7/1/95 were permitted by the State Oil and Gas Board, and which on some date were active or inactive.
- Licensing: None. Site survey required on all sites with results reported on Form 21.
- Cleaning Equipment: Required for "release for unrestricted use" but not regulated.
- Disposal of Waste: Permitted under Rule 68 for disposal in wells being plugged and abandoned, or offsite at a licensed low level radioactive waste or NORM disposal facility.
- Subsequent Use of Equipment: No restrictions if transferred to another producer. Radiation limits if released for unrestricted use.
- Subsequent Use of Materials: No restrictions if used by another oil and gas producer.
- Release/Sale of NORM-Contaminated Land: No restrictions if transferred to another producer. Radiation limits for release for unrestricted use.
- Respondent: W. Kent Ford

MISSOURI

State agency: State Oil and Gas Council, P. O. Box 250, Rolla, Missouri 65402. Phone (573) 368-2168.

Regulatory agency: Missouri Department of Natural Resources, Wellhead Protection Section, P.O. Box 250, Rolla, Missouri 65402. Phone (573) 368-2170. Fax (573) 368-2111.

- Relevant Statute/Regulations: There are currently no regulations in place or proposed that deal with NORM.
- Respondent: Evan Kifer

MONTANA

State agency: Board of Oil and Gas Conservation, P.O. Box 217, Helena, Montana 59624. Phone (406) 449-2622. Technical Office: 2535 St. Johns Avenue, Billings, Montana 59102. Phone (406) 656-0040. Northern Field Office: 218 Main Street, P.O. Box 690, Shelby, Montana 59474. Phone (406) 434-2422.

Regulatory agency: Montana Department of Public Health and Human Services.

- Relevant Statute/Regulations: None; will be developing regulations within the next year, based on the CRCPD's state suggested regulations.
- Respondent: George Eicholt

NEBRASKA

State agency: Nebraska Oil and Gas Conservation Commission, P. O. Box 399, Sidney, Nebraska 69162. Phone (308) 254-6919.

Regulatory agency: HHS Regulation and Licensure, Public Health Assessment, Radioactive Material Program, P. O. Box 95007, Lincoln, Nebraska 68509. Phone (402) 471-2168.

- Relevant Statute/Regulations: At the present time, Nebraska has not adopted specific NORM regulations. Occurrences of NORM problems are currently handled under the state's general regulations for the control of radiation.
- Respondent: Brian Hearth

NEVADA

- No NORM regulations at this time.

NEW MEXICO

State agency: New Mexico Energy, Minerals and Natural Resources Department, Oil Conservation Division, 2040 South Pacheco Street, Santa Fe, New Mexico 87505. Phone (505) 827-7131. Fax (505) 827-8177.

Regulatory agency:

(a) Radiation Licensing and Registration Section, New Mexico Environmental Department (NMED).
(b) Oil Conservation Division, New Mexico Energy, Minerals and Natural Resources Department (OCD).

- Relevant Statute/Regulation:
  (a) NMED: Naturally Occurring Radioactive Materials in the Oil and Gas Industry (Subpart 14)
    - Scope: Apply to persons who engage in extraction, transfer, storage or disposal of NORM. Apply to sludges and scale and storage and cleaning of tubulars and equipment.
  (b) OCD: Disposal of Regulated Naturally Occurring Radioactive Material (Rule 714)
    - Scope: Establish procedures for the disposal of regulated NORM.
- Licensing: General and specific
- Cleaning Equipment: Allowed under worker protection plans and limits of exposures in the regulations.
- Disposal of Waste: Exempt if under 30 picocuries per gram of Ra226 above background or 150 picocuries per gram of any other NORM radionuclide above

background. Disposal per regulation in non-retrievable flowlines and pipelines, in commercial-centralized facilities, in plugged and abandoned wells and in Class I and II injection wells.

- Subsequent Use of Equipment: Facilities and equipment containing regulated NORM shall not be released for unrestricted use.
- Storage of Materials: NORM can be stored up to one year under general licenses, longer under specific licenses or an extension granted by NMED.
- Projected Volume of Stored NORM in the State: Unknown
- Respondent: Jerrie Moore, NMED; Roger Anderson, OCD

NEW YORK

State agency: Department of Environmental Conservation, Division of Mineral Resources, 50 Wolf Road, Room 290, Albany, New York 12233-6500. Phone (518) 457-7480. Region 9 Office, 128 South Street, Olean, New York 14760. Phone (716) 372-0645. Region 8 Office, 6274 East Avon-Lima Road, Avon, New York 14414. Phone (716) 226-2466.

Regulatory Agency: Department of Environmental Conservation (DEC), Bureau of Pesticicles and Radiation, 50 Wolf Road, Room 402, Albany, New York 12233-7255. Phone: (518) 457-2225. Fax: (518) 485-8390.

- Relevant Statute/Regulations: 6 NYCRR Part 380 - Rules and Regulations for Prevention and Control of Environmental Pollution by Radioactive Materials.
- Scope: Discharge and disposal of radioactive materials; applies to NORM if
  (a) processed and concentrated and
  (b) subject to radioactive materials licensing.
- Licensing: Department of Environmental Conservation is not a radioactive materials licensing agency. The licensing agencies in New York state (State Health Department, State Labor Department, New York City Health Department) have not required licenses for NORM from oil and gas production.
- Release/Sale of NORM-Contaminated Land: DEC has cleanup guidelines for soils contaminated with radioactive materials (DSHM, TAGM 4003); DEC does not regulate sale of NORM-contaminated land.
- Projected Volume of stored NORM in the State: DEC has not made this estimate.
- Respondent: Paul Merges

NORTH CAROLINA

State agency: Department of Environment and Natural Resources, Division of Land Resources, P.O. Box 27687, Raleigh, North Carolina 27611. Phone (919) 733-3833.

Regulatory agency: Division of Radiation Protection, 3825 Barrett Dr., Raleigh, North Carolina 27609-7221. Phone (919) 571-4141. Fax (919) 571-4148.

- Relevant Statute/Regulations: G.S. 104E and 15A NCAC Chapter 11.
- Scope: All aspects of radiation protection.
- Licensing: Uses and sources of radioactive material and particle accelerators.
- Cleaning Equipment: U.S. Department of Transportation contamination limits.

- Disposal of Waste: LLRW.
- Subsequent Use of Equipment: Per case basis.
- Subsequent Use of Materials: Per case basis.
- Release/Sale of NORM-Contaminated Land: Per case basis.
- Projected Volume of stored NORM in the State: Unknown; large PO4 plant.
- Respondent: Richard Fry.

NORTH DAKOTA

State agency: North Dakota Industrial Commission, Oil and Gas Division, 600 East Boulevard Ave., Dept. 405, Bismarck, North Dakota 58505-0840. Phone (701) 328-8020.

Regulatory agency: North Dakota Department of Health, P.O. Box 5520, Bismarck, North Dakota 58506-5520. Phone (701) 328-5188. Fax (701) 328-5200.

- Relevant Statute/Regulations: Regulations: North Dakota Radiological Health Rules, North Dakota Administrative Code article 33-10. Statute: North Dakota Century Code chapters 23-20, 23-20.1, and 23-20.2
- Scope: The regulations cover all ionizing radiation sources, including NORM. However, there isn't a specific chapter on NORM in regulations. North Dakota has not adopted regulations equivalent to the CRCPD's Part N yet.
- Licensing: Licensing of NORM is handled the same way as licensing of other radioactive materials, using North Dakota Radiological Health Rules chapter 33-10-03, which is based upon the CRCPD's Part C, "Licensing of Radioactive Materials." Also, anyone who owns NORM is considered to be a general licensee and would need to comply with applicable portions of the North Dakota Radiological Health Rules.
- Cleaning Equipment: No specific standards for cleaning equipment. Would need to obtain a license to provide NORM decontamination services.
- Disposal of Waste: Must receive approval of North Dakota Department of Health before disposing of NORM. In the past, we have approved disposal in a plug and abandon well; approval is on a case-by-case basis.
- Subsequent Use of Equipment or Materials: Equipment and materials must be permanently decontaminated below or equal to the standards in Appendix F of Chapter 33-10-04.1. A survey must be made after decontamination and the North Dakota Department of Health and subsequent transferee or owner must be provided with a copy of the survey. Equipment or materials can't be sold, leased, or transferred until the decontamination survey has been verified and accepted by the North Dakota Department of Health.
- Release/Sale of NORM-Contaminated Land: Must be 5 picocuries of radium or less per gram of dry soil. Results of surveys must be provided to North Dakota Department of Health and property owner or subsequent tenant or transferee. Property can't be vacated, sold, or transferred until a decontamination survey has been verified and accepted by North Dakota Department of Health.
- Projected Volume of stored NORM in the State: Unknown.
- Respondent: Ken Wangler

OHIO

State agency: Department of Natural Resources, Division of Oil and Gas, Building B, Fountain Square, Columbus, Ohio 43224. (Chapter 1509, Ohio Revised Code). Phone (614) 265-6922.

Regulatory agency: Department of Natural Resources, Division of Oil and Gas, 4383 Fountain Sq. Ct., Bldg. B, 3rd Floor, Columbus, Ohio 43224. Phone (614) 265-6893. Fax (614) 268-4316.

- Relevant Statute/Regulations: Ohio has no rules specific to oil and gas NORM.
- Respondent: Tom Tugend

OKLAHOMA

State agency: Oklahoma Corporation Commission, Oil and Gas Conservation Division, P.O. Box 52000-2000, Oklahoma City, Oklahoma 73152-2000. Phone (405) 521-2301. Fax (405) 521-3099. E-mail: m.battles@occmail.occ.state.ok.us. OCC Web site is www.occ.state.ok.us.

Regulatory agency: Department of Environmental Quality, Radiation Management Section, 1000 N.E. 10th St., Oklahoma City, Oklahoma 73117. Phone (405) 271-7484.

- Relevant Statute/Regulation: Oklahoma Department of Quality has no rules to specifically address NORM, Existing radiation rules are interpreted on a case-by-case basis as necessary.
- Scope: NORM rules have been proposed by industry, but exact scope and content are influx.
- Disposal of waste: Solid waste rules prohibit disposal of solid waste landfills (RCRA landfills).
- Respondent: Mike Broderick

OREGON

State agency: Department of Geology and Mineral Industries, Suite 965, 800 N.E. Oregon St., #28, Portland, Oregon 97232. Phone (503) 731-4100. Fax (503) 731-4066.

Regulatory agency: Oregon Health Division, Radiation Protection Services, 800 N.E. Oregon St., Portland, Oregon 97232. Phone (503) 731-4014.

- Relevant Statute/Regulations: OAR 333-117-010 to -370.
- Scope: Anyone who engages in extraction, mining, beneficiating, processing, use, transfer or disposal.
- Licensing: Yes.
- Cleaning Equipment: Yes.
- Disposal of Waste: Yes.
- Subsequent Use of Equipment: Yes.
- Subsequent Use of Materials: Yes.

- Release/Sale of NORM-Contaminated Land: Must meet decommissioning and decontamination criteria.
- Respondent: Ray Paris and Dan Wermiel

PENNSYLVANIA

State agency: Department of Environmental Protection, Bureau of Oil and Gas Management, central office: P. O. Box 8765, Harrisburg, Pennsylvania 17105-8765. Phone (717) 772-2199. Regional office: 400 Waterfront Drive, Pittsburgh, Pennsylvania 15222-4745. Phone (412) 442-4015. Regional office: 230 Chestnut Street, Meadville, Pennsylvania 16335. Phone (814) 332-6860.

Regulatory agency: Department of Environmental Protection, Bureau of Oil and Gas Management, P.O. Box 8765, Harrisburg, Pennsylvania 17105. Phone (717) 772-2199.

- Relevant Statute/Regulations: None existing or proposed. Surveys have shown NORM is not an issue with oil and gas production in Pennsylvania.
- Respondent: James E. Erb

Regulatory agency: Department of Environmental Protection, Bureau of Radiation Protection, P.O. Box 8469, Harrisburg, Pennsylvania 17105. Phone (717) 787-3720.

- Relevant Statute/Regulations: Pennsylvania has no NORM regulations.
- Scope: NORM problems are addressed using existing regulations and EPA/NRC standards on a case-by-case basis.
- Respondent: Stuart Levin

SOUTH CAROLINA

Regulatory agency: Division of Radioactive Material Licensing and Compliance, Bureau of Radiological Health, 2600 Bull Street, Columbia, South Carolina 29201-1708. Phone (803) 737-7406.

- Relevant Statute/Regulations: Part IX, "Licensing of Naturally Occurring Radioactive Material (NORM)," of South Carolina Department of Health and Environmental Control, Regulation 61-63, Radioactive Materials (Title A).
- Scope: This part establishes radiation protection standards for the possession, use, transfer, transport, and/or storage of naturally occurring radioactive material (NORM) or the recycling of NORM contaminated materials not subject to regulation under the Atomic Energy Act of 1954, as amended. The requirements of this part are in addition to and not in substitution for other applicable requirements of Parts I, II, III, VI, and VII of these regulations. Except as otherwise specifically provided, these regulations apply to all persons who engage in the extraction, mining, beneficiating, processing, use, transfer, transport, and/or storage of NORM. Also the recycling of NORM contaminated materials in a manner that alters the chemical properties or physical state of natural sources of radiation or the potential exposure pathways to humans or environment.
- Licensing: General and specific.
- Respondent: David King

SOUTH DAKOTA

State agency: Department of Environment and Natural Resources, Oil and Gas Program, 2050 W. Main, Suite #1, Rapid City, South Dakota 57702. Phone (605) 394-2229. Fax (605) 394-5317.

Regulatory agency: Department of Environment and Natural Resources, 2050 W. Main, Suite 1, Rapid City, South Dakota 57702. Phone (605) 394-2229.

- Relevant Statute/Regulations: South Dakota does not have any oilfield rules addressing NORM at present. There are no NORM rules being proposed at present.
- Scope: Not applicable.
- Licensing: Not applicable.
- Cleaning Equipment: Not applicable.
- Disposal of Waste: Not applicable.
- Subsequent Use of Equipment: Not applicable.
- Subsequent Use of Materials: Not applicable.
- Release/Sale of NORM-Contaminated Land: Not applicable.
- Projected Volume of stored NORM in the State: Not applicable.
- Respondent: Fred V. Steece

TENNESSEE

State agency: State Oil and Gas Board, 13th Floor, L & C Tower, 401 Church St., Nashville, Tennessee 37243-0445. Phone (615) 532-0166. Fax (615) 532-1517. E-mail mburton@mail.state.tn.us.

Regulatory agency: Department of Environment and Conservation; Division of Radiological Health, 401 Church St., 3rd Fl., L & C Annex, Nashville, Tennessee 37243.

- Relevant Statute/Regulations: State Regulations for Protection Against Radiation, 1200-2-4, 1200-2-5, 1200-2-10.
- Scope: The state of Tennessee does not distinguish between NORM and any other radioactive material (NARM, byproduct, tanuranic, special nuclear material). All radioactive material is subject to the regulations of the state of Tennessee.
- Licensing: All radioactive material including NORM is subject to the licensing of the state of Tennessee unless excluded on a case-by-case basis. This includes possession, storage, use, transfer, receive, own or the acquisition of any radioactive material unless otherwise exempted (NRC, Agreement State Exemptions).
- Cleaning Equipment: This would require a specific license issued by the state of Tennessee for the authorization of a particular process.
- Disposal of Waste: Waste must be disposed of as radioactive unless otherwise specifically authorized by the state of Tennessee (case-by-case).
- Subsequent Use of Equipment: Equipment can be "free-released" if it meets the requirements of 1.86, NRC Regulatory Guide.
- Subsequent Use of Materials: Materials must be specifically licensed for use as any other radioactive material unless specifically authorized by the state of Tennessee (case-by-case).

- Release/Sale of NORM-Contaminated Land: Not encountered. Property would have to be decontaminated to levels at or very near 'true background.' Land could possibly be sold with institutional controls and restrictions if it was not completely "clean." (case-by-case)
- Projected Volume of stored NORM in the State: Unknown, not characterized in this fashion.
- Respondent: Michael Page.

TEXAS

State agency: Railroad Commission of Texas, Oil and Gas Division, 1701 N. Congress, Austin, Texas 78701. Mailing address: P.O. Box 12967, Austin, Texas 78711-2967. Phone (512) 463-6887.

- At the end of 1994, the Commission adopted a rule (Rule 94) for disposal of oil and gas naturally occurring radioactive material (NORM). In Texas, the RRC regulates disposal of oil and gas NORM waste and the Texas Department of Health (TDH), Bureau of Radiation Control, regulates all other aspects of oil and gas NORM management. In 1994, the RRC adopted regulations for disposal of oil and gas NORM waste (Rule 94). These regulations were developed in consultation with the TDH. NORM that occurs in oil and gas products is exempt from regulation under TDH rules. NORM that occurs in produced water is exempt from TDH rules applicable to transportation and storage and is not subject to special NORM disposal regulations. The rule is based on risk of exposure to NORM. The rule authorizes certain disposal methods for NORM oil and gas waste under certain conditions, and requires specific authorization for other disposal methods. Staff from the RRC, TDH and the Texas Natural Resource Conservation Commission (TNRCC) meet quarterly to discuss radiation issues and to coordinate efforts. In addition, the Texas Radiation Advisory Board (TRAB), which consists of 18 members appointed by the governor, is charged with providing recommendations and technical advise to the RRC, the TDH, and Texas Natural Resources Conservation Commission.

UTAH

State agency: Department of Natural Resources, Division of Oil, Gas and Mining, 1594 W. North Temple, Suite 1210, P.O. Box 145801, Salt Lake City, Utah 84114-5801. Phone (801) 538-5340. Fax (801) 359-3940.

Regulatory agency: Department of Environmental Quality, Division of Radiation Control, P.O. Box 144850, Salt Lake City, Utah 84114-4850. Phone (801) 536-4250. Fax (801) 533-4097.

- Relevant Statute/Regulations: R313-19-13(2)(a)(i)(B) provides that naturally occurring radioactive material (NORM) containing less than 15 picocuries per gram radium-226 is exempt from regulation. Amounts greater than this are subject to licensing.
- Scope: Current rules are somewhat limited in scope. The Conference of Radiation Control Program Directors (CRCPD) has released draft rules for the licensing and

regulation of Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM). The Division of Radiation Control supports this effort.

- Licensing: Requirements for licensing are found in the Utah Rules at R313-22.
- Cleaning Equipment: Licensees are allowed to clean and release equipment for unrestricted release. Methods and procedures are generally approved as part of the licensing process but they may also be approved when a licensee undergoes decommissioning.
- Disposal of Waste: Licensed radioactive waste is generally disposed of by transfer to a licensed low-level radioactive wasteland burial facility. Radiation Control Rules in R313-15-1002 provide for other disposal procedures (on-site burial).
- Subsequent Use of Equipment: Contaminated equipment may be released for unrestricted use once the licensee has decontaminated the equipment Division standards. The standards used as those found in Nuclear Regulatory Commission Regulatory Guide 1.86 (June 1974).
- Subsequent Use of Materials: Licensed materials may be transferred to others for subsequent use provided the transfer is in accordance with R313-19-41.
- Release/Sale of NORM-Contaminated Land: Licensed facilities (land) must meet decommissioning clean-up standards before it may be used for unrestricted purposes.
- Projected Volume of stored NORM in the State: Unknown.
- Other: Radiation Control Rules on Internet: www.eq.state.ut.us/eqrad/dre_hmpg.htm.
- Respondent: Craig Jones

VIRGINIA

State agency: Department of Mines, Minerals and Energy, Division of Gas and Oil, Box 1416, Abingdon, Virginia 24212. Phone (540) 676-5423.

Regulatory agency: Department of Mines, Minerals and Energy, Division of Gas and Oil, P.O. Box 1416, Abingdon, Virginia 24212. Phone (703) 676-5423. Fax (703) 676-5459.

- Relevant Statute/Regulations: At this time, the Commonwealth of Virginia does not have regulations regarding NORM and does not have nor anticipate proposing regulations for naturally occurring radioactive material in oil and gas production.
- Respondent: Byron Fulmer

WASHINGTON

Stage agency: Department of Natural Resources, Olympia, Washington 98504. Phone (206) 459-6372.

Regulatory agency: Department of Health, Division of Radiation Protection, P.O. Box 47827, Olympia, Washington 98504-7827. Phone (360) 753-3459. Fax (360) 753-1496.

- Relevant Statute/Regulations: No specific NORM regulations.
- Scope: WAC 246-221-001 establishes standards for protection against radiation hazardous including Radium-226.
- Licensing: WAC 246-232-120 lists the amount of Radium-226 that is exempt from licensing.

- Cleaning Equipment: WAC 246-232-140 Schedule D lists acceptable surface contamination levels for alpha, beta and gamma.
- Disposal of Waste: 246-249-080 Large volumes of NORM (acceptance criteria).
- Subsequent Use of Equipment: Same as 246-232-1-40.
- Subsequent Use of Materials: Same as 246-232-120.
- Release/Sale of NORM-Contaminated Land: 246-235 Specific License criteria.
- Projected Volume of stored NORM in the State: Not determined.
- Respondent: Gary Robertson

WEST VIRGINIA

State agency: West Virginia Oil and Gas Conservation Commission and the Division of Environmental Protection, Office of Oil and Gas are both located at 10 McJunkin Dr., Nitro, West Virginia 25143-2506. Phone (304) 759-0516.

Regulatory agency: Bureau for Public Health.
- Relevant State/Regulations:
- Scope: Regulations cover radioactive materials but not specific to NORM.
- Licensing: Does not license.
- Respondent: Beattie DeBord

WYOMING

State agency: Wyoming Oil and Gas Conservation Commission, P. O. Box 2640, Casper, Wyoming 82602. Phone (307) 234-7147.

Regulatory agency: Wyoming Oil and Gas Conservation Commission, P.O. Box 2640, Casper, Wyoming 82602. Phone (307) 234-7147.
- Relevant Statute/Regulations: Rule 404(J.).
- Disposal of Waste: Rule 404(J.) - Dispose of produced water, tank bottoms and other miscellaneous solid waste in a manner which is in compliance with the Commission's rules and other state, federal, or local regulations.
- Respondent: Janie Nelson

Regulatory agency: Department of Environmental Quality, Water Quality Division, 122 W. 25th St., Herschler Bldg., 4W, Cheyenne, Wyoming 82001. Phone (307) 777-7082.
- Relevant Statute/Regulations: Chapter 1, Section 22, Water Quality Rules and Regulations. Applied to NPDES permits.
- Scope: Class 1 and 2 waters not to exceed radiological limits established on the most recent Federal Primary Drinking Water standards published by EPA. Class 3 and 4 waters radium-226 concentration shall not exceed 60pci/l.
- Licensing: NPDES individual permit.
- Respondent: Tod Parfitt