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NEGOTIATING NORM CLEANUP AND LAND USE LIMITS: PRACTICAL USE OF DOSE ASSESSMENT AND COST BENEFIT ANALYSIS

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ABSTRACT

Oil companies are presently faced with complex and costly environmental decisions, especially concerning NORM cleanup and disposal. Strict cleanup limits and disposal restrictions are established, in theory, to protect public health and environment. While public health is directly measured in terms of dose (mrem/yr), most NORM regulations adopt soil concentration limits to ensure future public health is maintained. These derived soil limits create the potential for unnecessary burden to operators without additional health benefit to society. Operators may use a dose assessment to show direct compliance with dose limits, negotiating less restrictive cleanup levels and land use limits. This paper discusses why a dose assessment is useful to oilfield operators. It also discusses NORM exposure scenarios and pathways, assessment advantages, variables and recommendations and one recent dose assessment application. Finally, a cost benefit analysis tool for regulatory negotiations will be presented allowing comparison of Oilfield NORM health benefit costs to that of other industries. One use of this tool–resulting in the savings of approximately $100,000–will be discussed.

INTRODUCTION

Radiation rules, standards, and regulations have been in place almost since the discovery of radiation over 100 years ago. These standards and regulations mostly take the form of dose limits for occupational workers and/or members of the public. When establishing property cleanup levels, however, regulations generally adopt soil concentration limits to simplify implementation. These soil limits often overestimate the controls necessary to meet the existing dose limits. As a result, remediation and disposal costs may unnecessarily burden operators without providing the assumed additional health benefit.

Alternative land use options, such as the use of a "centralized facility" for company owned and operated disposal or long term storage, are currently in place in both Texas(RRC,1995) and New Mexico(NMED,1995). Other states allow alternative disposal options on a case by case basis(SOGB,1994). Not all companies will wish to assume the commitment of a company owned storage or disposal facility. For those that do, however, the potential cost and liability savings may be significant.

Dose assessments can be a key tool in negotiating both cleanup levels and effective land use criterion. Significant environmental savings can be realized while ensuring protection of the public and the environment.

DOSE VS. CONCENTRATION LIMITS

Radiation regulations often incorporate a dizzying array of numerical limits and units that to the layperson may appear confusing and even contradictory. Importantly, however, all state and federal radiation regulations adopt either directly, by reference, or through statutory trace ability primary dose limits for occupational workers and members of the public. These dose limits are the last "not to exceed" levels, excepting radiological emergencies, and are based on (1) current scientific knowledge of the biological effects of radiation and (2) careful economic and societal consideration. Typically, federal and state regulations establish 5000 mrem/yr and 100 mrem/yr as the occupational and public dose limits, respectively (NRC,1991).

Secondary limits, such as property release levels, are ultimately derived from the primary dose limits. These soil limits are established, presumably, to ease compliance with the regulation. In theory, soil limits are derived through comprehensive exposure scenario and pathway analysis that assume an endpoint public dose limit such as the 100 mrem/yr. Typical NORM soil limits for unrestricted use are 5 pCi/gm and/or 30 pCi/gm, combined radium 226 and radium 228.

While some states and regulations have adopted soil limits for the release of properties for unrestricted use, most non-NORM regulations omit soil limits in place of primary dose limits and objectives. The EPA has adopted 25 mrem/yr as the public dose limit for nuclear power operations (EPA,1977). The NRC has adopted 25 mrem/yr as the public dose objective for land disposal of radioactive wastes(NRC,1982). Neither regulation prescribes soil limits for property release

Even recently and soon to be proposed regulations are Even recently and soon to be proposed regulations are adopting dose vice soil limits. The EPA's 40CFR196,

Radiation Site Cleanup Regulations, proposes 15 mrem/yr as the public dose limit for unrestricted release of federally controlled sites. The NRC is also expected to propose a dose based regulation. In addition, the Conference on Radiation Control Program Directors (CRCPD) has recently begun work to revise their Suggested State Regulation, Part N, NARM/NORM, to that of a dose based regulation.

While state NORM regulations usually adopt soil levels as release for unrestricted use limits, many other regulations are choosing limits in terms of the primary issue–dose–thereby ensuring that environmental and public health is maintained.

WHY USE A DOSE ASSESSMENT?

Cost Savings

Dose assessments provide several economic and liability advantages when negotiating alternative cleanup and land use limits. The dose assessment allows operators to negotiate modified limits for properties being released for unrestricted use, potentially reducing remediation and disposal volumes and costs. Committed environmental dollars may then be applied to additional sites.

As discussed earlier, soil concentration limits are based on acceptable risk and dose levels, such as the 100 mrem/yr public dose limit. When the 100 mrem/yr public dose limit is applied to a dose assessment incorporating an unrestricted use scenario, soil concentration limits will vary but may be considerably higher than the 5 pCi/gm limit, depending on site specifics. One previous Oilfield assessment assumed the 100 mrem/yr public dose limit and returned a combined radium 226/228 allowable soil concentration limit of approximately 18 pCi/gm(RAE,1996). See the dose assessment case study.

For "centralized facilities", a dose assessment may not only justify higher use levels, it may be the primary basis for the facility's acceptance. Regulatory approval will certainly be nearer when proposed land use levels are shown to maintain public and environmental health through compliance with the primary dose limits.

For properties being retained for restricted use purposes, such as storage or disposal "centralized facilities", dose assessment methods have proven useful. Again depending on site restrictions and conditions, dose assessments adopting the public dose limit of 100 mrem/yr have returned soil concentration limits of 300 and 2000 pCi/gm(Rogers,1996).

Technical and Liability Issues

In addition to the potential remediation and disposal cost savings, dose assessment applications may provide other benefits. The primary public and environmental health issue–dose limits–can be directly addressed. The assumptions, applications, and limitations associated with secondary derived limits often generate significant debate. By directly addressing public dose limits, technical arguments and concerns over future changes to soil limit(s) may be bypassed.

Liabilities associated with changing regulations and limits, long term CERCLA related disposal liabilities and compliance rhetoric may also be averted. In addition, regulatory rapport may be enhanced.

ASSESSMENT METHODS

Exposure Scenarios

NORM exposure scenarios are of two general types: restricted and unrestricted future site use.

Unrestricted future use scenarios are those where the site will be utilized without regard to the presence of radioactive material(s). The most comprehensive unrestricted future use scenario is where a family lives on the released property, grows a portion of its food on the property and drinks water from a well located on the property. Less restrictive unrestricted future use scenarios may be employed if, for example, local geology prevents the growth of food on site or if a public water supply is in place. Other considerations, such as the type of home and construction methods may be important.

Restricted future use scenarios, such as a company owned "centralized facility", may also be chosen. If the property is not to be released for unrestricted use, factors such as site accessibility and occupancy times, radiological transport through the environment, land use, proximity to commercial or residential areas, on site structures and radiological conditions must be considered.

Exposure Pathways

Once the exposure scenario is chosen, pertinent exposure pathways are identified and evaluated. Exposure pathways include those possibilities where an individual could be exposed to contaminated soils, air, water, or food. Pathways include direct irradiation, inhalation and/or ingestion routes. Skin adsorption, while possible, is seldom considered. Based on the above, exposure pathways may include

(Miller,1991), for example:

Soil to man (direct irradiation)
Cloud to man (immersed gaseous cloud)
Soil to air/water/milk/dust/vegetation to man
Soil to vegetation/water to meat/milk to man
Water to fish/shell fish to man
Sediment to fish/shellfish to man

Analysis

The analysis of exposure scenarios, pathways, assumptions, and data is complex. Computations may be performed by hand, using empirical formulas, or by computer, using specifically designed models and software.

Direct irradiation exposures are quantified in terms of exposure rates and time. Inhalation and ingestion exposures are analyzed based on (1) the quantity of radioactive material contained in the water/air/food/soil etc., (2) transfer factors relating inhaled/ingested masses/volumes to that transferred through lungs/intestine into body fluids and (3) amounts of contaminated material inhaled, ingested and consumed per year.

ASSESSMENT ADVANTAGES, VARIABLES AND RECOMMENDATIONS

Advantages

Soil limits in existing NORM regulations were ultimately derived using dose (or risk) assessment methods. Applying a dose assessment to negotiating an alternative cleanup or land use limit poses several advantages, however. General and unnecessarily conservative assessment variables used in the soil limit derivations can be replaced by current and site specific data. In addition, future use of the site can be incorporated.

The methods and assumptions used in deriving soil limits from dose limits are by nature general and conservative. When performing a dose assessment, site specific, current or recent data may be utilized, however, providing more accurate values. Select site specific data may be gathered thereby reducing the effect of inaccurate assumptions. Recent technical data may also be available that more accurately portrays transfer factors, uptake rates, external dose equivalent rates, etc.

Additionally, for properties that are not being released for unrestricted use, such as storage or disposal sites, factors such as site accessibility and location, access control and deed restrictions may be incorporated to negotiate modified use limits.

Variables

The following is a list of site specific and/or technical variables that, depending on assumptions or specifics, may impact assessment results.

1. Radium 226 to Radium 228 ratios
2. Site source characteristics such as homogeneity, depth, distribution, etc.
3. Geologic parameters
4. *f1* value, relating radionuclide transfer rates across the GI tract(Raabe,1996)
5. Survey instrumentation, energy dependence and directional response(Ansari,1996)
6. Effective external dose equivalent rates(Ansari,1996)
7. Radionuclide concentrations

Recommendations

The following may prove useful when performing a dose assessment:

1. Obtain site specific data, where possible. Site specific parameters such as soil density, moisture content, and chemical structure, for example, may increase assessment accuracies and credibility.

2. Conduct a technical review of radiation and NORM literature to assure that current and appropriate assessment variables such as bioaccumulation factors, ingestion and inhalation rates, dust loading, radon emanation coefficients, transfer rates, etc. are used.

3. Select site survey instrumentation carefully. Understand instrument limitations concerning energy dependence and directional response. Give consideration to obtaining site readings using energy independent instrumentation(Ansari,1996).

4. Perform a site characterization determining: radionuclide concentrations and ratios, surface and subsurface contamination profiles, radiation levels, etc.

5. Consider holding a scoping meeting with the appropriate regulatory agency to determine their policies, knowledge and restrictions concerning the proposed assessment application and methods. Enlist their assistance in planning the site characterization and dose assessment, as appropriate.

A DOSE ASSESSMENT CASE STUDY

An excellent example of the application of dose assessment methods in determining alternative cleanup or in situ levels is the technical basis for the recently promulgated Mississippi Oil and Gas Board Rule 69, Control of Oilfield NORM(RAE,1996). The assessment scenario, exposure pathways and assumptions are as follows:

A public individual establishes residence on a site released for unrestricted use after Oilfield operations are terminated. The resident lives in a slab on grade house and spends 700 hours per year indoors and 6300 hours per year outdoors. The resident grows part of his food on the site land which exhibits a heterogeneous NORM profile originating from scale contamination. The resident is exposed through direct irradiation, radon inhalation, food ingestion, and inadvertent dust inhalation and soil ingestion. Assumptions include a 100 mrem/yr public dose limit, a 1:1 radium 226 to radium 228 ratio, and a radon emanation coefficient is 5%.

The dose assessment and analysis concluded that the 100 mrem/yr corresponds to a combined total radium soil concentration of about 18 pCi/gm. The unrestricted use scenario and 100 mrem/yr public dose limit clearly establish acceptable cleanup levels well above the currently prevalent criterion of 5 pCi/gm.

COST BENEFIT ANALYSIS

Society's acceptance or rejection of particular laws, regulations, safety features, consumer products, and/ or health care actions by default provide a picture of the value we place on public health and safety. These safety actions and their public value each vary in cost to society and those bearing that cost burden. Ideally, costs and benefits should be balanced so that overall public policy is promoted without undue burden to particular sectors of society. By performing a cost benefit analysis regarding NORM cleanup levels and options, operators can, with a common language and set of tools, help determine whether they are bearing undue cost burdens. The cost benefit analysis may best be employed as support when it "makes sense", in practical, business and regulatory terms, that a modified cleanup or site use criterion be negotiated.

Studies have shown that societal costs per life saved vary significantly. The value of costs per life saved for health care actions, transportation safety, and consumer product safety are estimated at 2.6, 1.9 and 1.4 million dollars, respectively (Baum,1994). Costs per life saved for occupational safety and radiation related activities are estimated at 85 and 490 million dollars(Baum,1994). The mean avoided fatality cost is estimated to be 2.1 million dollars (Baum,1994).

"Value of Dose Avoided"

When radiation risk/dose coefficients are applied to these and other safety actions and public health cost averages, "the value of dose avoided" is determined. The "value of dose avoided" is used to determine if the benefits of a given safety action or practice are consistent with the costs. The "value of dose avoided" is estimated using national and international practices to be approximately $1000 per person-rem for members of the public(Baum,1994). Nuclear power plants adopt dose avoidance values of between $2500 and $25,000 per person-rem.

While the above concepts, estimates, and calculations are complex and beyond the scope of this paper, the "value of dose avoided" can be utilized in discussions and negotiations with radiation regulatory agencies. Operators can perform a dose assessment to determine the radiation dose associated with a proposed site release or use scenario (A more accurate dose would be the differential dose between the proposed scenario and the strict compliance scenario). The differential cost associated with not adopting the proposed scenario is then ratioed to the scenario dose (or differential dose) and compared to the generally accepted $1000 per person-rem. Radiation agencies may show particular interest in comparison to other radiation industries, such as commercial nuclear power.

A COST BENEFIT ANALYSIS CASE STUDY

One oil company was faced with the remediation of NORM materials on the bottom of a shallow lake bed. State NORM regulations specified radium 226 and 228 limits of 5 pCi/gm or 30 pCi/gm above background as the release for unrestricted use criterion, depending on the radon emanation rates. NORM concentrations varied from background to well above 30 pCi/gm with the average of NORM levels below 30 pCi/gm being closer to 5 pCi/gm than 30 pCi/gm. A dose assessment analysis was performed with an unrestricted use scenario and water/sediment to shellfish to man exposure pathways. Direct irradiation, radon, inhalation and ingestion pathways were disregarded.

Individual annual and lifetime dose estimates were calculated as .4 mrem/yr and 28 mrem/70 year lifetime. Remediation and disposal costs for the NORM materials below 30 pCi/gm were estimated to be approximately $100,000. These estimates were based on 122 bbls (93 drums) below 30 pCi/gm, remediation rates of $10,000/ day and disposal costs of $500/drum.

Cost Benefit ratios yielded results of $35,000 per person-mrem. Nuclear power industry "values of dose avoided" were assumed to be $10,000 per person-rem, or $10 per person-mrem. Based on the above, the project cost to cleanup to the 5 pCi/gm level equated to a standard 3500 times more stringent than that adopted by common commercial nuclear power plants (35,000 times more stringent than the "value of dose avoided"). The applicable regulatory agency approved the adoption of the 30 pCi/gm standard.

In this case study it "made sense" to adopt a modified cleanup standard. Future use of the site was improbable. Viable exposure pathways were few and those given analysis were themselves improbable. The cost benefit analysis gave the operator a tool and common language with which to negotiate regulatory approval for what simply "made sense".

CONCLUSION

Environmental issues pose many challenges for oil companies. Aside from other associated and myriad issues (long term liability, regulatory compliance, public perception, near and long term litigation potentials, property value, corporate responsibility and business prudence), near term cleanup and disposal costs may be prohibitive. Dose assessment methods and cost benefit analysis may provide companies the tools to significantly reduce those costs, however, while ensuring that environmental and public health is maintained.

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