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# DRAFT

## ISSUES RELATED TO REGULATION OF REUSE/RECYCLE OF SCRAP METAL SLIGHTLY CONTAMINATED BY RADIOACTIVITY

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# SUMMARY

The United States Nuclear Regulatory Commission (NRC) is considering options for the regulation of reuse/recycle and release of metals contaminated by low levels of radioactivity. While the Commission's regulations have long provided for release to unrestricted areas of small amounts of gaseous and liquid radioactive matter to air and water, they do not address releases of slightly radioactive solid materials to unrestricted areas. For a number of years, the NRC staff has provided criteria for such releases to specific dispositions, but until recently there has been no apparent need to develop generic regulations for reuse/recycle of scrap metal (RRSM) slightly contaminated by radioactivity. The question now before the Commission is: Is there a need for the Commission to revise its regulations regarding such material; if so, to what extent should they be revised and according to what criteria? The purpose of this paper is to address the question and present significant issues associated with it.

This document is divided into two parts. The first is a discussion of the background of the subject matter, a summary of the current status in government and industry regarding RRSM, and a discussion of possible regulatory approaches. The second part addresses the significant issues related to RRSM and considers pertinent questions surrounding each issue. Responses of stakeholders to these issues and questions are solicited.

Should the Commission decide to go forward with rulemaking, it will use the responses of stakeholders as a guide in developing a draft amendment to its regulations and a draft Environmental Impact Statement (EIS). Each of these will be published for public comment. Based in part on the responses of stakeholders, the Commission may also decide against going forward with rulemaking. Instead, the Commission might direct its staff to revise the current Regulatory Guides to address RRSM issues. Draft versions of revised Regulatory Guides would also be subject to public comment.

The Commission has identified the following primary issues concerning RRSM:

- *Is there a need for NRC rulemaking to provide for unrestricted release of RRSM into public commerce?*
- *Should the Commission proceed with rulemaking? If so, how should it proceed?*
- *If the Commission were to proceed with rulemaking, what should be the scope of the rulemaking?*
- *What should be the objective for regulating reuse/recycle material?*
- *At what numerical levels would the objective(s) for regulating reuse/recycle material provide an acceptable basis for protection of the public health and safety and the environment?*
- *How should practicality considerations be applied in any radiological criteria for a reuse/recycle rule?*

Related sub-issues and secondary issues are presented in the main text, together with a brief discussion of their scope and implications.

# 1. BACKGROUND

## 1.1 Introduction

The United States Nuclear Regulatory Commission (NRC) is soliciting the assistance of stakeholders in its development of regulatory options for reuse/recycle of metal (RRSM) slightly contaminated by radioactivity. Historically, the Commission has allowed various practices involving radioactive materials under controlled conditions such that persons in off-site, unrestricted areas would not experience radiation exposure from the practice that is greater than a fraction of natural background radiation levels. In developing a regulatory approach to RRSM, the Commission intends to maintain this historical stance of protecting public health and ensuring environmental safety.

Potential stakeholders in this case include other federal agencies; state and local governments; Native American tribes; industry representatives; public interest groups; and members of the public. Their comments will be used to assist the Commission in determining whether there is a need for a new regulation (also known as a rule) and if so, what issues such a rule should address and how it should address them. The Commission will proceed slowly and deliberately in this rulemaking process; this formal request for comments of stakeholders is a crucial first step. If the Commission should decide to pursue rulemaking in this matter, the comments received will provide input to the development of a proposed regulation. Further stakeholder comments will be requested at that time.

Pursuant to the National Environmental Policy Act of 1970 (NEPA), if rulemaking is pursued, the Commission will also publish an Environmental Impact Statement (EIS) in conjunction with this rulemaking. Since a Generic Rulemaking is contemplated, the Environmental Statement will be referred to by the Commission and the NRC staff as the Generic EIS, or GEIS. The GEIS will cover a number of topics, such as why this rulemaking is being undertaken, what relief the rule is expected to provide, and what environmental consequences may be expected as a result of the rule. Persons submitting license applications pursuant to NRC regulations also may be required to submit an EIS for a specific practice.

The NRC may hold public hearings on the GEIS. A draft GEIS will be distributed for review to NRC Public Document Rooms and to interested groups, including federal and state government agencies, Native American tribes, industry representatives, public interest groups, and international agencies. Comments received by the Commission will be thoughtfully considered.

At the outset, it would be helpful to define the terms "reuse," "recycle," and "release;" they have specific meanings when used in regulations of the kind discussed here. In this context, "reuse" implies use of an object that has not been physically or chemically changed, whereas "recycle" implies a change in the form or use of the material. This change may include physical and chemical changes, including melting and re-fabrication. "Release" means allowing radioactive materials to enter unrestricted areas (such as the public domain), which are generally beyond the boundaries of NRC-licensed facilities, for unrestricted use. Many materials are "reused" within the NRC-licensed nuclear industry. No new regulatory effort is contemplated in that regard.

## 1.2 Types of Recycling

Three types of recycling are possible: closed, open, and restricted. In closed recycling, the radioactive material never leaves the licensed system, and no changes to NRC regulations would be necessary. Under current regulations, a furnace operator must have a license to receive any radiologically contaminated metal to be melted and blended with other non-radioactive metal. The licensee must conform to all applicable regulations in its operations, including those of the NRC, as well as federal, state, and local environmental protection agencies. As described below, this closed cycle recycling (licensee to licensee) of slightly radioactive iron and carbon steel is currently being conducted on a moderate scale at selected U.S. Department of Energy (DOE) facilities.

Open recycling, which currently is not allowed generically under NRC regulations would involve what is referred to as "free release" or "release for unrestricted use." In this case, a licensee would be authorized to release solid materials into unregulated commerce, which could involve melting, re-fabrication, use of slightly radioactive scrap metal in the public sector, or disposal of slightly radioactive scrap metal in a private or public landfill.

The third kind, restricted commercial recycling, also is not allowed generically under current NRC regulations. Such recycling might involve melting radioactive scrap metal at a licensed facility (a licensed furnace), and subsequently releasing the metal for a specific, unlicensed (but perhaps regulated) "first use." This designated initial use most probably would be in heavy industry, such as for bridge supports, locomotive parts, structural supports for large buildings, or for a military application. Radioactive scrap material having very low radioactivity might be used for consumer products such as automobile engine blocks. Since restricted first use is amenable to controls and inspections, exposure rates of workers and the public can be controlled, and maintenance of an inventory is possible. The products of such first use of recycled metals could be labeled, much as irradiated produce is labeled.

## 1.3 Release of Radioactive Material

For decades, non-dangerous concentrations of radionuclides in gaseous and liquid forms have been released from NRC-licensed facilities into the air and water of unrestricted areas under tightly controlled conditions specified in NRC regulations.[1] In addition, certain common household items, such as smoke detectors, contain small amounts of radionuclides; these and certain other devices containing radionuclides are exempted from licensing requirements, although the manufacturers of such devices are subject to NRC regulations.

However, release of slightly radioactive solids is not addressed in current NRC regulations. As discussed below, NRC staff has provided guidance regarding release of surface-contaminated materials through the Commission's Regulatory Guide 1.86 ("Termination of Operating Licenses for Nuclear Power Plants"), but neither the Commission nor its staff has addressed acceptable conditions for release of materials with volumetric contamination.

## 1.4 Approach to Rulemaking

In an attempt to address a broad range of actions, including exemptions from Commission regulations and the development of generic health and safety standards, the NRC published a draft Below Regulatory Concern (BRC) Policy in 1990. Subsequent to publication of the draft policy, the Commission placed an indefinite moratorium on BRC Policy implementation in consonance with new legislation resulting from adverse public concern. In an effort to address public concerns before issuance of new policies and regulations in this regard, the Commission has since decided on a new approach—enhanced participatory rulemaking with a more focused scope. This approach has been employed recently to address the critical need for generic site cleanup and decommissioning standards for NRC-licensed facilities. In this type of rulemaking activity, the input of stakeholders is actively solicited at the outset. The

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[1] 10 CFR Part 20 "Standards for Protection Against Radiation; Final Rule", 56 FR 98, pp 23360-23474, May 21, 1991.

Commission believes that such a process will result in regulations that more accurately acknowledge pertinent issues and address stakeholder concerns while preserving public health and safety. It is in this spirit that the Commission is soliciting participation in the proposed development of a rule for RRSM.

The NRC shares regulatory authority with the United States Environmental Protection Agency (EPA) regarding releases of radioactivity into the public domain. Concurrent with this rulemaking effort, the NRC and EPA have undertaken a cooperative effort to avoid redundancy. In particular, EPA is expected to conduct appropriate public workshops with regard to recycling, whereas the NRC will not. Accordingly, the NRC plans to consult extensively with EPA throughout this rulemaking process. The NRC will also participate in other EPA efforts in this area, such as the activities of the EPA Interagency Working Group on Radiation Protection. The objective of these cooperative efforts is to help ensure that any NRC rules established in this enhanced participatory rulemaking will be sufficient to protect public health and safety and utilize resources in a more cost-effective manner.

The NRC is well aware of current discussions in the technical community regarding dose and health effects models used to assess human health effects from exposure to low-level radiation. For its dose and health effects estimates the NRC will continue its past practices as summarized in its discussions pursuant to its recent revisions of 10 CFR Part 20.[2] Also, the Commission will model and assess both individual and collective doses and health effects. For dose estimates the Commission will continue to use the standard model of the International Commission on Radiation Protection (ICRP), as described in ICRP Publication No. 30, "Limits for Intake by Workers" as modified appropriately to account for age distributions in the population. For health

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[2] Ibid.

effects estimates, the Commission will rely predominantly on the recommendations of the National Academy of Sciences and the National Council on Radiation Protection.

The Commission regards any reconsideration or alteration of these models as beyond the scope of this rulemaking.

# 2. NEED FOR RULEMAKING

## 2.1 Decommissioning and Decontamination of Nuclear Sites

This paper addresses issues that arise from efforts of the nuclear industry and federal, state, and local governments to decommission, decontaminate, and clean up nuclear facilities and sites. Most of the radioactivity at such sites is either stored on site or disposed of in licensed Low Level Waste (LLW) facilities. Commercial LLW burial sites are licensed by the NRC, as provided for by the Atomic Energy Act of 1954, as amended, and the Low Level Waste Policy Act of 1985. LLW burial sites operated by DOE accommodate only DOE wastes, and do not fall under NRC jurisdiction. These sites are also subject to a variety of EPA licensing requirements as well as to state and local government laws and regulations.

NRC regulations currently do not set out criteria under which solid materials (e.g., metals) containing low levels of radioactive contamination may be safely released by licensees into the public domain. In the absence of such regulatory criteria it may be that materials which could be safely utilized by the public are being stored indefinitely or disposed of as radioactive waste. The NRC desires to explore approaches to amending NRC regulations to allow reuse/recycle of such materials while maintaining protection of public health and safety and the environment.

The cost for commercial disposal of LLW in 1997 is about $300 per cubic foot. While the range from site to site is great, the average operational cost for DOE disposal in 1994 was approximately $45 per cubic foot for LLW disposal at DOE facilities.[3] In addition to such economic costs, replacement of metals requires many energy

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[3] Warren, S., *et. al.*, <u>Cost Model for DOE Radioactively Contaminated Carbon Steel for Recycling</u>, U.S. Department of Energy, November 1995.

consuming steps (mining, milling, smelting, etc.), resulting in at least some environmental contamination and/or degradation, as well as risks to workers. For some scrap materials, there may be a net reduction in such adverse effects by recycling slightly radioactive scrap metal stored at NRC- and state-licensed facilities.

The scope of these concerns with RRSM can be illustrated using iron, steel, and nickel as examples. At DOE facilities alone, the market value of slightly radioactive scrap iron, steel, copper, and aluminum has been estimated to be in the range of two hundred million dollars. The market value of nickel stored in DOE facilities has been estimated at one to two billion dollars. The amount of scrap steel that will be available from commercial nuclear power plants decommissioned by the year 2000 is very small by comparison. These points are illustrated in Table 1 below:

**Table 1: Steel Production and Use in the United States**

| SOURCE | AMOUNT OF STEEL (Metric Tonnes) | VALUE (Millions $) |
|---|---|---|
| DOE Sites | 1,300,000 | 140 Total |
| Nuclear Power Plants | 85,000 | 10 Total |
| U.S. Annual Production | 100,000,000 | 11,000 per Year |

Although the values in this table are approximate[4], they illustrate the point that the total mass of slightly radioactive steel to be reused/recycled is only a small fraction of the annual production of steel in the United States. While quantities of steel produced and used have been estimated, the NRC is unaware of any compilation of radionuclide inventories associated with slightly radioactive scrap metal in the United States.

[4] Establishing Cleanup Standards for Radioactive Scrap Metal, March 14, 1994, The Energy, Environment, and Resources Center, University of Tennessee.

The 240,000 tons of nickel stored in DOE facilities is very large compared to annual United States consumption (63,000 tons in 1989)[5]. Thus, DOE scrap nickel amounts approximately to a four-year supply for the United States. Although the stored nickel may be very valuable in total dollars, it would have to be released at a very slow rate, perhaps over decades, to avoid any serious adverse effect on the market. The net monetary values of radioactive scrap metal presented above need to be adjusted downward to account for costs (uncertain at present), associated with reuse/recycle and release.

As nuclear power plants are decommissioned, a large amount of high quality steel and other metals will be available for reuse/recycle or for disposal and burial. In a viable nuclear power plant construction economy, such material might be reused/recycled (in a closed system) in new nuclear power plants. However, since new construction of nuclear power plants is currently not occurring in the United States, this metal will have to be disposed of in some other fashion. Recycling to other uses could be a viable alternative for at least some of this high quality steel.

## 2.2 Regulatory Environments

### 2.2.1 Introduction

A full understanding of regulatory issues concerning RRSM and possible approaches to their resolution requires examining them in the context of the current regulatory environment in the United States, other countries, and international organizations. This

[5] "Establishing Cleanup Standards for Radioactive Scrap Metal," March 14, 1994, The Energy, Environment, and Resources Center, University of Tennessee.

section provides a brief summary of relevant regulations and practices in the United States and selected foreign countries.

### 2.2.2 Possible Future Regulatory Environment

It should be noted that although the NRC does not currently regulate DOE facilities, legislation currently being drafted[6] by DOE could change this situation over the next decade or so. If any such legislation is enacted, the NRC or the Agreement States would then regulate and license any DOE facility reusing, recycling, releasing, or disposing of radioactively contaminated materials.

### 2.2.3 Related NRC Regulations and Practices

NRC regulations are found in Title 10 (Energy) of the Code of Federal Regulations (10 CFR, in brief). Part 20 of this Code[7] limits releases of gaseous, liquid, and particulate radioactivity to air and water from restricted areas (in the on-site, regulated environment). Releases from operating nuclear power plants are allowed only to the extent that exposures of any person in the unrestricted area due to all such releases will not exceed 100 millirem per year. For other than nuclear power plants, off-site exposure rates must not exceed ten millirem per year.[8] As a reference point, the average dose rate in the general environment due to naturally occurring radioactivity—principally terrestrial radon and cosmic rays—is approximately 300 millirem per year. Also, the variation in the dose rate in the United States from naturally occurring radioactivity is in the range of 100 millirem per year, such that a person living

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[6] DOE Press Release, R-96-182, December 20, 1996.

[7] 10 CFR 20, "Standard for Protection Against Radiation"; Final Rule, FR, 56, 98, pp 23360-23474, May 21, 1991.

[8] 61 FR 65120, December 9, 1996; effective date January 9, 1997.

in some Western geographic locations (e.g., Denver) may receive a dose rate one third greater than that of persons in a Southeastern river delta region.

Permissible radioactive effluents to water and radioactive emissions to air from NRC-licensed sites are carefully controlled and monitored. The environment in the vicinity of major nuclear facilities is also carefully monitored to assure that allowed off-site exposures (doses) are not exceeded. Monitoring is routinely conducted by the licensees, with oversight by the NRC and the state in which the licensed facility resides, to ensure that precluded doses are not exceeded at the site boundary (public exposures from operations are usually found to be much smaller than the limits imposed by the regulations).

NRC regulations at 10 CFR Part 30.70 (Schedules A and B - Exempt Quantities) contain tables of exempt quantities and concentrations of certain radionuclides, for which an NRC license is not required (as provided for in the Atomic Energy Act). These are very small quantities of radioactivity (in the microcurie range), the commerce of which is unregulated. However, the generators of such quantities and concentrations may be regulated.

Over the years the NRC staff has developed a series of publications called Regulatory Guides (containing Staff Regulatory Positions) that it uses to provide guidance on complying with the Commission's Regulations. An applicant for a license must conform either to the Staff Regulatory Position(s), provide an alternative acceptable to the staff, or (in rare cases) request relief from the Commission.

NRC Staff Regulatory Guide Number 1.86, <u>Termination of Operating Licenses for Nuclear Reactors</u>, June 1974, is important to note. It provides a table of acceptable smearable surface levels of radioactivity for objects whose surfaces are slightly radioactive but which may be released unconditionally to unrestricted areas. While

Reg. Guide 1.86 is not a regulation, it is used as guidance in disposing of some low-level surface-contaminated radioactive material.

The EPA has provided descriptions of levels of effort that might be applied to cleanup activities at Superfund sites (see BACT, BDT, GACT, MACT, and residual risk definitions in Appendix A). The relevant question for reuse/recycle is, "What control technology must a licensee use to clean metals contaminated by surface radioactivity before the metal can be released to unrestricted areas and general commerce?"

In 1981, the NRC's Office of Inspection and Enforcement (IE) issued IE Circular No. 81-07, Control of Radioactively Contaminated Material, which set forth detection capabilities and criteria for releases of slightly contaminated materials from nuclear power plants. Its provisions were essentially the same as those of Reg. Guide 1.86.[9]

In many Agreement States, Reg. Guide 1.86 is an accepted standard for unconditional release of materials with radioactive surface contamination. This Guide is the basis for a similar table in DOE Order 5400.5 (Radiation Protection of the Public and the Environment)[10], which is the pertinent guidance for DOE sites and their contractors. DOE is currently preparing a final rule (regulation) that will encompass much of DOE Order 5400.5. Also, a committee of the American National Standards Institute (ANSI) is currently developing a new national standard based on Reg. Guide 1.86. NRC staff is represented on this committee.

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[9] Copies of Reg Guide 1.86 and IE Circular No. 81-07 can be found in Appendix B.

[10] A copy of Table IV-1 from DOE Order 5400.5 is also provided in Appendix B. This Appendix illustrates the current U.S. practices in regard to the release of radioactively contaminated solids to unrestricted areas.

It is noted that Reg. Guide 1.86 is based on detection (instrument) capabilities, not on risk. Moreover, being a surface density guide, it places no limit on the amount of radioactivity that could be released to unrestricted areas. The NRC does not have criteria for release to non-licensees of materials contaminated volumetrically (in bulk) by radioactivity. Further, while the NRC regulates radioactive source, byproduct, and special nuclear material, it does not regulate commerce involving naturally occurring or accelerator-produced radioactivity.

In 1995 the NRC published a draft regulation[11] containing criteria for decommissioning a nuclear power plant site and releasing it for unrestricted use. The Commission is now considering publication of a final decommissioning regulation. It was proposed in the draft that unrestricted use of a radiologically contaminated site would be acceptable if the expected dose rate to individuals occupying and/or utilizing the site would not exceed 15 millirem per year, i.e., a small fraction of the natural background dose rate.

2.2.4 Agreement States

The Atomic Energy Act of 1954, as amended, provides for regulation of certain radiological operations and facilities by states provided the state regulations are at least as restrictive as those of the NRC. About half of the states have opted to perform these regulatory functions. Such states are called "Agreement States," reflecting the fact that a formal agreement between the state and the NRC has been signed.

The Low Level Waste Policy Act of 1985 granted the states the right to carry out certain acts regarding disposal of radioactive wastes, including establishment of State Compacts and development of LLW disposal sites. It is clear that state and local

[11] 59 FR 43200, "Radiological Criteria for Decommissioning (Proposed Rule)," August 22, 1994.

agencies play a vital role in disposing of radioactively contaminated materials. In this regard, while the Commission recognizes that federal, state, and local responsibilities may overlap, such overlap is beyond the scope of this rulemaking and any such issues will be addressed in a different venue.

### 2.2.5 U.S. Department of Energy

In September 1996 DOE initiated an effort to recycle scrap steel presently located on DOE sites into fabricated carbon steel containers for storage of low level radioactive waste awaiting shipment and burial in a DOE LLW disposal (burial) site. Manufacturing Sciences Corporation in Tennessee (an Agreement State) has been contracted[12] to recycle some 750 tons of DOE scrap into waste containers under a State of Tennessee radioactive materials license. This is an example of restricted first use recycling. In this case, the refabricated metal is returned to DOE from the licensed furnace, never leaving the regulated environment.

As noted above, DOE Order 5400.5 (Radiation Protection of the Public and the Environment) includes a table similar to that in Reg. Guide 1.86. Like the NRC, DOE does not have criteria for the release of materials containing bulk radioactivity. In 1993, DOE published a draft regulation for comment that contained the essentials of Reg Guide 1.86. This rule has yet to be finalized.

### 2.2.6 U.S. Environmental Protection Agency

EPA has proposed to address the subject of RRSM, but it has not yet done so. EPA has promulgated two pertinent rules, however. In 1976 EPA published a uranium fuel cycle rule, 40 CFR 190, which provided for an annual dose rate limit of 25 millirem to an

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[12] The Small Scale Metals Recycle Project at DOE's K-25 Site.

off-site individual due to all activities in the commercial uranium fuel cycle. This 25 millirem per year figure is approximately one twelfth the annual dose rate to an individual due to natural background radiation. At the time EPA promulgated this rule, it had not explicitly considered recycle or release of slightly radioactive materials in the public domain. Since it is highly unlikely that a member of the general public would be exposed to radioactivity from more than one commercial fuel cycle activity, 25 millirem per year to an individual might represent a maximum dose rate criterion for off-site doses from recycling. But a fraction of 25 millirem per year could also be inferred, simply because recycling has been considered to be in the "other minor impacts" category, i.e., a small part of the commercial uranium fuel cycle.

EPA has also promulgated a rule regarding cleanup of so-called "Superfund" sites. Under this rule, a Superfund site may be released for unrestricted use if the lifetime cancer incidence risk due to an individual's use of the site is estimated to be in the range $10^{-6}$ to $10^{-4}$ cancers per person[13] due to all contaminants, including radioactivity remaining on the site after cleanup is completed. No Superfund site has met the EPA's criteria for unrestricted use, and no such site has been released from regulatory controls. As with the NRC's decommissioning rule, however, once a Superfund site is released from regulatory controls and then sold, the new owner could dispose of residual radioactivity or other contaminants in any way.

### 2.2.7 International Criteria

As it pursues reuse/recycle rulemaking, the NRC expects to continue to take into account principles and criteria developed by international organizations. There is a continuing viable international effort to cooperate in development of and adherence to laws, regulations, and practices associated with nuclear energy and radiation. Although

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[13] One cancer per million individuals to one cancer per ten thousand individuals.

the Commission is not soliciting comments at this time about these international activities, the current status of such activities may be of interest to stakeholders.

Efforts by the international community to achieve consensus on relevant matters have had a focal point in a program begun in 1973 at the International Atomic Energy Agency (IAEA). State-of-the-art reports in 1983, 1985, and 1986 on facility decontamination and decommissioning pointed to the need for "exempt quantity or concentration" criteria to permit unrestricted reuse/recycle or release.

This observation led in 1988 to IAEA Safety Series No. 89 (SS-89) which outlined internationally agreed-upon principles for developing criteria for exempting sources and practices from regulatory control, including reuse/recycle. Two criteria determined exemption candidates: (1) individual risks must be sufficiently low not to warrant regulatory concern; and (2) radiation protection, including the cost of regulatory control, must be optimized by exemption. To meet the first criterion an individual dose considered trivial had to be defined, and for the second, optimization analysis techniques, (e.g., cost-benefit analyses) were needed.

Using two approaches—choosing a risk and corresponding dose of "no significance to individuals" and using natural background as a reference level—the IAEA concluded that a "trivial" individual dose would be about one millirem[14] per year. It also concluded that, using a minimum value of $30 per person-rem, a practice-related trivial collective dose would be a few hundred person-rem. It further suggested limiting the contribution of an individual practice to one millirem per year for individual dose and a commitment of 100 person-rem per year of practice for collective dose.

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[14] The sum of all individual doses, in rems, is called the "collective dose" and is assigned the unit, "person-rem."

A 1988 state-of-the-art report on component recycle/reuse and another in 1992 on monitoring for unrestricted release summarized the application of exemption criteria and the range of criteria values in use internationally, using scrap metal recycling as an illustration. Criteria are set in most countries on a case by case basis and, for mass activity, range from 0.1 Becquerel per gram (Bq/g) to 10 Bq/g.

Using this work as background, IAEA Report SS-111-P-1.1 in 1992 outlined a methodology for applying SS-89 exemption principles to develop numerical criteria for reuse/recycle of materials, including steel. Using scenarios that model metal reuse/recycle from scrap delivery to consumer product distribution, and accounting for public exposure to slag in asphalt, sheet steel in buildings, appliances, and automobiles and even steel in frying pans and equipment, calculations were made of: (1) concentrations (Bq/g or Bq/cm$^2$) that result in the individual exemption criterion of one millirem/yr; and (2) the annual quantity of reused/recycled material released at these concentrations should result in a collective dose commitment of no more than 100 person-rem.

The concentration in IAEA Report SS-111-P-1.1 for alpha emitters was 0.3 - 1.0 Bq/g (with an acceptable reuse/recycle amount of 2x10$^4$ to 6x10$^4$ tonnes/year) and for photon emitters, 0.1- 0.6 Bq/g (acceptable amount, 5X10$^3$ to 6X10$^4$ tonnes/year). In general, the derived individual exemption levels were three to five orders of magnitude more restrictive than the derived collective exemption levels.

A sensitivity study of the effects of nuclide partitioning, dilution with non-active steel, and a larger mass recycled per year showed that the results were robust: alpha emitter levels three to four times more restrictive (smaller) than the base case due to increased reuse/recycle (10,000 tonnes/year of steel compared with the base case of 100 tonnes/year), and photon emitter levels about ten times less restrictive (larger) due to dilution.

The report noted that, to protect sensitive materials, limits lower than those derived based on health concerns may be required. The report also noted that, once material left regulatory control for unrestricted use, some of it might be disposed of as waste rather than being reused/recycled, but that even if a significant fraction was so disposed of, criteria for exemption for landfill disposal were unlikely to be exceeded. Nevertheless, the report observed, national authorities may require a more robust evaluation of alternative potential future uses of exempt materials.

Among key principles fundamental to radioactive waste management as put forth in the 1995 IAEA Report SS-111-F, one recognized that although the preferred approach to acceptable protection of the environment is concentration and containment of radioactive waste rather than dilution and dispersion, the reuse of materials and the release of substances within authorized limits are both legitimate practices. Another principle recognized that generation of waste could be kept to the minimum practicable through appropriate design and by employing effective operating and decommissioning practices, including materials reuse/recycle.

In 1996, six international intergovernmental agencies agreed on revised basic safety standards (SS-115) which recognize that "justified" practices, and sources within practices, may be exempted if they meet the criteria of one millirem/yr for individual dose and 100 person-rem/yr committed collective dose.

# 3. ISSUES FOR DISCUSSION

The Commission requests comments regarding amendment of NRC regulations to allow RRSM. Before the Commission formally decides whether to proceed with rulemaking regarding RRSM, it is prepared to consider a wide range of alternative approaches, including maintaining the status quo, revising its Regulatory Guides, or reviewing its regulations. The basic question before the Commission is: "Should the Commission proceed with rulemaking, and if so, how should it be structured to assure adequate protection of public health and safety and of the environment?" The answer to this question must be reasonable, practical to implement, and enforceable for the broad range of materials or objects which may be reused/recycled or released.

The Commission believes that the key issues and sub-issues discussed below are at the foundation of the basic question posed above. Secondary issues which are relevant to some degree are also identified. Accordingly, the Commission solicits comments and information on these issues before proceeding with a proposed rulemaking. Comment on these issues, as well as other relevant and substantive issues identified by interested parties, will help the Commission determine whether to proceed with rulemaking and—if the Commission does decide to proceed—will be used by the NRC in developing a proposed rule.

The issues which are presented are posed as questions. A discussion then follows to define the scope of the questions and to clarify the issue.

It is important to recognize that the Commission does not regulate naturally-occurring radioactivity or fallout from weapons or other such sources beyond its authority. Therefore, the following issues are to be considered only as they apply to radioactivity that is attributable to NRC-licensed operations and detectable above natural background levels.

***ISSUE 1: Is there a need for NRC rulemaking to provide for unrestricted release of RRSM into public commerce?***

Discussion:

As indicated in the introductory material, a need may exist for rulemaking in this area. However, before proceeding, the Commission seeks to obtain input from interested parties as to whether there is sufficient potential public benefit to justify proceeding with such a rulemaking. A key question is whether RRSM in the commercial marketplace is necessary or desirable in the near future. It may be that the currently permitted closed cycle recycling at licensed facilities is sufficient for practical purposes. On the other hand, there are risks associated with a "do nothing" option. These might include costs in terms of worker person-rems, as well as costs of storage, controls, and loss of resources related to the value of slightly radioactive scrap metal. Other costs might be represented by environmental impacts of producing additional metals for use in commerce instead of recycling existing metals. In addition, a fundamental tenet of sound radiation protection practice is that no exposures to ionizing radiation should be allowed without commensurate benefits. Expecting that very low public exposures would be allowed by an NRC rule, at least commensurate benefits should be expected.

***Sub-issue 1.1: Is such reuse/recycle in the public interest? What would be the justification for allowing commercial, open-ended RRSM? What are the benefits, and to whom would they accrue? Can they be quantified so that risks and benefits can be compared? If so, how?***

***Sub-issue 1.2: What are the potential risks? Can a reasonable estimate of risks be made?***

***Sub-issue 1.3: Assuming that allowed individual and population exposures, as well as contamination of property would be very small, would there in fact be a commercial market for slightly radioactive reused/recycled metals or other materials? Commercial scrap dealers currently protect themselves from inadvertently receiving radioactive materials. Would establishment of a licensing process, however simple, encourage dealers to accept these materials?***

***Sub-issue 1.4: Given the extent of international commerce, and the fact that reuse/recycle of slightly radioactive materials in this country may affect people and industries in other countries, and conversely that reuse/recycle of radioactive materials in other countries may affect people and industries in this country, to what extent can or should the international implications of such reuse/recycle be addressed in this rulemaking?***

***ISSUE 2: Should the Commission proceed with rulemaking? If so, how should it proceed?***

***<u>Sub-issue 2.1</u>: Should the Commission proceed with expedited rulemaking?***

***<u>Sub-issue 2.2</u>: Should the Commission engage in a normal rulemaking schedule?***

***<u>Sub-issue 2.3</u>: Should the Commission proceed with rulemaking only after publication of a reuse/recycle standard by EPA?***

***<u>Sub-issue 2.4</u>: Should the Commission defer rulemaking until a later time?***

<u>Discussion</u>:

The Commission will proceed with rulemaking only if a clear need is established. The Commission is interested in whether there is any urgency for such a rulemaking, and whether implications are understood for deferred action or no action. Otherwise, it may defer rulemaking until a later time. Regarding how the Commission should proceed, the Commission has already undertaken a cooperative effort with EPA to avoid redundancy and conserve resources. In EPA's work on development of a regulatory standard, a scheduled December 1996 publication of its draft standard for reuse/recycle has been delayed. Should NRC defer further action until the EPA standard is published, or should it proceed on the basis if its own analysis and judgment?

***ISSUE 3: If the Commission were to proceed with rulemaking, what should be the scope of the rulemaking? Should it be as broad as possible, e.g., reuse/recycle of all materials, or as narrow as possible, e.g., reuse/recycle of scrap nickel for use by licensed fabricators of specialized industrial equipment?***

Discussion:

There is a variety of slightly radioactive materials (e.g., metals, wood, concrete) and items (e.g., tools, vehicles, etc) which could be beneficially reused/recycled for public or private use. If the Commission were to proceed with rulemaking, should the rulemaking be broad enough to cover reuse/recycle of all materials and items or should it be limited to specific materials or items? Although this paper assumes that rulemaking would focus on RRSM, this scope could be contracted or expanded to address other materials for which reuse/recycle may be useful.

***Sub-issue 3.1: To what extent can or should the NRC rely on control of first use of reused/recycled materials to reduce potential public risk from reuse/recycle of materials containing small quantities of radioisotopes?***

Discussion:

The Commission could reduce potential public risk from reuse/recycle of materials containing small quantities of radioisotopes by restricting the first use of these materials. For example, the Commission might allow reuse/recycle of steel only for railroad tracks, steel girders, or military applications. However, it should be noted that once the material has been incorporated in the designated product (e.g., steel girders) the Commission (under the first use practice) would no longer retain control over this material. Consequently, the product could be reused/recycled again and the steel might be used in other products without regulatory supervision or control.

*Secondary Issue 3(a): What would be the relationship of an RRSM rule to Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) legislation, as well as to state laws and regulations?*

Discussion:

A metal recycling rule must be compatible with various laws, regulations, and DOE Orders. For instance, there is a question as to how much radioactive waste would be exempt from provisions of the Resource Conservation and Recovery Act (RCRA) under such a rule. State laws and regulations must also be considered; potentially conflicting federal and state issues and objectives need to be examined. It would be worthwhile to explore the possibility that recycling of slightly radioactive iron could be accomplished satisfactorily by Agreement State licensees under current laws and NRC regulations. Relatively minor changes to existing regulations might more easily accomplish the objective of a new rule. Also, alternative solutions that are currently not entirely apparent to federal authorities may be more evident to the states. A dialogue between federal and state agencies is encouraged.

***ISSUE 4: What should be the objective for regulating reuse/recycle material?***

Discussion:

There are five fundamental objectives that might serve as the starting point for developing radiological criteria for reuse/recycle: (a) risk limits for the entire reuse/recycle practice; (b) risk limits for individual reuse/recycle licensees; (c) a risk goal below which risks to individual members of the public are deemed trivial; (d) best effort to remove residual radioactivity with available technology; and (e) return to background levels. These objectives are described briefly below.

*Objective (a): Risk Limits for Entire Reuse/Recycle Practice*

*(a.1) Population Risk Limit* - Establish an acceptable upper limit for the cumulative risk to the public from the entire practice (i.e., all reuse/recycle) and derive generic residual radioactivity limits for reuse/recycle from this limit.

*(a.2) Population Risk Limit with ALARA* - This would be the same as Objective (a.1) above, except that each licensee proposing to reuse/recycle radioactive material would have to demonstrate that the residual radioactivity in the material it proposed to reuse/recycle is as far below the specified residual radioactivity limit for reuse/recycle as is reasonably achievable.

*(a.3) Individual Risk Limit* - Establish a limit above which risks to individual members of the public from the entire practice are deemed unacceptable, and derive generic residual radioactivity limits for reuse/recycle from this limit.

*(a.4) Individual Risk Limit with ALARA* - This would be the same as Objective (a.3) above, except that each licensee proposing to reuse/recycle slightly radioactive material would have to demonstrate that the residual radioactivity in the material the licensee proposes to reuse/recycle is as far below the specified residual radioactivity limit for reuse/recycle as reasonably achievable.

*Objective (b): Risk Limits for Individual Reuse/Recycle Licensees*

*(b.1) Individual Risk Limit* - Establish a limit above which the risk to individual members of the public from any individual reuse/recycle activity is deemed unacceptable.

*(b.2) Individual Risk Limit with ALARA* - This would be the same as Objective (b.1) above, except that each licensee proposing to reuse/recycle slightly radioactive material would have to demonstrate that the residual radioactivity in the material he proposed to reuse/recycle is as far below the limit as reasonably achievable.[15]

*Objective (c): Risk Goal* - Establish a risk goal below which the risks to individual members of the public or population groups are deemed trivial. Once the risk goal is established, decontamination would then be required to levels which are either below the goal, or as close to the goal as practical. If residual radioactivity levels were below the goal, the material could be released without further decontamination.

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[15] In practical terms, Objectives (a.2), (a.4), and (b.2) would mean that expected doses from radioactivity remaining in or on materials to be reused/recycled must be below some upper limit established by the NRC as representing the boundary of unacceptable exposure to an individual or group of individuals. Allowed exposures below the limit would be determined by applying the principle of "As Low As Reasonably Achievable" (ALARA) taking into account various factors of practical implementation (cost versus benefit), and socioeconomic considerations.

In practical terms, residual radioactivity levels greater than the corresponding risk goal would be accepted provided they are as close as reasonably achievable to the risk goal. If the levels of radioactivity were below the levels corresponding to the goal, then no decontamination would be required, regardless of feasibility. The Risk Goal could be used in place of ALARA in Objectives (a.2), (a.4), or (b.2).

*Objective (d): Best Effort* - Apply a best effort, emphasizing use of available technology. The objective in this case would be to establish criteria representing what is achievable using the best available technology. Material would be released for reuse/recycle if the only residual radioactivity is that material which cannot be removed using the best available technology. This objective is technologically driven. Theoretically, it could lead to removal of all radioactivity attributable to licensed activities or to an undefined level limited by the effectiveness of the technology. Cost can be a factor, but is not taken into consideration on the basis of cost versus benefit balancing. Best Effort could be used in place of ALARA in objectives (a.2), (a.4), or (b.2).

*Objective (e): Return to Background Levels* - This objective would release material for reuse/recycle only if all radioactivity attributable to licensed activity were removed. In practical terms, this would have the same effect as prohibiting any reuse/recycle of radioactive material.

<u>Discussion:</u>

The following is a discussion of regulatory objectives based on Risk Limits, Risk Goals, and Best Efforts:

*Risk Limits Objectives*

The fundamental principle underlying all NRC regulations and activities has been that radiation doses to members of the public from licensed activities must be reduced to levels established as limits (Risk Limits objective).[16] The limits pose the boundary of unacceptable public risk regardless of the cost required to achieve such reduction, and risks should be further reduced to levels which are ALARA. This principle is articulated in 10 CFR Part 20, and the Commission currently uses this principle as the basis for most licensed activities and releases of radioactive materials into the public domain. This principle is also the basis for certain actions by the EPA in the area of radiation protection, and is a fundamental principle outlined in both national and international recommendations.

In its recent recommendations on radiation protection, the International Commission on Radiological Protection (ICRP) has introduced the concept of a "constraint" in establishing the appropriate level of protection for any particular source of radiation exposure such as reuse/recycle of radioactively contaminated material.[17] A constraint is a selected level, below the dose limit (the dose limit corresponds to an acceptable risk), to provide assurance that any given individual would not receive a dose in excess of the dose limit, even if that individual were to be exposed to several sources simultaneously. As described by the ICRP, the concept of ALARA would be applied after the constraint was met. This approach is similar to the approach already utilized by the NRC in establishing criteria for effluents from nuclear power plants in 10 CFR Part 50 Appendix I and by the EPA in the generally applicable environmental standards

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[16] Although NRC regulations are designed to limit risk, not all limits in the regulations were established on the basis of risk.

[17] International Commission on Radiation Protection, ICRP Publication 60, November 1990.

such as 40 CFR Part 190 and in 40 CFR Part 61, the regulations implementing the Clean Air Act.

In addition, several national and international agencies and organizations, including the NRC, have adopted or proposed numerical risk or dose levels for public exposure from activities and practices involving radioactive materials. These risk levels may provide a basis for initiating a dialogue on numerical levels of risk or dose which would provide an acceptable basis for establishing radiological criteria for reuse/recycle. EPA has established or proposed other risk objectives that should be considered, such as EPA standards related to the Clean Air Act, the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as "Superfund") which may need to be considered in establishing criteria. For example, the EPA has established health-based limits for numerous chemicals under RCRA. On May 20, 1992, (57 FR 21450) the EPA published a proposed rulemaking on the identification of hazardous waste which included, as an option, the use of multiples of these health-based limits in determining the appropriate approach to management of the waste as hazardous or other solid waste. Although the proposed approach has been withdrawn, EPA plans to continue assessing the merits of approaches used by others ( 57 FR 49280, October 30, 1992).

### *Risk Goal Objectives*

The Risk Goal objective was recently applied by the EPA in selecting values for radionuclides in drinking water. In its proposal, the EPA established maximum contaminant level goals (MCLGs) for radionuclide levels, then established maximum contaminant levels (MCLs) which were greater than the goals in recognizing factors such as availability of technology, costs to remove radionuclides, and numbers of individuals involved. This is an extreme application of the risk goal principle, because the risk goal was legislatively set equal to zero. It is recognized that these goals may not be achievable. Apparently, some confusion has resulted from failure to distinguish between levels and goals.

*Best Effort Objective*

The EPA Clean Air Act and regulations provide practical examples of the application of the Best Effort regulatory principle. Among other things, the Clean Air Act requires the EPA Administrator to set new standards for emission of air pollutants based on the best, adequately demonstrated, technological system, taking into account the cost of achieving emission reduction, energy requirements, and any non-air impacts on the quality of health and the environment. Another section of the Clean Air Act permits the EPA Administrator, based on the same considerations listed above, to set standards based on design, equipment, work practice, operational standard, or combination of these.[18] The EPA uses several implementing concepts in promulgating Clean Air Act regulations, including maximum achievable control technology (MACT), generally available control technologies (GACT), and best demonstrated technology (BDT). Each of these concepts includes considerations of cost and other factors listed in the Clean Air Act.[19] These terms are further defined in Appendix A of this document.

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[18] Public Law 101-549 (104 STAT. 2399) November 15, 1990, (Clean Air Act Amendments of 1990, Sections 111 and 112).

[19] For examples, see 56 FR 64382, December 9, 1991, "National Emission Standards for Hazardous Air Pollutants for Source Categories: Perchloroethylene Emissions From Dry Cleaning Facilities (Proposed Rule)," and 55 FR 26953, June 29, 1990, "Standards of Performance for New Stationary Sources; Volatile Organic Compound (VOC) Emissions from the Synthetic Organic Chemical Manufacturing Industry (SOCMI) Reactor Processes (Proposed Rule)".

*— Application of Objectives*

The NRC has several possible approaches to codifying radiological criteria for reuse/recycle. One approach is to establish in the regulation general limits in terms of dose and then provide listings of specific radioactivity levels for different radionuclides either as an Appendix to the regulation or as a Regulatory Guide. This is the approach of 10 CFR Part 20 for the dose limits, where the values in Appendix B of Part 20 serve as a method for demonstrating compliance with the dose limit, rather than being a limit themselves. Alternatively, the Commission could codify specific radioactivity values for each radionuclide within the text of the regulation itself. Similarly, a Risk Goal could be codified in terms of a dose or a risk, or as specific levels of radioactivity. If the chosen reuse/recycle objective were Best Effort, then the regulation could specify either a particular technology or codify a method of determining the appropriate technology.

The terms of the regulation could be important to the extent that they could affect the Commission's flexibility in applying the regulation and also the flexibility the licensees would have in demonstrating compliance. If objectives were codified in terms of specific measurable quantities such as concentrations of radioactive materials, neither the Commission nor the licensees would have flexibility to take factors associated with a specific reuse/recycle request into account when trying to determine the acceptability of the proposed practice. However, if the objective were codified in terms of individual doses from a single reuse/recycle activity, individual licensees could present an analysis to demonstrate that their particular reuse/recycle proposal would meet the Commission's objective with different residual radioactivity levels than those determined by the Commission based on a generic, conservative analysis.

Past experience has shown that changes to the regulations containing specific radioactivity concentration criteria are much more difficult to complete and require more resources than if the criteria are contained in a Regulatory Guide. However, past experience has also shown that enforcement of specific, measured values is unambiguous, direct, and unencumbered by lengthy litigation.

Thus, Issue 4 resolves into a series of related questions, as follows:

*<u>Sub-issue 4.1</u>:* ***What alternatives should be considered as a general framework for establishing a regulatory objective? Should the Commission consider a combination of fundamental objectives and if so, on what basis?***

*<u>Sub-issue 4.2</u>:* ***Should the objective for regulating reuse/recycle material be to limit annual risk to individuals expected to be most highly exposed: 1) from any single reuse/recycle activity; 2) from the entire reuse/recycle practice?***

*<u>Sub-issue 4.3</u>:* ***Should the objective for regulating reuse/recycle material be to limit annual population risk: 1) from any single reuse/recycle activity; 2) from the entire reuse/recycle practice?***

*<u>Sub-issue 4.4</u>:* ***Should the objective for regulating reuse/recycle material be some combination of the above, i.e., should the Commission include consideration of an exposed population in addition to providing criteria for individuals? If so, how should this influence the criteria?***

*<u>Sub-issue 4.5</u>:* ***Should the Commission base its considerations on a theoretical, maximally exposed individual, or upon some type of "critical group" approach?***

*Secondary Issue 4(a)*: *What additional considerations should be taken into account when establishing radiological criteria for reuse/recycle?*

Discussion:

In developing criteria, there is often a question of exactly who the standard is designed to protect. For example, the criteria may be established to protect a theoretical, maximally exposed individual, regardless of whether such an individual could actually exist. Alternatively, the criteria could be established on the basis of providing protection for more realistically exposed individuals, and could include consideration of a so-called "critical group" which would be a small number of individuals that are representative of that population likely to receive the greatest dose. A "critical group" approach would often mean that it would be possible for the exposure of some single individual to be greater than the average of the group, and therefore experience a dose or risk in excess of the criteria.

Related to the question of the characteristics of the individual to be protected is the question of whether protecting individuals assures adequate protection for the entire population that might be exposed. Various positions have been advanced on this subject, with some indicating that protection of each individual automatically assures protection of the population as a whole, and others indicating that additional criteria might be needed to protect the population.

Another consideration in selecting radiological criteria is the time frame over which the criteria should be applied. There have been a number of different values suggested and used in various standards of the NRC and EPA, ranging from 100 years to over 10,000 years. For radionuclides with relatively short half-lives, decay negates the need for evaluation in the distant future. However, for long-lived radionuclides, and particularly for radionuclide decay chains where daughter products will gradually increase until equilibrium is reached (e.g., uranium and thorium), the consideration of the time frame is potentially important. Time periods are also important when certain pathways, such as a groundwater pathway, are considered, since the movement of radionuclides through such a pathway could be very slow.

The GEIS might therefore need to consider the environmental impact of second and subsequent passes of the radioactivity as it cycles through the public sector, perhaps from generation to generation. Long-term changes in the environment, such as global warming, ice age cycles, and other geologic changes, also could be factored into an analysis. Questions will need to be resolved regarding how far into the future such an analysis regarding criteria applicability should be carried out, whether the Commission should place a maximum value on the time frame to be considered, or whether criteria should be applicable irrespective of time at which a maximum exposure could occur.

<u>Secondary Issue 4(b)</u>: *What pathways of exposure to people would be important to consider for unrestricted RRSM?*

<u>Discussion:</u>

The Commission requests comments specifically on the pathways of exposure that may result from this rulemaking. Pathways are defined here as any routes of radiation exposure from radionuclides that may be released to the environment due to RRSM and unrestricted release. For example, the NRC currently provides for unrestricted releases of small amounts of radioactive materials from licensed facilities to the atmosphere and to water (10 CFR Part 20 and Appendix I to 10 CFR Part 50). There are many possible pathways of exposure. The principal atmospheric pathways are direct radiation from gamma ray emitters in the atmosphere (often called cloud shine), inhalation of radioactive materials in the atmosphere, and exposure to radioactive materials deposited on the ground from the atmosphere (with rainfall, for example).

The latter exposure pathway is often broken down further into ground shine (direct exposure to gamma rays emitted by radionuclides deposited on the ground), and food pathways (radionuclides entering the ground, being absorbed by plants and animals, and subsequently being consumed by people). The principal aquatic pathways are gamma ray shine (from swimming and boating), drinking potable water, and consuming plants irrigated by slightly radioactive water.

Current pathways being considered are: exposures of workers on site in preparing materials for release (for both release and no release cases); exposures of workers and persons while transporting such materials off site; exposures of workers at a municipal solid waste treatment facility; exposures of workers at furnaces where materials such as iron and steel might be melted; exposures of workers who would fabricate the recycled materials into useful objects; exposures of workers who would transport the slag from a furnace melt to a licensed low level waste disposal site; exposure of the general public to atmospheric emissions from a furnace; exposures of persons driving on roads containing slag from such furnaces; exposures of persons who would use reused/recycled steel or slag in buildings, homes, vehicles, offices, and objects (e.g., chairs, personal computers, toasters, coffee pots). The NRC wishes to make certain that a potentially important pathway of exposure does not escape the attention of its staff in preparing a GEIS. Accordingly, the Commission is interested in receiving suggestions regarding possible additional pathways of exposure that can result from the unrestricted release of slightly radioactive materials, for consideration in its GEIS. This should include consideration of potential reconcentration of radioisotopes from various sources over long periods of time.

***ISSUE 5: At what numerical levels would the objective(s) for regulating reuse/recycle material provide an acceptable basis for protection of the public health and safety and the environment?***

***<u>Sub-issue 5.1</u>: If the Commission chooses an Individual Risk Limit objective, should the Commission use the 100 millirem/yr in 10 CFR 20 for public dose limits, the 25 millirem/yr dose limit in 40 CFR 190 for the commercial uranium fuel cycle, the proposed 15 millirem/yr for decommissioning as the limit on doses from residual radioactivity, or should the Commission establish separate constraints for reuse/recycle? If separate constraints are set, what should be the basis for these constraints?***

***<u>Sub-issue 5.2</u>: If the Commission chooses a population risk objective, at what numerical level should it be set?***

***<u>Sub-issue 5.3</u>: What consideration should be given to standards or objectives proposed or adopted by other groups (e.g., the IAEA)?***

*<u>Secondary Issue 5(a)</u>: What consideration should the Commission give to the potential adverse impact of RRSM on sensitive operations or practices in industry and research?*

<u>Discussion:</u>

Some activities, such as the operation of a very low level radioactivity counting laboratory, would be adversely affected by even slightly elevated levels of radioactivity. Such laboratories use extreme precautions, including selection of materials having very low concentrations of natural radioactivity. Other operations, such as some in the photographic film industry, would be adversely affected by the presence of radioactivity, although those levels usually are expected to be higher than the levels anticipated from this rulemaking. In view of such concerns, the Commission solicits identification of especially sensitive practices that might be adversely affected by commercial circulation of slightly radioactive scrap metal (excluding naturally occurring radioactivity).

<u>Secondary Issue 5(b)</u>: *Can a few critical receptors be identified or postulated whose exposures and risks could be readily estimated, and who could be adequate surrogates for all individuals and populations that could be exposed?*

<u>Discussion:</u>

Identification of a number of surrogates for all individuals and populations that may be exposed to a radioactive effluent stream is a well-established method used by regulatory agencies in the United States and world-wide to establish regulations and reasonable limits for both analyses of consequences of a generic rule, and for estimating environmental impacts. The method is also used to help establish controls and monitoring systems at planned release points at a facility, such as an emission sample point in a stack (atmospheric releases), or at an aquatic release point. In essence, the critical receptors are generally those persons and pathways identified as most likely to be most heavily exposed from an allowed practice. Regulatory restrictions based on such receptors are then deemed to be restrictive enough to adequately protect real individuals and real populations. The critical receptors must be chosen judiciously to accomplish the simultaneous goals of reasonably providing for a practice while adequately protecting public health and safety.

<u>Secondary Issue 5(c)</u>: *From a practical point of view, how should NRC codify radiological criteria for reuse/recycle? Should controls be applied in terms of radioisotope concentration? Total radioisotope release? Individual dose? Annual risk? Lifetime risk?*

<u>Discussion:</u>

In some cases radioactivity (Curies), radioactivity flow (Ci/yr) and/or radioactivity concentrations (Ci/milliliter, or Ci/gm) are regulated; whereas in other cases doses and risks are regulated. However, an important operational distinction is recognized—people are not required to wear dosimeters or air samplers in the public domain and food on the domestic table is not required to pass rigid tests for radioactivity content. While neither risk nor dose is directly observable in the public domain, inspection and enforcement of regulations require an observable unit.

Conversely, external gamma and beta dose rates, radioactivity levels (Curies), or radioactivity concentrations (picocuries/milliliter), or surface concentrations (picocuries/square centimeter) are distinctly measurable units. Quite rigid technical specifications can be imposed on licensee operations in terms of such observable units. Nevertheless, acceptable values for these observable units are derived from dose, risk, and pathway models that relate them to the objective of adequate protection of public health and safety.

***ISSUE 6: How should practicality considerations be applied in radiological criteria for a reuse/recycle rule—particularly if the Commission were to adopt either the Risk Limit objective or the Risk Goal objective?***

Discussion:

Application of ALARA means making every reasonable effort to reduce or maintain exposures to radiation as far below established individual dose limits as is practical, taking into account a number of things. These include the state of technology; the costs of improvements in relation to the state of technology; the costs of improvements in relation to public health and safety; appropriate utilization of nuclear energy and licensed material in the public interest; and other socioeconomic considerations. Examining these issues encompasses a broad range of activities, including cost-benefit analysis of procedures and practices, availability and application of measurement technologies, and availability of disposal facilities.

The same factors that have been traditionally used in radiation protection (Risk Limit objective based) are also the factors that would be used in determining how close practical criteria can be made to a Risk Goal objective. Thus, in the present context, the term ALARA can be used to represent the practical process of reaching either the lowest acceptable risk below a predetermined Risk Limit or the lowest risk above a selected Risk Goal as discussed in Issue 4.

The employment of practicality considerations, including cost and availability of technology, has been recognized as valid in a number of contexts, both in the area of radiation protection and in regulation of hazardous chemicals and wastes. For example, in recommendations approved by the President regarding Radiation Protection Guidance to Federal Agencies for Occupational Exposure, the concept of

ALARA was specifically included.[20] Likewise, the EPA has acknowledged the validity of considering costs and benefits in determining levels for regulation of chemicals in various arenas, as illustrated by the EPA response to a petition requesting revocation of food additive regulations.[21] The Commission's rulemaking is being conducted under the Atomic Energy Act, which allows consideration of ALARA, provided the public health and safety are protected.

There are a variety of ways the principle of ALARA can be applied. In both the Risk Limit and Risk Goal objectives, ALARA can be applied on a case-by-case basis with analysis required for each proposed reuse/recycle activity. Alternatively, generic ALARA criteria could be established which would be applicable to all reuse/recycle, or all reuse/recycle of a particular class of material (e.g., nickel).

A credible ALARA analysis must consider all the costs and benefits associated with decontaminating materials to be reused/recycled to different residual radioactivity levels and must be carefully documented to demonstrate that all reasonable alternatives and technologies have been considered. It should take into account: (1) radiation doses (public and occupational) and environmental impacts both from the process of decontaminating the materials and from the residual radioactivity which will remain in the materials or items after they have been decontaminated, and (2) all of the costs and other risks (e.g.,occupational, transportation) associated with decontamination and reuse/recycle of the materials. It should also include an analysis which clearly demonstrates how overall costs and benefits change with changing residual radioactivity levels. The analysis must be properly documented. This should include documentation of the methodology and sources of data used in the analysis, and an assessment of the uncertainties associated with the results of the analysis. ALARA

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[20] 52 FR 2822, January 27, 1987.

[21] 56 FR 7750, February 25, 1991.

analyses can be carried out on either a generic or site-specific basis. Generic analyses by their very nature will produce results with higher uncertainty than those obtainable from an analysis for a specific reuse/recycle activity. Therefore, a more conservative approach would have to be adopted when conducting a generic analysis to assure that its results are appropriate for all reuse/recycle activities to which the analysis is expected to apply. Normally, the NRC would develop a GEIS for a defined practice that it will regulate. Each individual licensee might then be required to develop a site-specific EIS.

*<u>Sub-issue 6.1</u>: **Should the Commission require that ALARA be determined for each recycle activity? If not, how should it be applied? Should the Commission establish generic ALARA criteria? If generic ALARA criteria are used, should a single ALARA criterion be established for all materials, or should different ALARA criteria be established for different categories of materials or items to be recycled? If ALARA criteria are established for different categories of materials or items, on what basis should the different categories be established?***

*<u>Sub-issue 6.2</u>: **Irrespective of whether ALARA is applied on an activity-specific basis or generically, on what basis should the ALARA analysis rest? What level of review by the NRC staff should be required to evaluate this basis? For example, how should the level of difficulty in measuring certain radionuclides in some circumstances be handled? How should the staff address societal and socioeconomic aspects of the ALARA analysis?***

*<u>Sub-issue 6.3</u>: **Should the Commission establish a Risk Goal objective as its basis for establishing ALARA criteria, on what basis should the goal be established?***

***Sub-issue 6.4:*** ***Should the Commission establish a Best Effort objective as its basis for establishing ALARA criteria, what level of technology availability should be used? How often should the applicable areas of technology be updated for this criteria? What criteria should govern application of the technology to achieve lower levels of residual radioactivity, i.e., how would the point of diminishing returns on invested cost/effort be established? Recognizing that different applications of technology could result in widely varying levels of residual radioactivity, should an additional limit be placed on the level of residual radioactivity? How should the phrase, "fixed radioactivity" be defined, as it applies to surface contamination?***

# APPENDIX A

## Glossary of Relevant Terms

*This appendix contains terms used by the NRC[22], concepts associated with the best effort (technology-based) approach put forth in the Clean Air Act[23], and international terms related to RRSM.*

Acceptable (authorized, regulatory) limits - Limits acceptable to the regulatory body [IAEA Report, Safety Series 52]

Acceptable contamination levels for unrestricted use - Specified levels for any use of the material without restrictions regarding radioactivity. [SS-52]

Activity (radioactivity) - The rate of disintegration (transformation) or decay of radioactive material. The units of activity are the curie (Ci) and the becquerel (Bq).

ALARA (acronym for "as low as is reasonably achievable") - Making every reasonable effort to maintain exposures to radiation as far below dose limits as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

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[22] 10 CFR Part 20.1003 [56 FR 24018, May 21, 1991].

[23] Public Law 101-549 (104 STAT. 2399) November 15, 1990, (Clean Air Act Amendments of 1990).

Background radiation - Radiation from cosmic sources, from natural terrestrial radiation including radon (except as a decay product of source or special nuclear material) and global fallout as it exists in the environment from the testing of nuclear explosive devices. "Background radiation" does not include radiation from source, byproduct, or special nuclear materials regulated by the Commission.

Best Available Control Technology (BACT) - An EPA concept which bases an emission limitation on the maximum degree of emission reduction that (considering energy, environmental, and economic impacts and other costs) is achievable through application of production processes and available methods, systems, and techniques. In no event does BACT permit emissions in excess of those allowed under any applicable Clean Air Act provisions. Use of the BACT concept is allowable on a case by case basis for major new or modified emissions sources in attainment areas and applies to each regulated pollutant.

Best Demonstrated Technology (BDT) - The technology on which the EPA will base its standards, i.e., application of the best technological system of continuous emission reduction which (taking into account the cost of achieving such emission reduction, and any non-air quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated.[24]

Becquerel - A unit of radioactivity, defined as one nuclear disintegration per second. This is a very small amount of radioactivity.

Byproduct material - (1) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material; and (2) The tailings or wastes produced

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[24] Clean Air Act Amendments of 1990, Section 111(a)(1).

by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by these solution extraction operations do not constitute "byproduct material" within this definition.

CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act (also known as "Superfund").

Clearance - Removal of radioactive materials or radioactive objects within authorized practices from any further control by the Regulatory Authority. (SS-115)

Clearance levels - A set of values set by the regulatory body in terms of activity concentrations and/or total activities at or below which sources of radiation can be released from nuclear regulatory control. [SS-111-P-1.1] Also, values established by the Regulatory Authority and expressed in terms of legal activity concentrations and/or total activity, at or below which sources of radiation may be released from regulatory control. (SS-115)

Collective dose - The sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation. Appropriate units for collective dose are expressed in person-rems or person-sieverts.

Commission - The Nuclear Regulatory Commission or its duly authorized representatives.

Curie - A unit of radioactivity, defined as $3.7 \times 10^{10}$ nuclear disintegrations per second.

Dose (radiation dose) - A generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent.

Exposure - Being exposed to ionizing radiation or to radioactive material.

Exempt waste - Waste released from regulatory control in accordance with clearance levels, because the associated radiological hazards are considered negligible. [SS-111-P-1.1]

External dose - That portion of the dose equivalent received from radiation sources outside the body.

Generally applicable environmental radiation standards - Standards issued by the Environmental Protection Agency (EPA) under the authority of the Atomic Energy Act of 1954, as amended, that impose limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material.

Generally Available Control Technologies (GACT) - The EPA Administrator may elect under certain circumstances to promulgate standards or requirements which provide for the use of generally available control technologies or management practices to reduce emissions of hazardous air pollutants.[25]

Government agency - Any executive department, commission, independent establishment, corporation wholly or partly owned by the United States of America,

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[25] Clear Air Act Amendments of 1990, Section 112(d)(5).

which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administrations or other establishment in the executive branch of the government.

Individual - Any human being.

Internal dose - That portion of the dose equivalent received from radioactive material taken into the body.

License - A license issued under the regulations in Title 10, Code of Federal Regulations, Parts 30 through 35, 39, 40, 50, 60, 61, 70, or 72.

Licensed material - Source material, special nuclear material, or byproduct material received, possessed, used, transferred or disposed of under a general or specific license issued by the Commission.

Licensee - The holder of a license.

Limits (dose limits) - The permissible upper bounds of radiation doses.

Maximum Achievable Control Technology (MACT) - Emissions limitations based on the best demonstrated control technology or practices in similar sources to be applied to man or sources emitting one or more of the listed toxic pollutants.[26]

Member of the public - An individual in a controlled or unrestricted area. However, an individual is not a member of the public during any period in which the individual receives an occupational dose.

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[26] Glossary of Terms - Clear Air Act Amendments of 1990.

Microsievert - One millionth of a sievert, μSv (see Rem).

Millirem - A unit of radiation exposure; natural background exposures in the United States average 100 millirem per year (100 millirem = 0.1 rem = 1 millisievert) [see Rem].

Monitoring (radiation monitoring, radiation protection monitoring) - The measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses.

NRC - The Nuclear Regulatory Commission or its duly authorized representatives.

Occupational dose - The dose received by an individual in a restricted area or in the course of employment in which the individual's assigned duties involve exposure to radiation and to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other persons. Occupational dose does not include dose received from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the general public.

Person-rem - The sum of all individual doses (the collective dose).

Potential exposure - Exposure that is not expected to be delivered with certainty but that may result from an accident at a source or owing to an event or sequence of events of a probabilistic nature, including equipment failures and operating errors. (SS-115)

Practice - Any human activity that introduces additional sources of exposure or exposure pathways or extends exposure to additional people or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed. (SS-115)

Public dose - The dose received by a member of the public from exposure to radiation and to radioactive material released by a licensee, or to another source of radiation either within a licensee's controlled area or in unrestricted areas. It does not include occupational dose or doses received from background radiation, as a patient from medical practices, or from voluntary participation in medical research programs.

Radiation (ionizing radiation) - Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in this part, does not include non-ionizing radiation, such as radio- or microwaves, or visible, infrared, or ultraviolet light.

Radioactive discharges (or effluents) - Radioactive substances arising from a source within a practice which are discharged as gases, aerosols, liquids or solids to the environment, generally with the purpose of dilution and dispersion. [Note: Radioactive discharges are governed by authorization rather than by clearance.] (SS-115)

Radioactive waste - Material, whatever its physical form, remaining from practices or interventions and for which no further use is foreseen (I) that contains or is contaminated with radioactive substances and has an activity or activity concentration higher than the level for clearance from regulatory requirements, and (ii) exposure to which is not excluded from the Standards. (SS-115)

RCRA - Resource Conservation and Recovery Act (RCRA).

Residual Risk - The quantity of health risk remaining after application of the MACT (Maximum Achievable Control Technology).[27]

Restricted area - An area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

Reuse - Implies use of an object that has not been physically or chemically changed.

Recycle - Implies a change in the form or use of the metal. This change may involve physical and chemical changes, including melting and re-fabrication.

Release - Allowing radioactive materials to enter unrestricted areas, which are generally beyond the boundaries of NRC-licensed facilities.

Rem - A unit of radiation exposure see millirem and sievert (sievert = 100 rem = 1,000 millirem).

Site boundary - That line beyond which the land or property is not owned, leased, or otherwise controlled by the licensee.

Source material - (1) Uranium or thorium or any combination of uranium and thorium in any physical or chemical form; or (2) Ores that contain, by weight, one-twentieth of one percent (0.05 percent), or more, of uranium, thorium, or any combination of uranium and thorium. Source material does not include special nuclear material.

[27] Glossary of Terms - Clear Air Act Amendments of 1990

Special nuclear material - (1) Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material that the Commission, pursuant to the provisions of section 51 of the Atomic Energy Act, determines to be special nuclear material, but does not include source material; or (2) Any material artificially enriched by any of the foregoing but does not include source material.

RRSM - Reuse/recycle of scrap metal slightly contaminated by radioactivity.

SS - Safety Series. (Publications of the IAEA).

Total Effective Dose Equivalent (TEDE) - The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Unrestricted area - An area, access to which is neither limited nor controlled by the licensee.

Uranium fuel cycle - The operations of milling of uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using uranium fuel, and reprocessing of spent uranium fuel to the extent that these activities directly support the production of electrical power for public use. Uranium fuel cycle does not include mining operations, operations at waste disposal sites, transportation of radioactive material in support of these operations, and the reuse of recovered non-uranium special nuclear and byproduct materials from the cycle.

## APPENDIX B

### Reproductions of:

- NRC Regulatory Guide 1.86, Termination of Operating Licenses for Nuclear Reactors
- NRC IE Circular No. 81-07, Control of Radioactively Contaminated Material
- Figure IV-1, "Surface Contamination Guidelines" (from DOE Order 5400.5)

## NRC Regulatory Guide 1.86

## Termination of Operating Licenses for Nuclear Reactors

June 1974

U.S. ATOMIC ENERGY COMMISSION

# REGULATORY GUIDE

DIRECTORATE OF REGULATORY STANDARDS

## REGULATORY GUIDE 1.86

## TERMINATION OF OPERATING LICENSES FOR NUCLEAR REACTORS

### A. INTRODUCTION

Section 50.51, "Duration of license, renewal," of 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires that each license to operate a production and utilization facility be issued for a specified duration. Upon expiration of the specified period, the license may be either renewed or terminated by the Commission. Section 50.82, "Applications for termination of licenses," specifies the requirements that must be satisfied to terminate an operating license, including the requirement that the dismantlement of the facility and disposal of the component parts not be inimical to the common defense and security or to the health and safety of the public. This guide describes methods and procedures considered acceptable by the Regulatory staff for the termination of operating licenses for nuclear reactors. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

### B. DISCUSSION

When a licensee decides to terminate his nuclear reactor operating license, he may, as a first step in the process, request that his operating license be amended to restrict him to possess but not operate the facility. The advantage to the licensee of converting to such a possession-only license is reduced surveillance requirements in that periodic surveillance of equipment important to the safety of reactor operation is no longer required. Once this possession-only license is issued, reactor operation is not permitted. Other activities related to cessation of operations such as unloading fuel from the reactor and placing it in storage (either onsite of offsite) may be continued.

A licensee having a possession-only license must retain, with the Part 50 license, authorization for special nuclear material (10 CFR Part 70, "Special Nuclear Material"), byproduct material (10 CFR Part 30, "Rules of General Applicability to Licensing of Byproduct Material"), and source material (10 CFR Part 40, "Licensing of Source Material"), until the fuel, radioactive components, and sources are removed from the facility. Appropriate administrative controls and facility requirements are imposed by the Part 50 license and the technical specifications to assure that proper surveillance is performed and that the reactor facility is maintained in a safe condition and not operated.

A possession-only license permits various options and procedures for decommissioning, such as mothballing, entombment, or dismantling. The requirements imposed depend on the option selected.

Section 50.82 provides that the licensee may dismantle and dispose of the component parts of a nuclear reactor in accordance with existing regulations. For research reactors and critical facilities, this has usually meant the disassembly of a reactor and its shipment offsite, sometimes to another appropriately licensed organization for further use. The site from which a reactor has been removed must be decontaminated, as necessary, and inspected by the Commission to determine whether unrestricted access can be approved. In the case of nuclear power reactors, dismantling has usually been accomplished by shipping fuel offsite, making the reactor inoperable, and disposing of some of the radioactive components.

Radioactive components may be either shipped offsite for burial at an authorized burial ground or secured

**USAEC REGULATORY GUIDES**

Regulatory Guides are issued to describe and make available to the public methods acceptable to the AEC Regulatory staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

Published guides will be revised periodically, as appropriate, to accommodate comments and to reflect new information or experience.

Copies of published guides may be obtained by request indicating the divisions desired to the U.S. Atomic Energy Commission, Washington, D.C. 20545, Attention: Director of Regulatory Standards. Comments and suggestions for improvements in these guides are encouraged and should be sent to the Secretary of the Commission, U.S. Atomic Energy Commission, Washington, D.C. 20545, Attention: Chief, Public Proceedings Staff.

The guides are issued in the following ten broad divisions:

1. Power Reactors
2. Research and Test Reactors
3. Fuels and Materials Facilities
4. Environmental and Siting
5. Materials and Plant Protection
6. Products
7. Transportation
8. Occupational Health
9. Antitrust Review
10. General

on the site. Those radioactive materials remaining on the site must be isolated from the public by physical barriers or other means to prevent public access to hazardous levels of radiation. Surveillance is necessary to assure the long term integrity of the barriers. The amount of surveillance required depends upon (1) the potential hazard to the health and safety of the public from radioactive material remaining on the site and (2) the integrity of the physical barriers. Before areas may be released for unrestricted use, they must have been decontaminated or the radioactivity must have decayed to less than prescribed limits (Table I).

The hazard associated with the retired facility is evaluated by considering the amount and type of remaining contamination, the degree of confinement of the remaining radioactive materials, the physical security provided by the confinement, the susceptibility to release of radiation as a result of natural phenomena, and the duration of required surveillance.

## C. REGULATORY POSITION

### 1. APPLICATION FOR A LICENSE TO POSSESS BUT NOT OPERATE (POSSESSION-ONLY LICENSE)

A request to amend an operating license to a possession-only license should be made to the Director of Licensing, U.S. Atomic Energy Commission, Washington, D.C. 20545. The request should include the following information:

a. A description of the current status of the facility.

b. A description of measures that will be taken to prevent criticality or reactivity changes and to minimize releases of radioactivity from the facility.

c. Any proposed changes to the technical specifications that reflect the possession-only facility status and the necessary disassembly/retirement activities to be performed.

d. A safety analysis of both the activities to be accomplished and the proposed changes to the technical specifications.

e. An inventory of activated materials and their location in the facility.

### 2. ALTERNATIVES FOR REACTOR RETIREMENT

Four alternatives for retirement of nuclear reactor facilities are considered acceptable by the Regulatory staff. These are:

a. Mothballing. Mothballing of a nuclear reactor facility consists of putting the facility in a state of protective storage. In general, the facility may be left intact except that all fuel assemblies and the radioactive fluids and waste should be removed from the site. Adequate radiation monitoring, environmental surveillance, and appropriate security procedures should be established under a possession-only license to ensure that the health and safety of the public is not endangered.

b. In-Place Entombment. In-place entombment consists of sealing all the remaining highly radioactive or contaminated components (e.g., the pressure vessel and reactor internals) within a structure integral with the biological shield after having all fuel assemblies, radioactive fluids and wastes, and certain selected components shipped offsite. The structure should provide integrity over the period of time in which significant quantities (greater than Table I levels) of radioactivity remain with the material in the entombment. An appropriate and continuing surveillance program should be established under a possession-only license.

c. Removal of Radioactive Components and Dismantling. All fuel assemblies, radioactive fluids and waste, and other materials having activities above accepted unrestricted activity levels (Table I) should be removed from the site. The facility owner may then have unrestricted use of the site with no requirement for a license. If the facility owner so desires, the remainder of the reactor facility may be dismantled and all vestiges removed and disposed of.

d. Conversion to a New Nuclear System or a Fossil Fuel System. This alternative, which applies only to nuclear power plants, utilizes the existing turbine system with a new steam supply system. The original nuclear steam supply system should be separated from the electric generating system and disposed of in accordance with one of the previous three retirement alternatives.

### 3. SURVEILLANCE AND SECURITY FOR THE RETIREMENT ALTERNATIVES WHOSE FINAL STATUS REQUIRES A POSSESSION-ONLY LICENSE

A facility which has been licensed under a possession-only license may contain a significant amount of radioactivity in the form of activated and contaminated hardware and structural materials. Surveillance and commensurate security should be provided to assure that the public health and safety are not endangered.

a. Physical security to prevent inadvertent exposure of personnel should be provided by multiple locked barriers. The presence of these barriers should make it extremely difficult for an unauthorized person to gain access to areas where radiation or contamination levels exceed those specified in Regulatory Position C.4. To prevent inadvertent exposure, radiation areas above 5 mR/hr, such as near the activated primary system of a power plant, should be appropriately marked and should not be accessible except by cutting of welded closures or the disassembly and removal of substantial structures and/or shielding material. Means such as a remote-readout intrusion alarm system should be provided to indicate to designated personnel when a physical barrier is penetrated. Security personnel that provide access control to the facility may be used instead of the physical barriers and the intrusion alarm systems.

b. The physical barriers to unauthorized entrance into the facility, e.g., fences, buildings, welded doors, and access openings, should be inspected at least quarterly to assure that these barriers have not deteriorated and that locks and locking apparatus are intact.

c. A facility radiation survey should be performed at least quarterly to verify that no radioactive material is escaping or being transported through the containment barriers in the facility. Sampling should be done along the most probable path by which radioactive material such as that stored in the inner containment regions could be transported to the outer regions of the facility and ultimately to the environs.

d. An environmental radiation survey should be performed at least semiannually to verify that no significant amounts of radiation have been released to the environment from the facility. Samples such as soil, vegetation, and water should be taken at locations for which statistical data has been established during reactor operations.

e. A site representative should be designated to be responsible for controlling authorized access into and movement within the facility.

f. Administrative procedures should be established for the notification and reporting of abnormal occurrences such as (1) the entrance of an unauthorized person or persons into the facility and (2) a significant change in the radiation or contamination levels in the facility or the offsite environment.

g. The following reports should be made:

(1) An annual report to the Director of Licensing, U.S. Atomic Energy Commission, Washington, D.C. 20545, describing the results of the environmental and facility radiation surveys, the status of the facility, and an evaluation of the performance of security and surveillance measures.

(2) An abnormal occurrence report to the Regulatory Operations Regional Office by telephone within 24 hours of discovery of an abnormal occurrence. The abnormal occurrence will also be reported in the annual report described in the preceding item.

h. Records or logs relative to the following items should be kept and retained until the license is terminated, after which they may be stored with other plant records:

(1) Environmental surveys,

(2) Facility radiation surveys,

(3) Inspections of the physical barriers, and

(4) Abnormal occurrences.

## 4. DECONTAMINATION FOR RELEASE FOR UNRESTRICTED USE

If it is desired to terminate a license and to eliminate any further surveillance requirements, the facility should be sufficiently decontaminated to prevent risk to the public health and safety. After the decontamination is satisfactorily accomplished and the site inspected by the Commission, the Commission may authorize the license to be terminated and the facility abandoned or released for unrestricted use. The licensee should perform the decontamination using the following guidelines:

a. The licensee should make a reasonable effort to eliminate residual contamination.

b. No covering should be applied to radioactive surfaces of equipment or structures by paint, plating, or other covering material until it is known that contamination levels (determined by a survey and documented) are below the limits specified in Table I. In addition, a reasonable effort should be made (and documented) to further minimize contamination prior to any such covering.

c. The radioactivity of the interior surfaces of pipes, drain lines, or ductwork should be determined by making measurements at all traps and other appropriate access points, provided contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or ductwork. Surfaces of premises, equipment, or scrap which are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement should be assumed to be contaminated in excess of the permissable radiation limits.

d. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated in excess of the limits specified. This may include, but is not limited to, special circumstances such as the transfer of premises to another licensed organization that will continue to work with radioactive materials. Requests for such authorization should provide:

(1) Detailed, specific information describing the premises, equipment, scrap, and radioactive contaminants and the nature, extent, and degree of residual surface contamination.

(2) A detailed health and safety analysis indicating that the residual amounts of materials on surface areas, together with other considerations such as the prospective use of the premises, equipment, or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.

e. Prior to release of the premises for unrestricted use, the licensee should make a comprehensive radiation survey establishing that contamination is within the limits specified in Table I. A survey report should be filed with the Director of Licensing, U.S. Atomic Energy Commission, Washington, D.C. 20545, with a copy to the Director of the Regulatory Operations Regional Office having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. The survey report should:

(1) Identify the premises;

(2) Show that reasonable effort has been made to reduce residual contamination to as low as practicable levels;

(3) Describe the scope of the survey and the general procedures followed; and

(4) State the finding of the survey in units specified in Table 1.

After review of the report, the Commission may inspect the facilities to confirm the survey prior to granting approval for abandonment.

5. REACTOR RETIREMENT PROCEDURES

As indicated in Regulatory Position C.2, several alternatives are acceptable for reactor facility retirement. If minor disassembly or "mothballing" is planned, this could be done by the existing operating and maintenance procedures under the license in effect. Any planned actions involving an unreviewed safety question or a change in the technical specifications should be reviewed and approved in accordance with the requirements of 10 CFR §50.59.

If major structural changes to radioactive components of the facility are planned, such as removal of the pressure vessel or major components of the primary system, a dismantlement plan including the information required by §50.82 should be submitted to the Commission. A dismantlement plan should be submitted for all the alternatives of Regulatory Position C.2 except mothballing. However, minor disassembly activities may still be performed in the absence of such a plan, provided they are permitted by existing operating and maintenance procedures. A dismantlement plan should include the following:

a. A description of the ultimate status of the facility

b. A description of the dismantling activities and the precautions to be taken.

c. A safety analysis of the dismantling activities including any effluents which may be released.

d. A safety analysis of the facility in its ultimate status.

Upon satisfactory review and approval of the dismantling plan, a dismantling order is issued by the Commission in accordance with §50.82. When dismantling is completed and the Commission has been notified by letter, the appropriate Regulatory Operations Regional Office inspects the facility and verifies completion in accordance with the dismantlement plan. If residual radiation levels do not exceed the values in Table I, the Commission may terminate the license. If these levels are exceeded, the licensee retains the possession-only license under which the dismantling activities have been conducted or, as an alternative, may make application to the State (if an Agreement State) for a byproduct materials license.

TABLE I

ACCEPTABLE SURFACE CONTAMINATION LEVELS

| NUCLIDE[a] | AVERAGE[b c] | MAXIMUM[b d] | REMOVABLE[b e] |
|---|---|---|---|
| U-nat, U-235, U-238, and associated decay products | 5,000 dpm $\alpha$/100 $cm^2$ | 15,000 dpm $\alpha$/100 $cm^2$ | 1,000 dpm $\alpha$/100 $cm^2$ |
| Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129 | 100 dpm/100 $cm^2$ | 300 dpm/100 $cm^2$ | 20 dpm/100 $cm^2$ |
| Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 | 1000 dpm/100 $cm^2$ | 3000 dpm/100 $cm^2$ | 200 dpm/100 $cm^2$ |
| Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above. | 5000 dpm $\beta$-$\gamma$/100 $cm^2$ | 15,000 dpm $\beta$-$\gamma$/100 $cm^2$ | 1000 dpm $\beta$-$\gamma$/100 $cm^2$ |

[a]Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b]As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c]Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

[d]The maximum contamination level applies to an area of not more than 100 $cm^2$.

[e]The amount of removable radioactive material per 100 $cm^2$ of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

## NRC IE Circular No. 81-07

## Control of Radioactively Contaminated Material

SSINS: 6830
Accession No.:
8103300375
IEC 81-07

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF INSPECTION AND ENFORCEMENT
WASHINGTON, D.C. 20555

May 14, 1981

IE Circular No. 81-07: CONTROL OF RADIOACTIVELY CONTAMINATED MATERIAL

Description of Circumstances:

Information Notice No. 80-22 described events at nuclear power reactor facilities regarding the release of radioactive contamination to unrestricted areas by trash disposal and sale of scrap material. These releases to unrestricted areas were caused in each case by a breakdown of the contamination control program including inadequate survey techniques, untrained personnel performing surveys, and inappropriate material release limits.

The problems that were described in IE Information Notice No. 80-22 can be corrected by implementing an effective contamination control program through appropriate administrative controls and survey techniques. However, the recurring problems associated with minute levels of contamination have indicated that specific guidance is needed by NRC nuclear power reactor licensees for evaluating potential radioactive contamination and determining appropriate methods of control. This circular provides guidance on the control of radioactive contamination. Because of the limitations of the technical analysis supporting this guidance, this circular is applicable only to nuclear power reactor facilities.

Discussion:

During routine operations, items (e.g., tools and equipment) and materials (e.g., scrap material, paper products, and trash) have the potential of becoming slightly contaminated. Analytical capabilities are available to distinguish very low levels of radioactive contamination from the natural background levels of radioactivity. However, these capabilities are often very elaborate, costly, and time consuming making their use impractical (and unnecessary) for routine operations. Therefore, guidance is needed to establish operational detection levels below which the probability of any remaining, undetected contamination is negligible and can be disregarded when considering the practicality of detecting and controlling such potential contamination and the associated negligible radiation doses to the public. In other words, guidance is needed which will provide reasonable assurance that contaminated materials are properly controlled and disposed of while at the same time providing a practical method for the uncontrolled release of materials from the restricted area. These levels and detection capabilities must be set considering these factors: 1) the practicality of conducting a contamination survey, 2) the potential of leaving minute levels of contamination undetected; and, 3) the potential radiation doses to individuals of the public resulting from potential release of any undetected, uncontrolled contamination.

Studies performed by Sommers[1] have concluded that for discrete particle low-level contamination, about 5000 dpm of beta activity is the minimum level of activity that can be routinely detected under a surface contamination control program using direct survey methods. The indirect method of contamination monitoring (smear survey) provides a method of evaluating removable (loose, surface) contamination at levels below which can be detected by the direct survey method. For smears of a $100 cm^2$ area (a de facto industry standard), the corresponding detection capability with a thin window detector and a fixed sample geometry is on the order of 1000 dpm (i.e., $1000 dpm/100 cm^2$). Therefore, taking into consideration the practicality of conducting surface contamination surveys; contamination control limits should not be set below $5000 dpm/100 cm^2$ total and $1000 dpm/ 100 cm^2$ removable. The ability to detect minute, discrete particle contamination depends on the activity level, background, instrument time constant, and survey scan speed. A copy of Sommers studies is attached which provides useful guidance on establishing a contamination survey program.

Based on the studies of residual radioactivity limits for decommissioning (NUREG-0613[2] and NUREG-0707[3]), it can be concluded that surfaces uniformly contaminated at levels of $5000 dpm/ 100 cm^2$ (beta-gamma activity from nuclear power reactors) would result in potential doses that total less than 5 mrem/yr. Therefore, it can be concluded that for the potentially undetected contamination of discrete items and materials at levels below $5000 dpm/100 cm^2$, the potential dose to any individual will be significantly less than 5mrem/yr even if the accumulation of numerous items contaminated at this level is considered.

Guidance:

Items and material should not be removed from the restricted area until they have been surveyed or evaluated for potential radioactive contamination by a qualified* individual. Personal effects (e.g., notebooks and flash lights) which are hand carried need not be subjected to the qualified individual survey or evaluation, but these items should be subjected to the same survey requirements as the individual possessing the items. Contaminated or radioactive items and materials must be controlled, contained, handled, used, and transferred in accordance with applicable regulations.

The contamination monitoring using portable survey instruments or laboratory measurements should be performed with instrumentation and techniques (survey scanning speed, counting times, background radiation levels) necessary to detect $5000 dpm/100 cm^2$ total and $1000 dpm/100 cm^2$ removable beta/gamma contamination. Instruments should be calibrated with radiation sources having consistent energy spectrum and instrument response with the radionuclides being measured. If alpha contamination is suspected appropriate surveys and/or laboratory measurements capable of detecting $100 dpm/100 cm^2$ fixed and $20 dpm/100 cm^2$ removable alpha activity should be performed.

*A qualified individual is defined as a person meeting the radiation protection technician qualifications of Regulatory Guide 1.8, Rev. 1, which endorses ANSI N18.1, 1971.

In evaluating the radioactivity on inaccessible surfaces (e.g., pipes, drain lines, and duct work), measurements at other appropriate access points may be used for evaluating contamination provided the contamination levels at the accessible locations can be demonstrated to be representative of the potential contamination at the inaccessible surfaces. Otherwise, the material should not be released for unrestricted use.

Draft ANSI Standard 13.12[4] provides useful guidance for evaluating radioactive contamination and should be considered when establishing a contamination control and radiation survey program.

No written response to this circular is required. If you have any questions regarding this matter, please contact this office.

## REFERENCES

[1]Sommers, J. F., "Sensitivity of Portable Beta-Gamma Survey Instruments," Nuclear Safety, Volume 16, No. 4, July-August 1975.

[2]U.S. Nuclear Regulatory Commission, "Residual Radioactivity Limits for Decommissioning, Draft Report," Office of Standards Development, USNRC NUREG-0613, October 1979.

[3]U.S. Nuclear Regulatory Commission, "A Methodology for Calculating Residual Radioactivity Levels Following Decommissioning," USNRC NUREG-0707, October 1980.

[4]Draft ANSI Standard 13.12, "Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for Uncontrolled Use," American National Standards Institute, Inc., New York, NY, August 1978.

Attachments:
1. Reference 1 (Sommers Study)
2. Recently issued IE Circulars

# Control and Instrumentation

**Edited by E. W. Hagen**

## Sensitivity of Portable Beta–Gamma Survey Instruments

By J. F. Sommers*

**Abstract:** *Development of a new generation of portable radiation survey instruments and application of the "as low as practicable" (ALAP) philosophy have presented a problem of compliance with guides for radioactive contamination control. Isolated, low-level, discrete-particle beta–gamma contamination is being detected with the new instruments. To determine the limits of practicability requires, in turn, the determination of the limits of detection of these surface contaminants. The data and calculations included in this article indicate the source detection frequencies that can be expected using the new generation of survey instruments. The author concludes that, in low-population groups of discrete particles, about 5000 dis/min of beta activity per particle is the minimum level of activity per particle which is applicable for confident compliance with surface contamination-control guides. Lower control levels are possible with additional development of instruments or through high-cost changes in radiation survey and contamination-control methods. Additional analyses are required for assessment of the hazard caused by widely dispersed discrete-particle contaminants.*

The common, historical way to classify surface radioactive contamination has developed into standard definitions, limits, and control guides which, in some instances, are difficult, if not impossible, to apply.

In general, the definition of "removable" radioactive contamination must be inferred from guides[1] and regulations[2] on the significance of the quantity of radioactive materials removed. "Fixed" contamination, although not as uniquely defined, is, by inference, the radioactive contaminants that remain on a surface after the surface has been checked and found to have less than some defined removable contamination level. There are many minor variations of these definitions, but these will suffice to outline a major problem that applied health physicists have to verify compliance with radioactive surface contamination limits and guides.

In recent years the lowering of limits and the emphasis on as low as practicable[3] (ALAP) hazard control has encouraged commercial development of more sensitive survey instruments, the big improvement being detectors with thin windows. Peripheral features, such as audible alarms with adjustable set points, external speakers (instead of earphones), and selectable meter time constants, are common. However, the strong commercial competition to supply this type of instrumentation, the extreme competition for funds that could be used to improve radiation protection equipment, and the health physicists' reluctance or inability to provide adequate specifica-

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tions have left something to be desired in quality and overall performance of many of the instruments.

Although present beta–gamma contamination-control practices are more rigorous than in the past, there is still less than complete control of low-activity low-density particulate sources within the operating areas. In a typical situation the highest density of these particles, outside of contamination-control zones, may be on the order of one detectable particle per $10^2$ to $10^3$ ft$^2$. The particles are removable beta–gamma activity, but because of the large areas involved, the multiple types of surfaces on which they are deposited, and the low area density of the particles, they are not subject to detection with any sensible frequency using the smear or wipe technique. Thus survey instruments must be used to detect and measure the activity of the removable particles.

The particles tend to be trapped and concentrated on certain types of surfaces, such as mopheads and acrylic fiber rugs. From these deposits it has been determined that the specific activities of most of the particles range from about $2 \times 10^3$ to $2 \times 10^4$ dis/min. In order to determine why the particles escape detection and control within the operating areas, experimenters devised a rigorous test to determine the expected frequency of detection of the particles using standard survey methods. The results of these experiments have shown that the main hope for improvement lies in the development of more sensitive survey instruments and portal monitors and the development and application of contamination-control methods similar to those used in facilities where the much more hazardous alpha-emitting materials are handled.

## THEORY

The ability of a count-rate meter to provide reliable information for detection of small-diameter sources during surveys for radioactive contaminants depends upon a number of factors. These factors, for any given type and energy of radiation sources, are the specific activity of the sources, the influence of background radiation, the instrument time constant, the source–detector geometry, and the relative source–detector velocities. When an alarm set point is used to indicate the presence of radioactive sources, investigation shows that the sensitivity of the instrument is increased by setting the alarm set point as low as possible without causing alarms due to the fluctuations of background: the response of the count-rate meter is modified from the equilibrium count rate when source residence time under the detector is on the same order of magnitude of or less than the time constant of the meter; the count rate of the instrument increases as the source–window distance decreases: and the response of the count-rate meter increases as the source residence time under the detector window increases.

On the basis of the approximate Gaussian distribution of a count rate around the true average count rate, an alarm set point $A$ has a probability $p$ of being reached and causing an alarm due to an average background count rate $B$ during a counting interval $T$ that can be expressed as

$$A = (1 - e^{-T/\tau})(B + k|T^{-1/2} B^{1/2}|) \qquad (1)$$

where $\tau$ is the time constant of the count-rate meter and $k$ is a constant that uniquely defines the probability of alarm.[4] The term $1 - e^{-T/\tau}$ (the fraction of equilibrium count rate obtained during $T$) is limited by design considerations of count-rate meters to the accuracy of the meter output. Most instruments have 1% (of full-scale reading) or larger accuracy limits. For this reason the value of $0.99 = 1 - e^{-T/\tau}$ has been assigned for this study. Knowing the value of $\tau$ allows solution for $T$, and the solution is used in the second term of Eq. 1. This solution can be thought of as the practical, constant, integrating interval observed by the count-rate meter.

The approximate response of an instrument to small-diameter sources can be calculated by defining standard survey conditions and relating them to the response characteristics of the instrument. For these calculations the velocity vector $v$ of a flat circular window of the detector is assumed to be parallel to the surface being surveyed, and the velocity is held constant. The sources passing under the window of the detector bisect the circular projection of the window on the surface. The beta-counting efficiency of the instrument is assumed to be positive and constant when a source resides in the circular projection of the window on the surface; otherwise, the efficiency for counting the source is zero. This latter assumption may cause significant perturbations of experimental data from calculated data when source–window distances are larger than 2.5 cm. Gamma-counting efficiencies, the same order of magnitude as the beta-counting efficiencies, may also cause significant perturbation of experimental results, depending on the detector shielding configuration and effectiveness. The ideal source residence time $t$ is assumed to be equal to the window diameter $d$ divided by the velocity vector $v$. Under field conditions, $t$ will usually be less than the ideal value because the source velocity vector will hardly ever exactly bisect the circular window projection on the surface being surveyed.

Using the ideal survey conditions and an average background count rate $B$, a source with a net equilibrium count rate $S$ will cause a count rate as large as, or larger than, $A$, with a probability $P_i$ that is uniquely defined by the constant $K_i$ when the source residence time under the window is $t$ and the time-dependent meter response term is $1 - e^{-t/\tau}$. The count rate $A$ can then be expressed as

$$A \geqq (1 - e^{-t/\tau})\,(B + S + K_i|t^{-1/2}(B+S)^{1/2}|) \quad (2)$$

By substitution of the alarm set-point count rate $A$ from Eq. 1 into Eq. 2 and rearrangement, the source strength is found to be

$$S \geqq \left(\frac{1 - e^{-T/\tau}}{1 - e^{-t/\tau}}\right)(B + k|T^{-1/2}B^{1/2}|) - (B + K_i|t^{-1/2}(B+S)^{1/2}|) \quad (3)$$

Analysis of Eq. 3 shows that $P_i$ is the probability, or time-dependent frequency, that $S$ will cause an alarm when $K_i$ is positive, and $(1 - P_i)$ is the probability that the alarm will be actuated when $K_i$ is negative. Solutions for $S$ can be obtained using selected values of $K_i$, $B$, $\tau$, $t$, and $T$.

## METHODS

In order to determine expected alarm-actuation frequencies during standard contamination surveys, experimenters established the following conditions. These conditions would also allow an experimental check of the calculated alarm-actuation probabilities that occur when the source strength, background, instrument time constants, and source residence time are changed.

Commercially available (two manufacturers) portable survey instruments were used as models for the calculations and experiments. Selectable time constants of 0.0159 and 0.159 min were calculated from the manufacturers' quoted time-response characteristics: "90% of the equilibrium count rates in 2.2 or 22 seconds." Survey velocities between 2.4 and 15 cm/sec were selected for analysis, velocities that cause the source residence times under the 5-cm-diameter detector windows to range from 0.33 to 2.1 sec. Cesium-137 sources having small diameter and low backscatter were used experimentally for verification of calculated data; these sources are counted with an efficiency of 0.1 count per beta at ½ in. from the center of 1.7 mg/cm², 5-cm-diameter windows of "pancake"-type semishielded Geiger-Mueller tubes. Extrapolation of the data to other beta emitters is a practical exercise; i.e., from Evans,[5] beta transmission factors through 3.0 mg/cm² (air plus window) were calculated and shown to be greater than 72% for betas with energy spectra having maximum-energy betas ($E_{max}$) greater than 0.2 MeV. Thus $^{137}Cs$ betas, with a mean $E_{max} \cong 0.58$ MeV, provide a beta-counting efficiency from the thin-window detectors which is typical of beta emitters with $E_{max}$ greater than 0.2 MeV. Also, background and source size data are presented in counts per minute, so that changes in beta energies of sources and/or source–window distances can be normalized, using observed counting efficiencies, to the calculated data presented in this article.

With some manipulation of Eq. 3, a computer program was used to obtain an iterative set of solutions for $S$ that are accurate to within 1% of the true values. The alarm set points were determined using Eq. 1. Selections of background count rates, relative detector–source velocities, and the instrument time constant were arbitrary but within the ranges chosen for investigation. Values of $K_i$ were chosen to provide known probabilities of alarm actuation.

An extensive set of experimental data was obtained by moving calibrated sources past the detector windows at measured velocities and source–window distances to check the validity of the calculations. The same experimental setup to determine source detection frequencies was used with the audio (speaker) output of the survey meters. The use of audio output during contamination surveys is a well-known practice and will not be described further.

When the experimental and calculated source detection frequencies were compared, it became apparent that the time constants of the commercial survey instruments were not equal to specified values. Variations were noted between instruments of one model and between the different alarm set points on the other model. By measuring the buildup of the indicated count rates to 90% of equilibrium, we were able to determine the actual time constant on the instruments for any particular alarm set point.

The experimental data were obtained on an instrument that exhibited the advertised time constants. However, the poor (time-dependent response) performance of these instruments as a group has caused us to abandon the alarm set-point method for source detection under field conditions.

## RESULTS

Alarm set points vs. background count rate were calculated from Eq. 1. These are illustarted in Fig. 1 for time constants of 0.0159 and 0.159 min. The $k$ value selected, 4.89, uniquely defines the probability of an alarm being caused by a constant average background as $5 \times 10^{-7}$ $min^{-1}$.

Figure 2 shows that the short-time-constant set point is more sensitive for source detection, even though the long-time-constant set point is the lowest. The relative difference between the two becomes less as the source residence time increases.

Figure 3 illustrates the improved sensitivity to be expected as the source residence time increases (detector velocity decreases). The set point is obtained from Eq. 1 or Fig. 1. Note that with a source residence time of 1 sec (5 cm/sec), it takes 5000 betas/min (500 counts/min) at a background of 60 counts/min to cause an alarm 90% of the time. As a practical illustration, if an individual surveys himself at 10 cm/sec, it will take about 3 min for him to survey half the surface area of his body, and the particles he discovers with a 90% confidence level will have a beta-emission rate of about 9000 per minute (900 counts/min).

Figure 4 illustrates the benefit of selecting low-background areas to perform contamination surveys. As indicated by Eq. 1, the alarm set point has to be changed each time the background changes, and, if the time constant is not dependable (known), the set point may not be correct. Changing background count rates are a common occurrence in our operations, and our inability to make time-constant determinations in the field has caused us to abandon the alarm set-point method for contamination surveys.

Figure 5 shows that the calculational method of determining source detection frequencies using the alarm set point is valid in comparison with experimental data. Both the time constant and the alarm set point were verified on the instrument used. In practice, there would be some ambiguity in the setting of the alarm owing to the crude alarm set-point dial furnished on this model instrument.

Figure 6 compares calculated alarm-actuation frequencies with experimental data on audio-output source detection frequencies at an average background of 120 counts/min and a relative surface–window velocity of 15 cm/sec. Using the speaker output method, smaller sources are detected with the same frequency that is obtained using the alarm set-point method. The improvement is about a factor of 3.

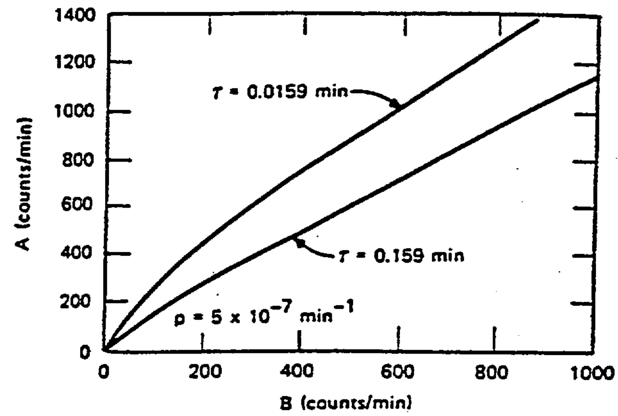


Fig. 1 Effect of background on the optimum alarm set point.

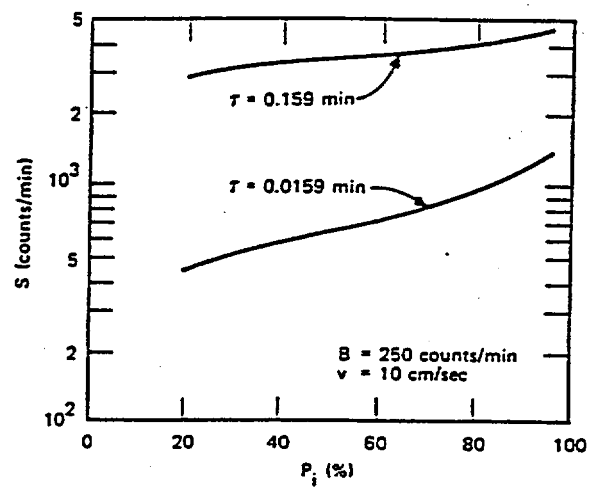


Fig. 2 Effect of instrument time constant on source detection frequency.

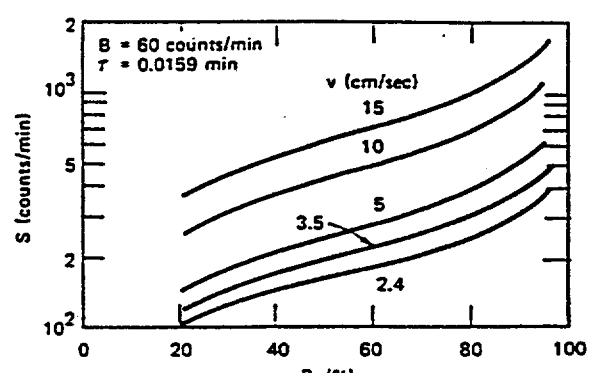


Fig. 3 Effect of probe velocity on source detection frequency.

Figure 7 shows a similar comparison using a detector velocity of 3.5 cm/sec. Here, the difference in detection frequencies narrows, and the alarm set-point method becomes better than the audio detection method for the larger sources at this low survey velocity.

Figure 8 compares experimental audio-output data for three different survey velocities at 120 counts/min background. The difference in source detection frequencies is surprisingly small when compared with the alarm-actuation method. This is explained by the adaptability of the human audio response; i.e., the effective time constant (human) adapts, within bounds, to the source size that can be detected with a given survey velocity and background count rate. Note that at 500 counts/min (5000 betas/min), the source detection frequencies appear to converge at about 80%. The results shown are averages of over 100 observations per datum point from two or more experienced surveyors. The largest variations in the data occurred between individuals; i.e., the largest variables were caused by the physical and psychological conditioning

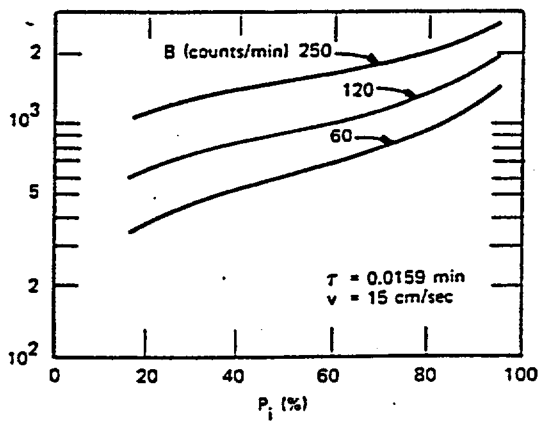


Fig. 4 Effect of background on source alarm-actuation frequency.

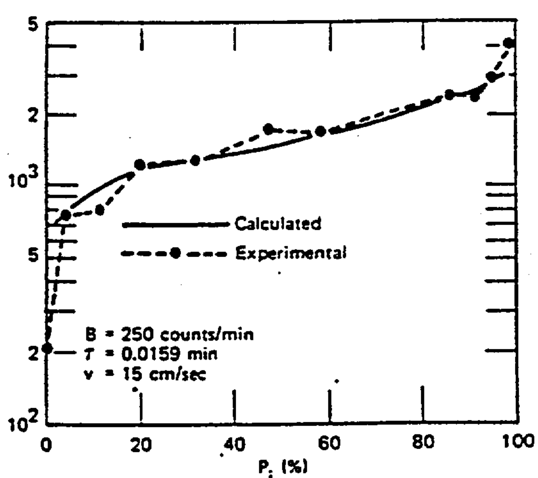


Fig. 5 Comparison of experimental and calculated data on source detection frequencies.

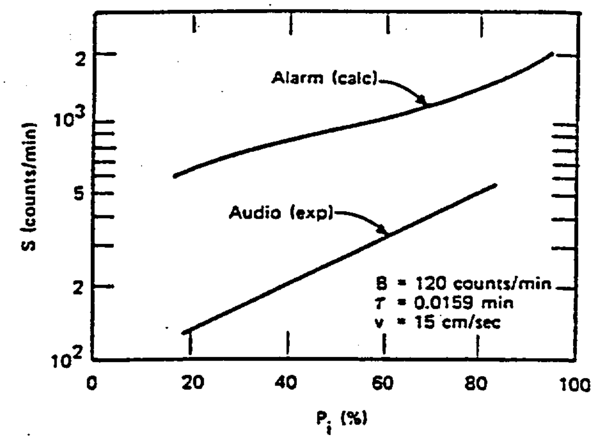


Fig. 6 Comparison of source detection frequencies using alarm set-point and audio detection methods.

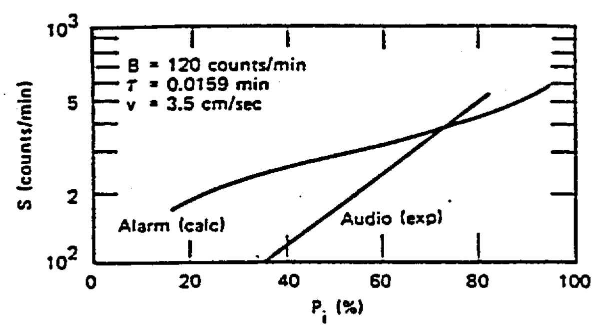


Fig. 7 Comparison of source detection frequencies using alarm and audio detection methods.

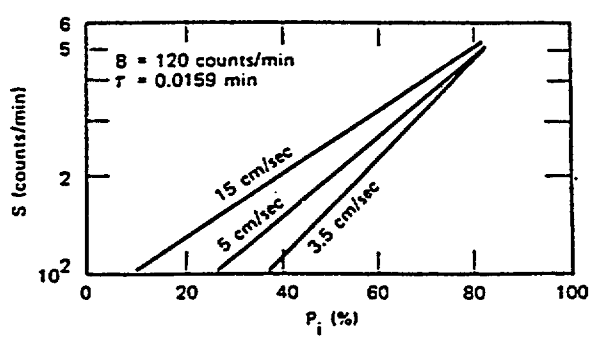


Fig. 8 Comparison of audio source detection frequencies and velocities.

of the surveyors. The lower detection frequencies have been ignored because of the statistical deviations that occurred. The time consumed to obtain reliable data at the higher detection frequencies was considerable, and, as our interest is in setting high-confidence-level control criteria, it was considered not practicable to obtain good, small source, detection-frequency statistics.

## DISCUSSION AND CONCLUSIONS

A method has been shown whereby detection frequencies of small-diameter radioactive sources can be calculated for portable survey instruments that have known time constants and alarm set points. Source detection frequencies are strongly dependent upon (1) source strength, (2) survey velocities, (3) background activity, (4) detector sensitivity, and (5) the time constant of the survey meter. With activity of a large-area uniform surface, the survey velocity and the time constant of the survey meter are immaterial (within reasonable bounds). The calculations show that, even under the most rigorous conditions (survey velocities <2.5 cm/sec), small-diameter sources emitting 3000 betas/min can only be detected in low-background areas with a confidence of about 90% using the alarm set-point method. At more sensible survey velocities of 10 to 15 cm/sec, it takes sources emitting 10,000 to 15,000 betas/min to provide the same detection frequency using the alarm set-point detection method.

At the higher probe velocities investigated, source detection frequencies are larger using the audio output rather than the alarm set-point method. With small-diameter sources emitting 5000 betas/min, source detection frequency at 120 counts/min background is about 80% using the speaker output, regardless of the survey velocities between 3.5 to 15 cm/sec. With 3000 beta/min sources, the speaker detection frequency, using the slowest survey velocity (3.5 cm/sec), is only about 65%. At this velocity the alarm set-point method is as good as or better than the audio method with sources larger than 3500 betas/min. Although most of the experimental data were obtained at only one background level (120 counts/min), it is apparent that it is not practical to set contamination-control limits on discrete particles of beta–gamma activity much below 5000 betas/min if we are to have confidence in our ability to detect discrete-particle sources before they escape the contamination-control areas.

These results then pose several problems. Are the particles of beta–gamma activity that escape detection, and thus control, a health hazard of consequence? Krebs[6] and Healy[7] have presented arguments on the relative hazards of discrete-particle and small-area sources in relation to more diffuse sources. However, the data used involved higher specific activity than that of the particles we have been observing. Healy has published[8] a comprehensive resuspension hazards analysis for diffuse contaminants which is difficult to apply to the low-density particle population we observe. Good hazards analyses are needed on the resuspension of discrete particles in the size range under discussion. Development of portable instruments for surveying large areas with a practical expenditure of time and effort appears possible, but it will take time and money to design, develop, and make them commercially available. In the meantime, the advisory, standards, and regulation agencies need to look at the control guides and limits to assure that the conservatism applied using the ALAP philosophy is, in fact, *practicable* for compliance with the equipment and methods available to the industry. For this particular problem (low-density discrete particles of removable beta–gamma activity), I suggest that removable contamination be defined in two categories, "uniform" and "dispersed," and then resuspension factors applied that have some reality in the calculation of exposure hazards. This is the only way at this time that the industry has any hope for practicable compliance with contamination-control limits.

## REFERENCES


1. Administrative Guide for Packaging and Transporting Radioactive Materials, ANSI-N14.10.1-1973, p. 7, American National Standards Institute, New York.
2. Department of Transportation. Hazardous Materials Regulations of the Department of Transportation, *Code of Federal Regulations*, Title 49, 173.397, effective Sept. 13, 1973.
3. Concluding Statement of the AEC Regulatory Staff in the "As Low As Practicable" Hearing, *Nucl. Safety*, 15(4): 443-452 (July–August 1974).
4. A. A. Jarrett, Statistical Methods Used in the Measurement of Radioactivity (Some Useful Graphs), USAEC Report AECU-262, 1946.
5. R. D. Evans, *The Atomic Nucleus*, pp. 627-628, McGraw-Hill Book Company, Inc., New York, 1955.
6. J. S. Krebs, The Response of Mammalian Skin to Irradiation with Particles of Reactor Debris, Report USNRDL-TR-67-118, U. S. Naval Radiological Denfense Laboratory, September 1967.
7. J. W. Healy, A Proposed Interim Standard for Plutonium in Soils, USAEC Report LA-5483-MS, Appendix C, Los Alamos Scientific Laboratory, January 1974.
8. J. W. Healy, Surface Contamination: Decision Levels, USAEC Report LA-4558-MS, Los Alamos Scientific Laboratory, September 1971.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF INSPECTION AND ENFORCEMENT
WASHINGTON, D.C. 20555

December 2, 1985

IE INFORMATION NOTICE NO. 85-92: SURVEYS OF WASTES BEFORE DISPOSAL FROM NUCLEAR REACTOR FACILITIES

Addressees:

All production and utilization facilities, including nuclear power reactors and research and test reactors, holding an operating license (OL) or construction permit (CP).

Purpose:

The purpose of this information notice is to supplement the guidance of IE Circular 81-07 as it applies to surveys of solid waste materials before disposal from nuclear reactor facilities. It is expected that recipients will review the information for applicability to their facilities. However, this information notice does not constitute NRC requirements; therefore, no specific action or licensee response is required.

Description of Circumstance:

Some questions have arisen concerning appropriate methods of surveying solid waste materials for surface contamination before releasing them as nonradioactive (i.e., as wastes that do not contain NRC-licensed material).

Discussion:

The need to minimize the volume of radioactive waste generated and shipped to commercial waste burial sites is recognized by the NRC and industry. Some nuclear power plants have initiated programs to segregate waste generated in radiologically controlled areas. Such programs can contribute to the reduction in volume of radioactive waste; however, care should be taken to ensure that no licensed radioactive material is released contrary to the provisions of 10 CFR Section 20.301. In practice, no radioactive (licensed) material means no detectable radioactive material.

In 1981, IE Circular 81-07 was issued by the NRC. That circular provided guidance on the control of radioactively contaminated material and identified the extent to which licensees should survey for contamination. It did not establish release limits. The criteria in the circular that addressed surface contamination levels were based on the best information available at the time and were related to the detection capability of portable survey instruments equipped with thin-window "pancake" Geiger-Mueller (G.M.) probes, which respond primarily to beta radiation. Monitoring of aggregated, packaged material was not addressed. In 1981, there was no major emphasis on segregating waste from designated contamination areas. As a consequence, large volumes of monitored wastes were not being released for unrestricted disposal. However, because of recent emphasis on minimizing the volume of radioactive waste, current practices at many nuclear power facilities result in large volumes of segregated, monitored wastes, containing large total surface areas, being released as "clean" waste.

When scanning surfaces with a hand-held pancake probe, there is a chance that some contamination will not be detected. (See the papers by Sommers,[1] for example.) There is the chance also that the total surface area will not be scanned completely. Thus, when numerous items of "clean" material (e.g., paper and plastic items) are combined, the accumulation of small amounts of contamination that have escaped detection with the pancake probe may be detected using a detector that is sensitive to gamma radiation (e.g., by using a sensitive scintillation detector in a low-background area). Such measurements of packaged clean waste before disposal can reduce the likelihood that contaminated waste will be disposed of as clean waste, then found to be contaminated after disposal. (Some operators of sanitary landfills have begun to survey incoming waste for radioactivity using scintillation survey meters which in some cases are supplemented by portable gamma-ray spectrometers.[2])

In order to preclude the unintentional release of radioactive materials, a good monitoring program likely would include the following:

1. Careful surveys, using methods (equipment and techniques) for detecting very low levels of radioactivity, are made of materials that may be contaminated and that are to be disposed of as clean waste. These survey methods should provide licensees with reasonable assurance that licensed material is not being released from their control.

2. Surveys conducted with portable survey instruments using pancake G.M. probes are generally more appropriate for small items and small areas because of the loss of detection sensitivity created by moving the probe and the difficulties in completely scanning large areas. This does not preclude their use for larger items and areas, if supplemented by other survey equipment or techniques.

3. Final measurements of each package (e.g., bag or drum) of aggregated wastes are performed to ensure that there has not been an accumulation of licensed material resulting from a buildup of multiple, nondetectable quantities (e.g., final measurements using sensitive scintillation detectors in low-background areas).

The foregoing does not constitute NRC requirements; therefore, no specific action or written response is required by this information notice. If you have any questions about this matter, please contact the Regional Administrator of the appropriate NRC regional office or this office.

Edward L. Jordan, Director
Division of Emergency Preparedness
and Engineering Response
Office of Inspection and Enforcement

Technical Contacts: John D. Buchanan, IE
(301) 492-9657

LeMoine J. Cunningham, IE
(301) 492-9664

Attachments:
1. References
2. List of Recently Issued IE Information Notices

Attachment 1
IN 85-92
December 2, 1985

## REFERENCES


[1] Sommers, J. F., (a) "Sensitivity of Portable Beta-Gamma Survey Instruments," Nuclear Safety 16 (No. 4), 452-457, July - August 1975, (b) "Sensitivity of GM and Ion-Chamber Beta-Gamma Survey Instruments," Health Physics 28 (No. 6), pp. 775-761, June 1975.

[2] Anonymous, "LA Nuclear Medicine Community Improves Radiation Monitoring at Landfills," J. Nuclear Medicine 26 (#4), 336-337, April 1985.

## Figure IV-1, "Surface Contamination Guidelines"
## from DOE Order 5400.5, Radiation Protection of the Public and the Environment

The attached figure from DOE Order 5500.5, Radiation Protection of the Public and the Environment, contains guideline values for residual radioactive material that are acceptable values for use of property without restrictions due to residual radioactive material. The generic surface contamination guidelines provided in Figure IV-1 are applicable to existing structures and equipment. The table in Figure IV-1, and instructions for its use, are generally consistent with the NRC's guidance in Regulatory Guide 1.86.

Figure IV-1
Surface Contamination Guidelines

| Radionuclides[2/] | Allowable Total Residual Surface Contamination (dpm/100 $cm^2$)[1/] Average[3/,4/] | Maximum[4/,5/] | Removable[4/,6/] |
|---|---|---|---|
| Transuranics, I-125, I-129, Ra-226, Ac-227, Ra-228, Th-228, Th-230, Pa-231. | RESERVED | RESERVED | RESERVED |
| Th-Natural, Sr-90, I-126, I-131, I-133, Ra-223, Ra-224, U-232, Th-232. | 1,000 | 3,000 | 200 |
| U-Natural, U-235, U-238, and associated decay product, alpha emitters. | 5,000 | 15,000 | 1,000 |
| Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.[7/] | 5,000 | 15,000 | 1,000 |

1/ As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

2/ Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

3/ Measurements of average contamination should not be averaged over an area of more than 1 $m^2$. For objects of less surface area, the average should be derived for each such object.

4/ The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

5/ The maximum contamination level applies to an area of not more than 100 $cm^2$.

5/ The amount of removable material per 100 $cm^2$ of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wiping with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 $cm^2$ is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.

7/ This category of radionuclides includes mixed fission products, including the Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched.

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## APPENDIX C

## Stakeholders

*The following categories (and examples) of stakeholders are suggested for solicitation of comments on issues discussed in this document. If desired, additional stakeholders may be identified from the Commission's docket files.*

**Cognizant Government Agencies and Government-sponsored Organizations**

Department of Energy

Department of Transportation

Environmental Protection Agency

National Academy of Science

**NRC Agreement States**

**Other State and Local Governments**

Council of State Governments

National Conference of State Legislators

National Governors Association

**Native American Tribes**

**Industry Representatives**

American Iron and Steel Institute

American Trucking Associations

Association of Radioactive Metal Recyclers

Electric Power Research Institute

Institute of Scrap Recycling Industries

National Association of Demolition Contractors

Nuclear Energy Institute

Steel Manufacturers Association

**Professional Societies**

American Association for the Advancement of Science

American Nuclear Society

Health Physics Society

**Public Interest Groups**

Natural Resources Defense Council

Public Citizen

Sierra Club

Union of Concerned Scientists

**General Public**

DRAFT

# COMPILATION OF

# ISSUES, SUB-ISSUES, AND SECONDARY ISSUES

**Related to**

# REGULATION OF REUSE/RECYCLE OF SCRAP METAL SLIGHTLY CONTAMINATED BY RADIOACTIVITY


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***ISSUE 1: Is there a need for NRC rulemaking to provide for unrestricted release of RRSM into public commerce?***

***<u>Sub-issue 1.1</u>: Is such reuse/recycle in the public interest? What would be the justification for allowing commercial, open-ended RRSM? What are the benefits, and to whom would they accrue? Can they be quantified so that risks and benefits can be compared? If so, how?***

***<u>Sub-issue 1.2</u>: What are the potential risks? Can a reasonable estimate of risks be made?***

***<u>Sub-issue 1.3</u>: Assuming that allowed individual and population exposures, as well as contamination of property would be very small, would there in fact be a commercial market for slightly radioactive reused/recycled metals or other materials? Commercial scrap dealers currently protect themselves from inadvertently receiving radioactive materials. Would establishment of a licensing process, however simple, encourage dealers to accept these materials?***

***<u>Sub-issue 1.4</u>: Given the extent of international commerce, and the fact that reuse/recycle of slightly radioactive materials in this country may affect people and industries in other countries, and conversely that reuse/recycle of radioactive materials in other countries may affect people and industries in this country, to what extent can or should the international implications of such reuse/recycle be addressed in this rulemaking?***

***ISSUE 2: Should the Commission proceed with rulemaking? If so, how should it proceed?***

***<u>Sub-issue 2.1</u>: Should the Commission proceed with expedited rulemaking?***

***<u>Sub-issue 2.2</u>: Should the Commission engage in a normal rulemaking schedule?***

***<u>Sub-issue 2.3</u>: Should the Commission proceed with rulemaking only after publication of a reuse/recycle standard by EPA?***

***<u>Sub-issue 2.4</u>: Should the Commission defer rulemaking until a later time?***

***ISSUE 3: If the Commission were to proceed with rulemaking, what should be the scope of the rulemaking? Should it be as broad as possible, e.g., reuse/recycle of all materials, or as narrow as possible, e.g., reuse/recycle of scrap nickel for use by licensed fabricators of specialized industrial equipment?***

***<u>Sub-issue 3.1</u>: To what extent can or should the NRC rely on control of first use of reused/recycled materials to reduce potential public risk from reuse/recycle of materials containing small quantities of radioisotopes?***

*<u>Secondary Issue 3(a)</u>: What would be the relationship of an RRSM rule to Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) legislation, as well as to state laws and regulations?*

***ISSUE 4: What should be the objective for regulating reuse/recycle material?***

***<u>Sub-issue 4.1</u>: What alternatives should be considered as a general framework for establishing a regulatory objective? Should the Commission consider a combination of fundamental objectives and if so, on what basis?***

***<u>Sub-issue 4.2</u>: Should the objective for regulating reuse/recycle material be to limit annual risk to individuals expected to be most highly exposed: 1) from any single reuse/recycle activity; 2) from the entire reuse/recycle practice?***

***<u>Sub-issue 4.3</u>: Should the objective for regulating reuse/recycle material be to limit annual population risk: 1) from any single reuse/recycle activity; 2) from the entire reuse/recycle practice?***

***<u>Sub-issue 4.4</u>: Should the objective for regulating reuse/recycle material be some combination of the above, i.e., should the Commission include consideration of an exposed population in addition to providing criteria for individuals? If so, how should this influence the criteria?***

***<u>Sub-issue 4.5</u>: Should the Commission base its considerations on a theoretical, maximally exposed individual, or upon some type of "critical group" approach?***

*<u>Secondary Issue 4(a)</u>: What additional considerations should be taken into account when establishing radiological criteria for reuse/recycle?*

*<u>Secondary Issue 4(b)</u>: What pathways of exposure to people would be important to consider for unrestricted RRSM?*

***ISSUE 5: At what numerical levels would the objective(s) for regulating reuse/recycle material provide an acceptable basis for protection of the public health and safety and the environment?***

***<u>Sub-issue 5.1</u>: If the Commission chooses an Individual Risk Limit objective, should the Commission use the 100 millirem/yr in 10 CFR 20 for public dose limits, the 25 millirem/yr dose limit in 40 CFR 190 for the commercial uranium fuel cycle, the proposed 15 millirem/yr for decommissioning as the limit on doses from residual radioactivity, or should the Commission establish separate constraints for reuse/recycle? If separate constraints are set, what should be the basis for these constraints?***

***<u>Sub-issue 5.2</u>: If the Commission chooses a population risk objective, at what numerical level should it be set?***

***<u>Sub-issue 5.3</u>: What consideration should be given to standards or objectives proposed or adopted by other groups (e.g., the IAEA)?***

*<u>Secondary Issue 5(a)</u>: What consideration should the Commission give to the potential adverse impact of RRSM on sensitive operations or practices in industry and research?*

*<u>Secondary Issue 5(b)</u>: Can a few critical receptors be identified or postulated whose exposures and risks could be readily estimated, and who could be adequate surrogates for all individuals and populations that could be exposed?*

*<u>Secondary Issue 5(c)</u>: From a practical point of view, how should NRC codify radiological criteria for reuse/recycle? Should controls be applied in terms of radioisotope concentration? Total radioisotope release? Individual dose? Annual risk? Lifetime risk?*

***ISSUE 6: How should practicality considerations be applied in radiological criteria for a reuse/recycle rule—particularly if the Commission were to adopt either the Risk Limit objective or the Risk Goal objective?***

***<u>Sub-issue 6.1</u>: Should the Commission require that ALARA be determined for each recycle activity? If not, how should it be applied? Should the Commission establish generic ALARA criteria? If generic ALARA criteria are used, should a single ALARA criterion be established for all materials, or should different ALARA criteria be established for different categories of materials or items to be recycled? If ALARA criteria are established for different categories of materials or items, on what basis should the different categories be established?***

***<u>Sub-issue 6.2</u>: Irrespective of whether ALARA is applied on an activity-specific basis or generically, on what basis should the ALARA analysis rest? What level of review by the NRC staff should be required to evaluate this basis? For example, how should the level of difficulty in measuring certain radionuclides in some circumstances be handled? How should the staff address societal and socioeconomic aspects of the ALARA analysis?***

***<u>Sub-issue 6.3</u>: Should the Commission establish a Risk Goal objective as its basis for establishing ALARA criteria, on what basis should the goal be established?***

***<u>Sub-issue 6.4</u>: Should the Commission establish a Best Effort objective as its basis for establishing ALARA criteria, what level of technology availability should be used? How often should the applicable areas of technology be updated for this criteria? What criteria should govern application of the technology to achieve lower levels of residual radioactivity, i.e., how would the point of diminishing returns on invested cost/effort be established? Recognizing that different applications of technology could result in widely varying levels of residual radioactivity, should an additional limit be placed on the level of residual radioactivity? How should the phrase, "fixed radioactivity" be defined, as it applies to surface contamination?***