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A Risk-Based Waste Clearance Concept for the D&D Program

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S.Y. Chen and S.K. Bhattacharyya

Argonne National Laboratory

Argonne, IL

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S.Y. Chen and S.K. Bhattacharyya
Argonne National Laboratory
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INTRODUCTION

Large amounts of radioactively contaminated wastes are expected to result from decontamination and decommissioning (D&D) activities at nuclear facilities. Many of the waste materials, such as concrete rubble and scrap metals, are only slightly contaminated and can be recycled to minimize waste streams, resulting in substantial savings from reducing conventional waste disposal costs and recovering the values of the raw materials. For instance, a recent projection[1] indicates that recycling estimated 30 million metric tons of radioactive scrap metal (RSM) worldwide, having a corresponding recoverable value of about 10 to 20 billion dollars, would avoid an estimated 5 billion dollars in disposal costs. As an average heuristic, waste disposition constitutes approximately 50% of total D&D costs. There is thus a strong incentive to minimize the waste from D&D activities.

In the United States, no specific standards have been developed for the unrestricted release of bulk contaminated materials, although standards for unrestricted release of radioactive surface contamination have existed for about 20 years.[2] The release of materials is not commonly practiced because of the lack of risk-based justifications. Recent guidance from international bodies has established a basis for deriving risk-based release limits for radioactive materials.[3] It is important, therefore, to evaluate the feasibility of recycling, because if it is feasible, risk-based release limits for the reusable materials will need to be established.

WASTE CLEARANCE CONCEPT

The International Atomic Energy Agency (IAEA) has published principles for exempting radiation sources and practices from regulatory control.[3] Two basic radiation protection criteria have been prescribed:

1. Individual risks must be low enough to not warrant regulatory concern.
2. Radiation protection, including the cost of regulatory control, must be optimized.

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The first criterion is aimed to protect of individuals. The second meets the as low as reasonably achievable (ALARA) principal for controlling the collective exposure to society. The numerical guidance recommended by IAEA includes:

- A dose limit of 10 μSv/yr dose limit per practice to an average member of "critical group."
- A collective dose commitment of 1 person-Sv from an annual practice.

On the basis of the health risk conversion factor of 5×10^{-2} cancer fatality per person-Sv of exposure recommended by the International Commission on Radiological Protection,[4] the annual limit of 10 μSv exposure corresponds to an individual lifetime risk in the range of 10^{-6} to 10^{-7}. The population dose of 1 person-Sv corresponds to a risk level of 10^{-2} to 10^{-1} annually. The IAEA has since published clearance levels in an interim report[5] for comment. A similar approach toward release is also contained in the proposed U.S. Department of Energy's 10 CFR 834 as "authorized release."

RELEASE ALTERNATIVES AND SCENARIOS

Unrestricted release of recyclable radioactive scrap materials may be followed by one of three major alternatives: reuse, recycle, or disposal.

The *reuse alternative* can be applied to a facility, equipment, small tools/motors, or other salvageable materials. Decontamination may be performed before release to satisfy standards. Exposure scenarios related to reuse primarily involve building occupants and people who reuse tools and equipment.

The *recycle alternative* is broader than the reuse alternative. Exposure scenarios involve workers associated with recovery activities (such as metal smelting) and members of the general public who use the products. Analysis of risk requires knowledge of the recycling process for each material and specific end-use potentials identified for the recycled products. Because the products' radioactive contents are usually mixed uniformly following recycling, standards for the recycle alternative should be issued on a volumetric (dispersed) basis.

The *disposal alternative* specifically applies to disposal at public landfills or by incineration. Scenarios for the disposal alternative involve numerous environmental pathways that are associated with the transport of contaminants at the disposal sites. For reasons stated previously, disposal of RSM is usually not a preferred alternative to recycling.

ASSESSMENT METHODOLOGY

Several risk assessments for the release of radioactively contaminated materials have been published,[6,7,8] including NUREG/CR-5512 issued by the U.S. Nuclear Regulatory Commission.[9] In all these assessments, pathway analysis has been used to assess risks to potentially exposed individuals. RESRAD-BUILD, a recently published approach developed Argonne National Laboratory, is designed to emphasize "site-specific" issues by using a room compartmental model.[9] The approach also considers pathways of radon (Rn-222 and Rn-220), which have been determined as being important to doses from parent nuclides of radon. Another code, RESRAD-RECYCLE, is currently under development at Argonne National Laboratory. RESRAD-RECYCLE assesses the exposure and risk to a worker and the public for various metal recycling and end-use scenarios. Assessment of doses from incineration can be performed by codes such as CAP88.[9] For assessment of risk from disposal, a multimedia pathway analysis code such as RESRAD should be used.[10]

Limits based on individual doses should be evaluated against the potential population dose commitment in meeting the criterion of 1 person-Sv annually.

KEY PARAMETERS

Realistic assumptions are typically employed in various dose assessment steps because of the uncertainty associated with appropriate parameter values. Such scenarios have been consistently assumed in the literature and are acknowledged in the Safety Series No. 111 report.[8]

Key parameters affecting dose estimates include metal dilution factor, nuclide partitioning factors, dust loading rate, ingestion rate, nuclide emission rate, and radon enamation factor. The parameters vary in importance from those that substantially affect multiple scenarios (e.g., dilution and partitioning factors) to those that affect only one exposure pathway for one scenario.

CONCLUSIONS

Recycling and reusing radioactively contaminated metals could be a viable alternative to D&D waste minimization. Release of such metals under the current international dose guideline would result in annual public risk levels of less than 10^{-6} for an individual and 10^{-2} for society. Methodology and data are available to strongly support a conservative yet practical analysis. It is feasible, therefore, to address the issues and to derive risk-based standards for the unrestricted release of RSM that are designed to prevent undue risk to the public.

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