TECHNICAL SUPPORT DOCUMENT

POTENTIAL RECYCLING OF SCRAP METAL FROM NUCLEAR FACILITIES

PART I: RADIOLOGICAL ASSESSMENT OF EXPOSED INDIVIDUALS

Volume 1

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EXECUTIVE SUMMARY

Introduction

Large quantities of radioactively contaminated scrap metal are generated during the decommissioning of nuclear facilities and, to a lesser extent, during the normal operation of these facilities. To evaluate the radiological impacts of releasing residually contaminated metals to the environment, the U.S. Environmental Protection Agency (EPA) performed exhaustive analyses of the release and recycling of carbon steel, aluminum, and copper scrap. The aim of the analyses was to calculate the annual dose and the lifetime risk of cancer to the reasonably maximally exposed (RME) individual, normalized to the specific activity of a given radioactive contaminant in the scrap, from one year of exposure. These results, presented as a set of tables that list the normalized doses and risks to the RME individual from each of 44 radionuclides and nuclide combinations that are potential contaminants of the three metals, can be used to assess the potential health effects of releasing scrap with a given level of contamination.

Description of Actual Work

The first step was constructing a series of exposure scenarios corresponding to the entire life cycle of each metal, comprising the transportation of the scrap; cutting and sorting at a scrap processing or recycling facility; melt-refining at a steel mill, secondary smelter facility, or an integrated copper production facility; fabrication of commercial products; and the use of such products. Also included were exposures to the primary byproducts of the furnace—slag (dross in the case of aluminum) and offgas. In the case of steel and aluminum, most of the offgas, which comprises both volatile and particulate matter, is captured by the emission control system and routed to the baghouse, where the fumes are cooled and filtered. Airborne effluent emissions include uncondensed gases and particulate matter that escape the collection and filtration system.

The RME individual is the person who, due to his occupation, location or living habits, would receive the maximum likely exposure from a given radionuclide. To identify this individual, the doses from one year's exposure to each scenario were calculated for all three metals. The person with the highest dose became the RME individual for a given radionuclide.

The exposure pathways fall into two general groups: external exposure to direct penetrating radiation and internal exposure from inhaled or ingested radionuclides. The internal exposure pathways consist of inhalation of radioactively contaminated dust; incidental ingestion of dust or other loose, finely divided material; and ingestion of contaminated food or water.

The 44 individual radionuclides and nuclide combinations studied in this analysis are those most likely to be present in contaminated scrap that may be a candidate for recycling. A literature search as well as thermodynamic calculations were used to develop partition ratios and vaporization fractions of the corresponding elements during the melt-refining of carbon steel, aluminum, and copper.

Results

Table S-1 summarizes the results of the analyses. The maximum normalized doses from one year of exposure span the range of approximately 3×10^{-3} to 700 μSv/a per Bq/g, reflecting the wide range of chemical and radiological properties of these nuclides. In 29 of the 44 cases, the normalized doses from the maximum exposure scenario for copper scrap are higher than the maximum doses from carbon steel or aluminum. In the majority of cases, the RME individual is a worker directly involved in handling or processing the scrap metal or its refinery byproducts. In several other cases, it is a person who is exposed to finished metal products as a result of his occupation. In three other cases, it is an individual who resides near a recycling or disposal facility and is exposed to airborne effluents or contaminated drinking water.

These results allow EPA and other interested parties to evaluate the potential radiological impacts of recycling scrap metals with known levels of residual contamination.

Table S-1. Maximum Exposure Scenarios and Normalized Impacts on the RME Individual from One Year of Exposure to Recycling of Carbon Steel, Aluminum, and Copper

Nuclide	Maximum Scenario	Metal	Dose		Lifetime Risk of Cancer[a] per:	
			mrem per pCi/g	μSv per Bq/g	pCi/g	Bq/g
C-14	Dross in landfill	Al	3.4e-04	9.2e-02	1.6e-10	4.4e-08
Mn-54	Lathe operator	steel	1.0e-01	2.7e+01	7.7e-08	2.1e-05
Fe-55	Slag worker	Cu	4.1e-05	1.1e-02	1.1e-11	2.9e-09
Co-60	Sailor exposed to hull plate	steel	4.7e-01	1.3e+02	3.5e-07	9.5e-05
Ni-59	Slag worker	Cu	9.5e-06	2.6e-03	6.4e-12	1.7e-09
Ni-63	Slag worker	Cu	2.6e-05	7.1e-03	2.0e-11	5.5e-09
Zn-65	Truck driver: baghouse dust	steel	7.1e-02	1.9e+01	5.4e-08	1.5e-05
Sr-90+D	Slag leachate in groundwater	steel	1.6e-02	4.2e+00	7.7e-09	2.1e-06

[a] Maximum risk—may correspond to a different scenario

Table S-1 (continued)

Nuclide	Maximum Scenario	Metal	Dose		Lifetime Risk of Cancer[a] per:	
			mrem per pCi/g	μSv per Bq/g	pCi/g	Bq/g
Nb-94	Slag pile worker	steel	2.3e-01	6.3e+01	1.8e-07	4.8e-05
Mo-93	Slag worker	Cu	3.3e-04	8.8e-02	3.3e-11	8.8e-09
Tc-99	Slag worker	Cu	1.8e-04	5.0e-02	5.9e-11	1.6e-08
Ru-106+D	Lathe operator	steel	2.6e-02	7.0e+00	2.0e-08	5.3e-06
Ag-110m+D	Lathe operator	steel	3.2e-01	8.5e+01	2.4e-07	6.5e-05
Sb-125+D	Sailor on naval support vessel	steel	6.2e-02	1.7e+01	4.7e-08	1.3e-05
I-129	Airborne effluent emissions	steel	3.3e-01	8.9e+01	1.5e-07	4.0e-05
Cs-134	Truck driver: baghouse dust	steel	1.8e-01	5.0e+01	1.4e-07	3.8e-05
Cs-137+D	Truck driver: baghouse dust	steel	6.6e-02	1.8e+01	5.0e-08	1.4e-05
Ce-144+D	Slag pile worker	steel	8.3e-03	2.3e+00	6.5e-09	1.8e-06
Pm-147	Slag worker	Cu	1.6e-04	4.2e-02	9.4e-11	2.5e-08
Eu-152	Slag pile worker	steel	1.7e-01	4.6e+01	1.3e-07	3.5e-05
Pb-210+D	EAF furnace operator	steel	5.6e-01	1.5e+02	1.6e-07	4.3e-05
Ra-226+D	Slag worker	Cu	3.0e-01	8.2e+01	2.1e-07	5.8e-05
Ra-228+D	Slag worker	Cu	2.4e-01	6.5e+01	1.2e-07	3.1e-05
Ac-227+D	Slag worker	Cu	2.5e+00	6.8e+02	1.2e-07	3.4e-05
Th-228+D	Slag worker	Cu	1.4e+00	3.7e+02	8.7e-07	2.3e-04
Th-229+D	Slag worker	Cu	2.3e+00	6.2e+02	4.7e-07	1.3e-04
Th-230	Slag worker	Cu	3.8e-01	1.0e+02	4.4e-08	1.2e-05
Th-232	Slag worker	Cu	6.6e-01	1.8e+02	8.2e-08	2.2e-05
Pa-231	Slag worker	Cu	9.8e-01	2.7e+02	5.3e-08	1.4e-05
U-234	Slag worker	Cu	2.4e-01	6.6e+01	1.1e-07	2.9e-05
U-235+D	Slag worker	Cu	2.4e-01	6.4e+01	1.1e-07	3.1e-05
U-238+D	Slag worker	Cu	2.1e-01	5.7e+01	9.8e-08	2.7e-05
Np-237+D	Slag worker	Cu	6.3e-01	1.7e+02	2.9e-07	7.8e-05
Pu-238	Slag worker	Cu	4.3e-01	1.2e+02	7.4e-08	2.0e-05
Pu-239	Slag worker	Cu	4.3e-01	1.2e+02	6.8e-08	1.8e-05
Pu-240	Slag worker	Cu	4.3e-01	1.2e+02	6.8e-08	1.8e-05
Pu-241+D	Slag worker	Cu	4.6e-03	1.2e+00	4.1e-10	1.1e-07
Pu-242	Slag worker	Cu	4.0e-01	1.1e+02	6.5e-08	1.7e-05
Am-241	Slag worker	Cu	1.1e+00	3.1e+02	3.0e-07	8.2e-05
Cm-244	Slag worker	Cu	7.2e-01	1.9e+02	1.9e-07	5.2e-05
U-Natural	Slag worker	Cu	1.6e+00	4.4e+02	5.2e-07	1.4e-04
U-Separated	Slag worker	Cu	4.7e-01	1.3e+02	2.1e-07	5.7e-05
U-Depleted	Slag worker	Cu	2.4e-01	6.4e+01	1.1e-07	3.0e-05
Th-Series	Slag worker	Cu	2.3e+00	6.1e+02	1.0e-06	2.8e-04

[a] Maximum risk—may correspond to a different scenario

PREFACE

In March, 1997, S. Cohen and Asociates, under contract to the Office of Radiation and Indoor Air of the U.S. Environmental Protection Agency (EPA), produced a draft report entitled "Technical Support Document: Evaluation of the Potential for Recycling of Scrap Metals from Nuclear Facilities".[1] The purpose of that report was to evaluate the potential public health impacts associated with the free release and recycling of scrap metal from nuclear facilities as an alternative to disposal at a licensed low level radioactive waste disposal facility. The report was also intended to be part of the technical basis for determining the need for regulatory action to ensure that recycle of scrap metal from nuclear facilities does not endanger public health and safety. The report was widely distributed by EPA to the U.S. Department of Energy, the U.S. Nuclear Regulatory Commission, representatives of U.S. metal recycling and steel manufacturing industries, the International Atomic Energy Agency, the European Commission, and other stakeholder groups for review. Several meetings were held with these organization to exchange information and receive comments on the Agency's draft report. In addition, a Task Group appointed by the National Council on Radiation Protection and Measurement performed a critical review of the Draft TSD.

The Draft TSD has been revised to address many of the questions and concerns raised during the review process and to incorporate a great deal of new information acquired since that report was issued. The present report, which constitutes Part I of the revised TSD, contains an expanded and revised assessment of the potential impacts of the free release of scrap metal from nuclear facilities on exposed individuals.

[1] This document was reprinted in July, 1997 with a revised cover page. The text was unchanged.