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TECHNICAL SUPPORT DOCUMENT

**POTENTIAL RECYCLING OF SCRAP METAL
FROM NUCLEAR FACILITIES**

**PART I: RADIOLOGICAL ASSESSMENT OF
EXPOSED INDIVIDUALS**

Volume 1

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Contents

	<u>page</u>
List of Tables	vii
List of Figures	viii
List of Appendices	ix
Executive Summary	xi
Preface	xv
1 Introduction	1-1
1.1 Purpose and Scope	1-1
1.2 Organization of the Report	1-2
Reference	1-4
2 Overview of Scrap Metal Operations	2-1
2.1 Characteristics of Scrap Sources	2-1
2.2 Industry Perspectives	2-3
2.3 Principal Scrap Metal Operations Considered	2-4
2.4 Current Recycle Practice of Nuclear Facilities	2-5
References	2-6
3 Screening Procedures to Define the Scope of the Analysis	3-1
3.1 Objectives	3-2
3.1.1 Characterization of the Potential Sources of Scrap Metal	3-2
3.1.2 Normalized Dose and Lifetime Risk of Cancer to the RME Individual	3-2
3.2 Sources of Scrap Metal: Administrative Categories	3-4
3.2.1 Department of Energy	3-6
3.2.2 Nuclear Regulatory Commission	3-6
3.2.3 Department of Defense	3-7
3.2.4 State or Superfund Authority	3-8
3.3 Types of Scrap Metal Considered	3-8
3.4 Radionuclides Selected for Consideration	3-10
3.5 Exposure Scenarios and Biological Endpoints	3-10
3.5.1 Multiple Pathways	3-11
3.5.2 Personal Devices	3-12
3.5.3 Other Pathways and Scenarios	3-12
3.5.4 Direct Disposal of Scrap Following Clearance	3-12
3.6 Summary of the Screening Process	3-13
3.6.1 Sources of Scrap Metal	3-13
3.6.2 Types of Scrap Metal from Nuclear Facilities	3-13
3.6.3 Scenarios, Pathways, Modeling Assumptions, and Biological Endpoints	3-13
References	3-15

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Contents (continued)

	<u>page</u>
4 Quantities and Characteristics of Potential Sources of Scrap Metal from DOE Facilities and Commercial Nuclear Power Plants	4-1
4.1 Existing and Future Scrap Metal Quantities Available from DOE	4-1
4.1.1 Background Information	4-1
4.1.2 Existing Scrap Inventories at DOE	4-8
4.1.3 Summary of Existing Scrap Inventories at DOE Sites	4-12
4.1.4 Scrap Metal Inventory by Metal Type	4-13
4.1.5 Scrap Metal from Future Decommissioning	4-15
4.1.6 Summary and Conclusions Regarding DOE Scrap Metal Inventories	4-18
4.2 Scrap Metal from the Commercial Nuclear Power Industry	4-19
4.2.1 Estimates of Contaminated Steel from Commercial Nuclear Power Plants	4-21
4.2.2 Contaminated Metal Inventories Other Than Steel	4-22
4.2.3 Timetable for the Availability of Scrap Metal from Decommissioning	4-23
4.3 Recent Recycling Activities (1995 - 1998)	4-22
4.3.1 DOE Materials	4-24
4.3.2 Activities of Members of the Association of Radioactive Metal Recyclers	4-27
References	4-29
5 Description of Unrestricted Recycling of Carbon Steel	5-1
5.1 Recycling Scrap Steel—an Overview	5-1
5.2 Reference Facility	5-3
5.3 Exposure Pathways	5-4
5.3.1 External Exposure	5-4
5.3.2 Internal Exposure	5-4
5.4 List of Operations and Exposure Scenarios	5-4
5.4.1 Dilution Factors	5-7
5.4.2 Scrap Transport	5-9
5.4.3 Scrap Processing Operations	5-9
5.4.4 Steel Mill	5-9
5.4.5 Processing EAF Dust	5-12
5.4.6 Use of Steel Mill Products	5-12
References	5-14
6 Radiological Assessment of the Recycling of Carbon Steel	6-1
6.1 Radioactive Contaminants	6-2
6.2 Specific Activities of Various Media	6-5

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Contents (continued)

	<u>page</u>
6.3 Exposure Pathways	6-9
6.3.1 External Exposures to Direct Penetrating Radiation	6-9
6.3.2 Inhalation of Contaminated Dust	6-13
6.3.3 Incidental Ingestion	6-17
6.3.4 Radioactive Decay	6-17
6.4 Unique Scenarios	6-19
6.4.1 Ground Water Contaminated by Leachate from Slag Storage Piles	6-19
6.4.2 Ingestion of Food Prepared in Contaminated Cookware	6-35
6.4.3 Impact of Fugitive Airborne Emissions from the Furnace on Nearby Residents	6-35
References	6-39
7 Results and Discussion of Carbon Steel Radiological Assessment	7-1
7.1 Normalized Doses and Risks to the RME Individual	7-1
7.2 Maximum Exposure Scenarios	7-1
7.2.1 Slag Pile Worker	7-2
7.2.2 Scrap Yard Worker	7-2
7.2.3 Lathe Operator	7-4
7.2.4 Sailor Sleeping next to Steel Hull-plate	7-5
7.2.5 Truck Driver: Baghouse Dust	7-5
7.2.6 EAF Furnace Operator	7-5
7.3 Evaluation of the Results of the Radiological Assessment	7-5
7.3.1 Dilution of Potentially Contaminated Steel Scrap	7-6
7.3.2 Exposure Pathways	7-6
7.3.3 Mass Fractions and Partitioning of Contaminants	7-9
7.3.4 Scenario Selection	7-9
7.3.5 Implementation of Clearance Criteria	7-10
References	7-12
8 Radiological Assessment of Recycling Aluminum	8-1
8.1 Distribution of Contaminants	8-1
8.1.1 Material Balance	8-1
8.1.2 Elemental Partitioning	8-2
8.2 List of Operations and Exposure Scenarios	8-4
8.2.1 Dilution	8-4
8.2.2 Scrap Transport	8-6
8.2.3 Secondary Smelter Operations	8-6
8.2.4 Industrial Uses of Mill Products: Aluminum Fabrication	8-8
8.2.5 Use of Finished Products	8-9
8.2.6 Off-Site Individuals Exposed to Smelter By-Products	8-10

Note: EPA no longer updates this information, but it may be useful as a resource or reference.

Contents (continued)

	<u>page</u>
8.3 Results	8-12
8.3.1 Shredder Operator	8-14
8.3.2 Scrap Transport Worker	8-14
8.3.3 Disposal of Dross in an Industrial Landfill	8-15
8.4 Evaluation of the Results	8-15
8.4.1 Dilution of Potentially Contaminated Scrap	8-15
8.4.2 Exposure Pathways	8-15
8.4.3 Airborne Effluent Releases	8-15
8.4.4 Ingrowth of Radioactive Progenies	8-16
References	8-18
9 Radiological Assessment of Recycling Copper	9-1
9.1 Recycling Copper Scrap—an Overview	9-1
9.2 Distribution of Contaminants	9-2
9.2.1 Material Balance	9-2
9.2.2 Elemental Partitioning	9-3
9.3 List of Operations and Exposure Scenarios	9-3
9.3.1 Dilution	9-4
9.3.2 Scrap Transport	9-6
9.3.3 Secondary Smelter Operations	9-7
9.3.4 Electrorefining	9-8
9.3.5 Use of Finished Products	9-9
9.3.6 Impact of Airborne Effluent Emissions on Nearby Residents	9-10
9.4 Results	9-11
9.4.1 Slag Worker	9-11
9.4.2 Airborne Effluent Emissions	9-14
9.4.3 Tank House Operator	9-14
9.5 Evaluation of the Results	9-14
9.5.1 Airborne Effluent Releases	9-14
9.5.2 Other Scenarios	9-14
References	9-17

Note: EPA no longer updates this information, but it may be useful as a resource or reference.

Tables

	<u>page</u>
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	x
3-1. Inventory of Sites That Are Known to Be Radioactively Contaminated	3-5
4-1. Groupings of DOE Materials in Inventory	4-9
4-2. Existing Scrap Metal Inventories at DOE Sites	4-11
4-3. Estimates of Existing DOE Inventories of Contaminated Scrap Metal	4-13
4-4. DOE Scrap Metal Inventory	4-14
4-5. Existing and Future Contaminated Scrap Metal at DOE Facilities	4-20
4-6. Comparison of Estimates of Ferrous Metal and Nickel Inventories	4-20
4-7. Residually Radioactive Steel from Nuclear Power Plants	4-22
4-8. Contaminated Metal Other than Steel Potentially Suitable for Clearance	4-24
4-9. Anticipated Releases of Scrap Metals from Nuclear Power Plants	4-25
5-1. Exposure Scenarios and Parameters for Radiological Assessments of Individuals	5-6
6-1. Implicit Progenies of Nuclides Selected for Analysis	6-3
6-2. Nuclides Included in Various Combinations and Decay Series	6-5
6-3. Partition Ratios (PR), Concentration Factors (CF), and Distribution Factors (DF)	6-8
6-4. Lung Clearance Types and Ingestion f_1 Values for Use with ICRP 68	6-16
6-5. Vadose Zone Parameter Values for Site Types A, B, and C	6-21
6-6. Potential Contaminants of Groundwater	6-22
6-7. Composition of Slag Used in Leaching Test	6-23
6-8. Leaching Parameters Values	6-25
6-9. Diffusion Coefficients for EAF Slag Monolithic Samples	6-26
6-10. Fraction of Various Toxic Elements Leached from Slags Using EPA TCLP Protocol	6-27
6-11. Aquifer Parameter Values for Site Types A, B, and C	6-31
6-12. Soil-Water Distribution Coefficients (K_d s) for Site Types A, B, and C	6-32
6-13. Locations and Results of CAP-88 Analyses	6-36
6-14. Calculation of Normalized Doses and Risks from Airborne Effluent Emissions	6-38
7-1. Maximum Exposure Scenarios and Normalized Impacts on the RME Individual from One Year of Exposure	7-3

Note: EPA no longer updates this information, but it may be useful as a resource or reference.

Tables (continued)

	<u>page</u>
8-1. Partition Ratios (PR) and Concentration Factors (CF) in Aluminum Smelting	8-3
8-2. Exposure Scenarios and Parameters for Radiological Assessments of Aluminum Recycling	8-5
8-3. Normalized Impacts from One Year of Exposure to Fugitive Airborne Emissions . . .	8-11
8-4. Maximum Exposure Scenarios and Normalized Impacts on the RME Individual from One Year of Exposure	8-13
9-1. Partition Ratios (PR) and Concentration Factors (CF)	9-5
9-2. Exposure Scenarios and Parameters for Radiological Assessments of Copper Recycling	9-6
9-3. Normalized Impacts from One Year of Exposure to Fugitive Airborne Emissions	9-11
9-4. Maximum Exposure Scenarios and Normalized Impacts on the RME Individual from One Year of Exposure	9-12

Figures

4-1. Nuclear Weapons Complex	4-2
5-1. Operations Analyzed in the Carbon Steel Recycle Analysis	5-2
6-1. Transport of Slag Leachate to Domestic Well	6-31
8-1. Simplified Material Flow for Secondary Aluminum Smelter	8-2
9-1. Simplified Mass Flow: Annual Throughput of Secondary Copper Smelter	9-2
9-2. Simplified Material Balance for Electrorefining of Copper Produced from Scrap	9-3

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Volume 2: Appendices A -F

- A. Scrap Metal Inventories at U.S. Nuclear Power Plants
- B. Aluminum Recycling
- C. Copper Recycling
- D. Selection of Radionuclides for Radiological Assessment
- E. Distribution of Contaminants During Melting of Carbon Steel
- F. Distribution of Contaminants During Melting of Cast Iron

Volume 3: Appendices G - L

- G. Dilution of Residually Radioactive Scrap Steel
- H. Detailed Scenario Descriptions for Carbon Steel
- I. Leaching of Radionuclides from Slags
- J. Radiological Impacts on Individuals—by Scenario
- K. Radiological Impacts on Individuals—by Pathway
- L. Radiological Impacts of the Disposal of Residually Contaminated Materials in Industrial Landfills

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

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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 $\mu\text{Sv/a}$ 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

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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

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PREFACE

In March, 1997, S. Cohen and Associates, 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.