Dedicated Steel Mill Feasibility Study

U.S. Department of Energy
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Preface

This study was conducted in the Summer and Fall of 2000 at the request Secretary of Energy Bill Richardson. The office of Energy Efficiency and Renewable Energy led the study. Several participants have many years of work and experience in the steel industry. The other participants are from the DOE community including persons currently involved in the Department's Environmental Management decommissioning and dismantling activities. The management of metal scrap from radiation areas is a sensitive divisive subject. It become evident as the participants met that we would not produce a consensus report. However, the participants collaborated in providing information. Persons who contributed in drafting the report content are listed below:

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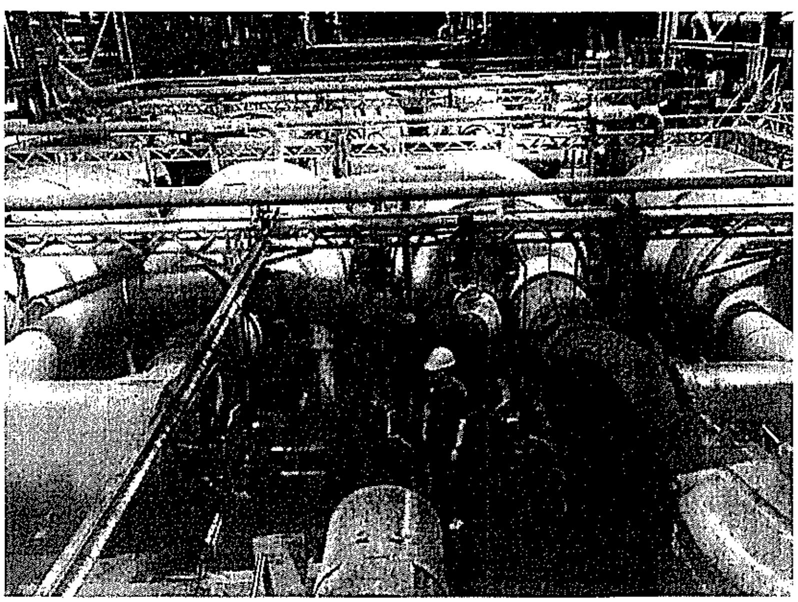


Oak Ridge Gaseous Diffusion Plant

Executive Summary

The Secretary of Energy Bill Richardson, in a Memorandum dated July 13, 2000, directed that the Department undertake activities to promote internal reuse and recycling. He also requested that the Department complete a feasibility study on the potential use of a dedicated mill to recycle steel for reuse within the DOE complex. A similar initiative is successfully recycling lead scrap from radiation areas into shielded storage containers for the DOE complex. A preliminary steel scrap analysis presented to the Secretary's Re-Use and Recycle Task Force this spring recommended the Department consider converting its steel and nickel from decommissioning activities into containers for radionuclide-contaminated wastes. This assessment suggested that a more in-depth analysis be performed to determine the excess metal inventories within the complex that may be suitable for recycling, the needs within the complex for fabricated metal containers that might not meet release criteria for use by the general public, and the feasibility (technical and cost) of alternatives for either disposal or recycling for restricted use within the DOE complex.

Information was obtained on the current and projected inventory of carbon steel, stainless steel, and nickel from the decommissioning of nuclear facilities over the next thirty-five years. Over the same period preliminary information was also obtained on the demand for restricted use products. The DOE internal restricted use product demand could absorb all the nickel and stainless steel generated from decommissioning. It could also use approximately 100,000 tons of the carbon steel inventories for these products.

Costs were developed for six alternatives for managing these metal scraps from decommissioning. These are (1) free release of metals with no detectable contamination before or after manual decontamination in compliance with the revised Order 5400.5 (2) disposal in a low level radiation waste cell and (3-6) furnace metal making alternatives for converting part of the inventory into restricted use products. Three of the alternatives used electric arc furnace technology (steelmaking) to generate carbon steel, stainless steel, and nickel alloy products. A fourth alternative is based on using an induction furnace to make nickel alloy products. These alternatives were selected to define assumptions and establish a framework for the cost estimates. In actual practice probably more than one alternative would be used and these may vary from the six described.

These alternatives provide estimates of total costs, and each has large uncertainties, effectively making them all still potentially viable. All the alternatives have estimated uncertainty cost ranges that significantly overlap. All alternatives had <u>potential</u> costs exceeding $2 billion. The lowest conceivable cost is $855 million and the highest conceivable cost is $2.895 billion. Both extremes are for electric arc furnace alternatives.

The free release alternative identifies costs to DOE that are competitive with the steelmaking furnace alternatives and the disposal alternative. However, the steel industry believes free release of steel scrap from decommissioning nuclear facilities will cost them market share if it enters consumer products (see Appendix C, Recycling of Steel) and therefore may not be accepted. This intangible cost has not been included in the free release alternative.

The concept of a dedicated steel mill for Department's scrap from the decommissioning of facility cannot be accepted or rejected because of the uncertainties in the estimated cost, primarily associated with the uncertain level of demand for product in the DOE complex (a data call generated only 100,000 tons of carbon steel needs) and the uncertain costs associated with disposal, decontamination, and regulation. The potential savings of such a pathway is sufficient that further study is recommended.

1. Summary

The Secretary of Energy Bill Richardson in a Memorandum dated July 13, 2000 directed that the Department undertake activities to promote internal reuse and recycling. He also requested that the Department complete a feasibility study on the potential use of a dedicated mill to recycle steel for reuse within the DOE complex. A preliminary steel scrap analysis presented to the Secretary's Re-Use and Recycle Task Force this Spring recommended the Department consider converting its steel and nickel from decommissioning activities into containers for radionuclide-contaminated wastes. This assessment suggested that a more in-depth analysis be performed to determine the excess metal inventories within the complex that may be suitable for recycling, the needs within the complex for fabricated metal containers that might not meet release criteria for use by the general public, and the feasibility (technical and cost) of alternatives for either disposal or recycling.

Restricted Reuse Metal Product Demand

In support of this Feasibility Study, there was a requirement to obtain current data on the potential metal product needs from the prospective users at the field sites to complement analysis already underway on mill alternatives and cost scenarios. To this end a formal Restricted Reuse Metal Product Demand or Product Needs Data Call was issued to collect information on the types and quantities of metal product needs across the Department of Energy complex. The Feeds Data Call, discussed in Section 3 of this report, focused on the Environmental Management (EM) Program's Deactivation and Decommissioning (D&D) activities as the source of most of the scrap metals available to the Department. The Product Needs Data Call was distributed across all of the Department's programs that were candidates for using recycled products manufactured from contaminated metals (Defense Programs, Environmental Management, Nonproliferation and National Security, Nuclear Energy, Science and Technology, Office of Science, and the Office of Civilian Radioactive Waste Management).

As a result of the decision to circulate the Needs Data Call to all relevant DOE elements, DOE administrative procedures required that a draft copy of the data call be circulated to the affected programs through the Field Management Council (FMC) process prior to its formal distribution. The FMC process is designed to give the programs an opportunity to provide comments and suggestions on proposed actions, such as this draft data call, to develop better end products and minimize the burden on field offices by eliminating redundant activities. This process required approximately three weeks to complete which resulted in a schedule delay from September 8 to September 22 for the request field offices to supply the Product Needs data to HQ. Since there was no corresponding relief on the completion schedule for the Feasibility Study, the Needs Data Call required the field to supply the information in less than a week. This quick turnaround impacted the field's ability to access information for all of the potential product needs. Therefore, there may be additional products that were not presented due to the schedule compression.

Several observations can be made on the overall data. Confidence in the data, especially in the out-years, was relatively low at many sites. This is a result of program immaturity at some sites and the uncertainties associated with attempting to predict specific product needs and quantities to support the D&D of facilities that are not yet fully characterized. The worst-case example of future waste container product needs resulted in a confidence range from – 50% to + 350%. Well-defined programs at other sites submitted data that were better developed and had much higher confidence levels. When sites were reporting on product needs to support ongoing non-D&D missions there was a higher degree of confidence in the quantities required. Most sites noted that they could have used more time in investigating the product needs and that they supplied the best information available within the allotted response time.

The Product Needs were classified into five categories using the Product Codes shown in Exhibit 1-1.

Exhibit 1-1. Product Category
• Boxes/small containers (< 1,000 lbs tare)
• Large containers/Roll-offs/Cargos/Sea Land
• Drums
• Infrastructure/Construction Products
• Other Products

Exhibit 1-2 shows each of these product categories, the total weight of the metal contained in the product category, the type of metals contained in each category and the weights of the component metals that are in the category.

Exhibit 1-2. Component Metal in Each Product Category

Product Category	Total Metal Weight (Tons)	Type of Metal in Category	Component Metal Weight (Tons)
Boxes/Small Containers (<1,000 lbs tare)	30,301	Carbon Steel	30,301
Large Containers/Roll-offs/Cargos/Sea Land	44,748	Carbon Steel	42,074
		Stainless Steel	2,675
Drums	17,668	Carbon Steel	17,668
Infrastructure/Construction	59,300	Carbon Steel	44,700
		Stainless Steel	14,600
Other Products	274,463	Carbon Steel	10,258
		Stainless Steel	154,284
		Alloy 22	109,920

The total quantity of metal required to satisfy the projected base needs is 426,480 tons. As seen in Exhibit 1-2 a significant quantity of the metals, 274,463 tons (64% of the total needs), resides in the Other Products category. The total metal weight required in the Other Product category is comprised of three metals: 4% carbon steel, 56% stainless steel and 40% Alloy 22. Most of these products support HLW and TRU waste program needs. The stainless steel and the Alloy 22 needs are products for the HLW repository.

Surplus Metal Inventory

To determine the quantities of contaminated radioactive metal that might be available for recycling, a data call was issued to sites within the DOE complex that requested the estimated weight (in tons) of current inventory and the projected generation of future scrap metal from D&D activities over the next 35 years. Basic information on the radiological nature of the metals was requested, including the primary isotopes, the percentage of metal requiring remote handling and whether the metal would be volumetrically contaminated, surface contaminated, or non-contaminated. No specific information on activity levels was requested due to the focus on the Gaseous Diffusion Plants (GDPs) and the level of information already

available for those feed streams. Finally, the percentage of metals that would be classified was requested. The data call included to the extent practical, materials from facilities currently in the EM program and material expected to be transferred into the EM program (e.g., Portsmouth and Paducah).
Except for the nickel quantity, an adjustment was made to the gross quantities supplied by the field to delete a percentage of the materials deemed unsuitable for the steel mill. Exhibit 1-3 identifies the adjusted total metal quantity projected to be available and the contribution of the four metals to this total quantity.

Exhibit 1-3. Potential Total Metal Quantities Available from DOE Sites

Metal	Inventory[1]	Generation from D&D	Total by Metal
Carbon Steel	85,187	780,332	865,519
Stainless Steel	6,609	167,394	174,003
Nickel	9,700	27,906	37,606
Iron	11	7,525	7,536
Total	101,507	983,157	1,084,664

[1]All metal quantities are shown in tons.

The metal quantities in the table list both the current inventory and the projected generation from D&D. The metal quantity values should be given no more significance than the nearest thousand tons.

Approximately 91% of the available metal is categorized as contaminated. However, discussions with the generating sites indicate that the contamination levels associated with the metals would be relatively low. The Gaseous Diffusion Plants (GDPs) adjusted surplus metal inventory accounts for approximately 57% of the total DOE quantity of current and forecasted scrap metal. As shown in Exhibit 1-4, GDPs also dominate the current and future generation of carbon steel and nickel.

Exhibit 1-4. Potential Current and Projected Metal Quantities Available from the Gaseous Diffusion Plants

Metal	Inventory[1]	Generation from D&D	Total of GDP Metal	Percentage of DOE Metal
Carbon Steel	64,062	513,182	577,244	66%
Stainless Steel	117	5,195	5,312	3%
Nickel	9,700	27,904	37,604	100%
Iron	0	0	0	0%
Total	73,879	546,281	620,160	57%

[1]All metal quantities are in tons.

Yearly generation rates and available metal types may be impacted by DOE site priorities and appropriated funding. By and large, the generation rates are consistent with site baselines. However, D&D activities are often not at the top of site clean-up priorities, and there is some probability that D&D schedules will slip, impacting the total yearly quantities and types of metals that will be generated during the 35-year survey period.

Alternatives for the Recycle/Disposal of Contaminated Metals

Alternatives for the recycle, reuse, and/or disposal of radioactively contaminated scrap metals have been defined to a high level in terms of the activities required to complete a particular recycle or disposal option. Primary alternatives are free-release, disposal, and recycling within the DOE complex. The radioactively contaminated material that would make up the possible feedstock for this process would come from three primary sources within the DOE complex: the enrichment processing facilities (EPFs, which include the gaseous diffusion plants [GDPs]), reactor facilities (RFs), and plutonium processing facilities (PPFs). This distinction has been made because handling and waste treatment requirements, licensing, and worker health and safety may be significantly impacted by the types of radioactively contaminated metals that are processed. The primary focal points of the alternatives presented are the EPFs—particularly the GDPs, as they are expected to be the major contributors of the scrap metal stock suitable for recycling.

- Definition of the alternatives for recycling/disposal
- Regulatory implications of the disposal/recycle alternatives
- The environmental feasibility of the recycle alternatives for the types of radioactively contaminated materials within the complex
- Worker health and safety implications of the various alternatives

The alternatives for the recycle/reuse of contaminated radioactive materials have been divided up into six categories. They are:

- *Alternative 1: Free release of metals with no detectable contamination before or after decontamination* - Potentially contaminated metals inventories are segregated and characterized. Metals with no detectable contamination (as defined in the revised DOE Order 5400.5) either before or after decontamination are released for unrestricted use. The contaminated fraction is disposed of at a DOE or commercial waste site.

- *Alternative 2: Disposal of all potentially contaminated metals* – Limited characterization and disposal or long-term storage of all potentially contaminated metals at a DOE or commercial waste site.

- *Alternative 3: Decontamination at a commercial Electric Arc Furnace (EAF) and reuse at DOE facilities* - Potentially contaminated metals are segregated at the facility where it was generated and the low-level contaminated metals are processed at a commercial EAF that was retrofitted and regulated for this application. The decontaminated but still slightly radioactive metal would then be rolled and fabricated into containers or other items for use within the DOE complex. Rolling and fabrication would be performed at commercial facilities assuming that the radioactive contamination levels in the metal meet more limited DOE criteria for rolling and fabrication.

- *Alternative 4: Recycle at a DOE Facility using an EAF moved to or built at that site* – An Electric Arc Furnace (EAF) system would be relocated or built at a regulated DOE facility where the contaminated metals would be processed for use within the DOE complex. The rolling mill and fabrication facilities may not be located at this site.

- *Alternative 5: Recycle at a new commercial EAF* – Recycling would be performed by a commercial company at an EAF that was constructed and regulated specifically for the purpose of processing low-level radioactively contaminated metals from the DOE complex.

- *Alternative 6: Recycle at an existing Radioactive Scrap Metal (RSM) facility* – Existing RSM processing facilities (with limited capacity) regulated for radioactive metals processing would be used for the initial decontamination with rolling and fabrication to be performed at commercial facilities.

Many of the alternatives have common elements, although the requirements for these common elements may vary depending on the alternative being addressed. The elements common to all scenarios are: 1) source of the radioactive material, 2) radioactive materials characterization requirements, 3) scrap metal component dismantlement and size reduction, 4) metal segregation by radioactive material content, 5) transportation and 6) disposal or recycling. These common elements have been evaluated for each of the alternatives and the relative hazards and costs associated with each of the elements have been assessed.

Environmental Technical Feasibility of the Recycle Alternatives

The environmental feasibility of alternatives for the disposal or recycling of DOE contaminated metals has been addressed. Specific issues include handling (for transportation, disposal or recycle), facility contamination and cleanup, transportation, and the potential radiation exposures to individuals who may come in contact with wastes and the metal product produced from recycle. The areas evaluated include:

- The expected radioactive material contamination levels in the feedstock for the recycle options (includes radioactively contaminated material from the EPFs, RFs, and PPFs).
- Facility operations and the potential dose impact on workers from initial contaminated material handling through use of the final recycle product within the DOE.
- Limits on the radioactive contamination in the feedstock material that would maintain facility contamination and radiation exposures at low and acceptable levels – the Metal Acceptance Criteria (MAC).

Three types of facilities were considered when evaluating the radionuclides present and their concentration. These facilities are the enrichment processing facilities (EPFs), reactor facilities (RFs), and plutonium processing facilities (PPFs). This assessment of technical feasibility suggests that for most alternatives, the primary waste stream suitable for recycling is that from the EPFs. The radioactive contamination that is generally present on these metals is primarily surface contamination composed of particulate, depleted, natural or enriched ^{235}U and long-lived ^{99}Tc that is concentrated in the converters as part of the enrichment process. Low levels of ^{237}Np and ^{239}Pu are also present. It has been estimated that of the total quantity of metals at the EPFs suitable for recycling that only about 50% is actually contaminated and that the remainder could potentially be released following characterization to assure that it meets the requirements of the proposed revisions to DOE Order 5400.5. The radioactive contamination levels are sufficiently low that the quantity of ^{235}U is expected to be less that 40 g per 50-ton charge of contaminated steel.

Factors evaluated for the recycling alternatives included design, and dose impact on the workers from either handling or using the scrap metal being processed but also the product material from the recycling alternatives. Facility processing issues including transportation safeguards, waste acceptance criteria and worker exposure limits:

- Initial separation and packaging of metals for transportation to the facility including initial characterization for processing
- Transportation to the processing facility
- Facility contamination potential during processing and mitigation requirements
- Handling and processing of effluents from the facility - baghouse dust and slag
- Metal processing at the rolling mill and fabrication facility
- Use of the contaminated metals at DOE facilities

The requirements for separation and packaging of the contaminated metals are similar for all alternatives along with the transportation costs, which vary depending on whether recycling or disposal is performed either locally or at a remote site.

The potential for contamination of the facilities used for recycling is a factor that must be considered and depends on the type and quantity of radionuclides to be processed. Development of a facility for processing of radioactive materials must depend on a combination of engineered and administrative controls to minimize worker radiation exposures, contamination of the facility, and the release of radioactive contamination. The fewest controls either engineered or administratively were identified for the contaminated metals from the EPFs.

Radiation exposures to facility workers were assessed for an Electric Arc Furnace (EAF) with a capacity of approximately 500,000 tons/yr of scrap metal. The critical group mass radiation doses were assessed and indicate that the primary dose effects are from handling the slag containing the $^{235,238}U$, which is concentrated there by the refining process (essentially all uranium is concentrated in the slag). The dose effect for the average uranium concentration in the Paducah steels is negligible (0.87 mrem/yr). The dose effects of the ^{99}Tc are negligible for all aspects of refinery process. For ^{237}Np, which has lower concentrations in the Paducah steels, the dose effect would be 0.08 mrem/yr.

Although there are no specific dose scenarios for the use of contaminated metals at DOE facilities, three scenarios provided some bounding data on uses. These scenarios are the proximity to large and small metal masses and the vehicle constructed of the metal product. The dose factors for the EPF radionuclides range from about 2.6E-6 to 4.8E-5 mrem/yr per pCi/g. In contrast, the dose factors for the RF generated radionuclides are much higher. They range up to 2.0E-1 for ^{60}Co. Consequently, the doses from the metal products from the EPFs would be expected to be the most benign and allow the highest concentrations of radioactive materials to be processed through the facility. In all cases, the dose from the use of the metal products from the Paducah plant would be well less than 0.1 mrem/yr.

The proposal is to use a currently operating rolling mill facility and fabrication facility and to limit the radionuclide content of the feedstock to these facilities to keep radiation exposures to safe levels. The calculated doses are very low for either handling the refined metal product at the refinery or during distribution. For the EPFs the key radionuclide of concern for the metal product is the ^{99}Tc that would be present.

The radioactive scrap metal process stream from the EPF's presents perhaps the best scenario for processing because of the decontamination of the metal product stream in the melt refining process. In this case, it is assumed that about 1% of the uranium and neptunium is partitioned to the metal product (this is considered to be a relatively conservative value) with the balance becoming waste as baghouse dust and slag. Ninety-five percent of the ^{99}Tc is assumed to partition to the metal product with the balance in the slag. The highest dose during processing is from ^{235}U during slag handling; however since the refinery EAF is expected to be a nuclear facility, worker exposures are expected and would be administratively controlled. If the Paducah concentration data is representative of the EPF steels, the maximum dose would be less than 1 mrem/yr with lesser doses from the ^{237}Np and ^{99}Tc.

Consequently, the primary limiting factor for recycling is the dose to workers and contamination of the rolling mill and fabrication facilities. Although a dose scenario for rolling plant personnel and welding during fabrication has not been developed, some long-term exposure scenarios provide an indication of the expected radiation exposures during this process. If the maximum exposure scenario is used, the total dose from the Paducah scrap metal would be less than 5 E-3 mrem/yr with the dose dominated by the trace amount of uranium that would still be present in the metal product. This would suggest that higher concentrations of uranium-contaminated steels (10^2) could be processed without exceeding a very limited exposure requirement for rolling and fabrication. Doses to end users of the metal would also be inconsequential. Therefore, relatively wide variations in the radionuclide concentrations in the feedstock could be accepted with affecting the quality and usefulness of the product.

The secondary issues to be addressed are the Special Nuclear Material (SNM) accountability and criticality issues. If the Paducah metal is considered representative, EAF charges of 50 tons of contaminated scrap metal would contain only about 41 of 235U per charge. The Paducah ^{235}U concentration data are assumed to be quite high for much of the scrap metal suitable for refining. Consequently, on the order of six charges of slag (where most of the uranium is concentrated) could be kept onsite. They very low concentrations in the steels would not be expected to significantly affect the site ^{235}U inventory for criticality purposes and consequently there would be no limit on steel storage at the EAF site.

The fact that the EAF is a batch process would allow the ^{235}U containing slag generated from the EAF process to be removed to a secured site on a batch basis. An alternative approach would be to use administrative controls to keep the average scrap metal stream to be processed at a fraction of the 350 g limit for a facility without a higher degree of SNM controls. These same limitations apply to criticality issues, which would be addressed through the same approach.

Evaluation of the Health and Safety Considerations Associated with a Dedicated Melting Facility Receiving Radioactively Contaminated Metal from Gaseous Diffusion Plants

This section provides an assessment of the potential health and safety implications of the six alternatives for the disposal/recycle of metals from the DOE complex. The emphasis is on the recycle options, as the health and safety effects from disposal are relatively well known and can be estimated based on current data published elsewhere. Subjects herein addressed include the personal radiation exposure pathways from demolition through stainless steel box fabrication.

Regulatory Implications of the Disposal/Recycle Alternatives

This section addresses differences in regulatory aspects in DOE and NRC regulation of a dedicated steel mill. The discussion in this section is for information purposes only.

Cost for a Dedicated Steel Mill

Six alternatives for the recycle, reuse, and/or disposal of radioactively contaminated scrap metals were defined to a high level. Rough order of magnitude estimates were generated for each of the alternatives. The primary alternatives are free-release (as the baseline), disposal, and recycle/reuse.

Alternative 1

The estimated uncertainty in the cost estimate for Alternative 1 is ±25%. Nearly all of the uncertainty is due to the cost of purchasing the metal needed for DOE's containers. The cost of decontaminating and verifying for free release is a significant cost driver but the cost is well documented with recent actuals. The accuracy range for Alternative 1 is $2,280,398K to $1,368,239K.

Alternative 2

The estimated uncertainty in the cost estimate for Alternative 2 is ±25%. As in Alternative 1, nearly all of the uncertainty is due to the cost of purchasing the metal needed for DOE's containers. The cost of disposal is a significant cost driver but disposal costs have been evaluated extensively by the Department and are well documented. The accuracy range for Alternative 2 is $2,486,385K to $1,491,831K.

Alternative 3

The estimated uncertainty in the cost estimate for Alternative 3 is +100% and -25%. The capital and operating costs of the steel mill were estimated for a steel mill processing clean scrap metal. The additional capital required to modify an existing steel mill and the additional operating cost required to accommodate radioactive materials has not been included in the cost estimate because the technical requirements have not been specified in the technical analysis. Likely additional costs include radiation containment systems and as-built drawings of the entire mill. This alternative requires radioactive materials be managed and processed in an existing non-radioactive facility. The accuracy range for the four options are Alternative 3A, $2,418,208K to $906,828K; Alternative 3B, $2,542,802K to $953,551K; Alternative 3C, $2,569,312K to $963,492K; Alternative 3D, $2,681,598K to $1,005,599K.

Alternative 4

The estimated uncertainty in the cost estimate for Alternative 4 is +100% and -25%. The uncertainty of this alternative is less than Alternative 3 because the EAF is moved to an existing DOE facility where radioactive materials are already managed. The upgrades to the existing steel mill and the added cost of operating with radioactive materials has not been included but are expected to be significantly less than Alternative 3. The accuracy range for the four options are Alternative 4A, $2,280,176K to $855,066K; Alternative 4B, $2,844,770K to $1,066,789K; Alternative 4C, $2,871,282K to $1,076,731K; Alternative 4D, $2,802,126K to $1,050,797K.

Alternative 5

The estimated uncertainty in the cost estimate for Alternative 5 is +100% and -25%. The uncertainty of this alternative is less than Alternative 3 because a new EAF is built and the additional costs to make the mill a radioactive materials facility would be a smaller percentage of the cost of a new mill than that of a retrofitted mill. Many of the capital costs will be higher for a radioactive facility but adding in those requirements at the beginning of the design and construction phase would result in a lower additional cost. The accuracy range for the four options are Alternative 5A, $2,304,022K to $864,008K; Alternative 5B, $2,868,616K to $1,075,731K; Alternative 5C, $2,895,128K to $1,085,673K; Alternative 5D, $2,825,972K to $1,059,740K.

Alternative 6

The estimated uncertainty in the cost estimate for Alternative 6 is +50% and -25%. The cost to produce stainless steel alloys in the MSC induction furnace is documented but producing a higher-grade alloy (Alloy 22) may result in higher operating costs. The accuracy range for Alternative 6 is $2,255,342K to $1,127,671K.

Conclusion and Recommendations

The concept of a dedicated steel mill for Department's scrap from the decommissioning of facility cannot be accepted or rejected because of the uncertainties in the estimated cost, primarily associated with the uncertain level of demand for product in the DOE complex (a data call generated only 100,000 tons of carbon steel needs) and the uncertain costs associated with disposal, decontamination, and regulation. The potential savings of such a pathway is sufficient that further study is recommended. The specific topics for further study are provided in Section 9, Conclusion and Recommendations.

2. Restricted Reuse Metal Product Demand

In support of this Feasibility Study, there was a requirement to obtain current data on the potential metal product needs from the prospective users at the field sites to complement analysis already underway on mill alternatives and cost scenarios. To this end a formal Restricted Reuse Metal Product Demand or Product Needs Data Call was issued to collect information on the types and quantities of metal product needs across the Department of Energy complex. The Feeds Data Call, discussed in Section 3 of this report, focused on the Environmental Management (EM) Program's Deactivation and Decommissioning (D&D) activities as the source of most of the scrap metals available to the Department. The Product Needs Data Call was distributed across all of the Department's programs that were candidates for using recycled products manufactured from contaminated metals (e.g., Defense Programs, Environmental Management, Nonproliferation and National Security, Nuclear Energy, Science and Technology, Office of Science, and the Office of Civilian Radioactive Waste Management).

The key objectives of the Product Needs Data Call were as follows:

- Develop reasonable estimates of future demand within DOE for metal products, including waste containers, equipment, and other items. The estimates cover the period beginning FY 2003 and include carbon steel, stainless steel, nickel alloy, and iron.

- Incorporate the collected data into complex-wide assessments of internal reuse and recycling proposals, including the use of a dedicated steel mill to produce restricted use products.

There were two data sheets supplied in the data call; the first, shown in Exhibit 2-1, was directed to container (boxes, drums, cargos, etc) needs. The second data sheet requested information on the

Exhibit 2-1. Recycled Product Needs Data Call Table

Field Office ________________ **Site** ________________

Points of contact:

Field Office ________________ Site ________________

Project ________________

Container					Quantity							
Description	Metal Type	Weight (lb)	Size (ft³)	Thickness (inches)	FY 2003-2005	FY 2006-2010	FY 2011-2015	FY 2016-2020	FY 2021-2025	FY 2026-2030	FY 2031-2035	Confidence[1] % (+/-)

1. Provide an estimate of your confidence (e.g. +/- 25%) for the quantity needed

Assumptions:

demand for Other Recycled Metal Products, such as structural steel, vessels, process piping, valves, shielding, or other products. The data call requested product needs information from FY 2003 through FY 2035. The data call's time frame began in FY 2003, which is the earliest possible date any recycled metal products could be produced. The potential users for products and containers were asked to consider: the new pollution prevention goals and the impact of efforts to reduce LLW, assumptions regarding the compaction of waste to reduce its volume, assumptions regarding methods of disposal, and programmatic issues that would impact the generation of waste. The Data Call also requested that future needs be realistic estimates based on the best available information, as opposed to an extrapolation of current generation rates. Small sites (<50 tons/year or 1,000 tons total product needs through year 2035) were exempt from the data call.

The data sheet incorporated an area for assumptions and explanatory notes given the awareness that the field sites may have difficulties in accurately predicting product needs out to FY 2035. Similarly, the final column on the data sheet requested respondents to provide the confidence band for their product quantities. The information provided in the assumptions, in concert with the confidence band, would allow for the establishment of projected maximum and minimum metal product needs for the sites, and ultimately the complex.

As a result of the decision to circulate the Needs Data Call to all relevant DOE elements, DOE administrative procedures required that a draft copy of the data call be circulated to the affected programs through the Field Management Council (FMC) process prior to the data call's formal distribution. The FMC process is designed to give the programs an opportunity to provide comments and suggestions on proposed actions, such as this draft data call, to develop better end-products and minimize the burden on field offices by eliminating redundant activities. This process required approximately three weeks to complete, which resulted in a schedule delay from September 8 to September 22 for the request field offices to supply the Product Needs data to HQ. Since there was no corresponding relief on the completion schedule for the Feasibility Study, the Needs Data Call required the field to supply the information in less than a week. The necessary quick turnaround impacted the field's ability to access information for all of the potential product needs. Therefore, there may be additional products that were not presented due to schedule compression.

These time constraints did not allow for an independent validation of the data from each site's submittal. However, a high level QA review was performed on the information to both determine its completeness and identify anomalies with the data. Each site was contacted, and specific questions were asked about the data, its basis, and the site's confidence in the accuracy of the information provided.

Several observations can be made regarding the data. Confidence in the data, especially in the out-years, was relatively low at many sites. This is a result of program immaturity at some sites and the uncertainties associated with attempting to predict specific product needs and quantities to support the D&D of facilities that are not yet fully characterized. The worst case example of future waste container product needs resulted in a confidence range from – 50% to + 350%. Well-defined programs at other sites submitted data that were better developed and had much higher confidence levels. When sites were reporting on product needs to support ongoing non-D&D missions there was a higher degree of confidence in the quantities required. Most sites noted that they could have used more time in investigating the product needs, and that they supplied the best information within the allotted response time.

The base Total Metal quantity to support all of the identified product needs equals 426,480 tons comprised of 34% carbon steel, 40% stainless steel, and 26% Alloy 22 (a 60% nickel alloy for the High Level Waste Repository outer package shells) as illustrated in Exhibit 2-2.

Exhibit 2-2. Distribution Of Product Needs By Metal Type
Total Metal Needs = 426,480 tons

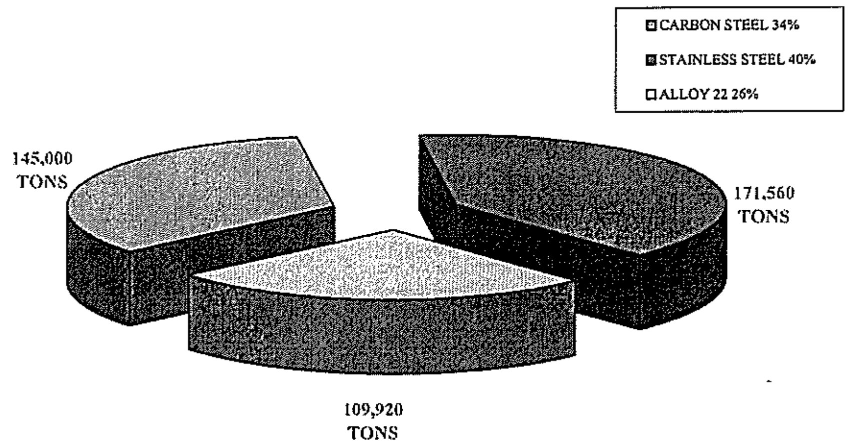
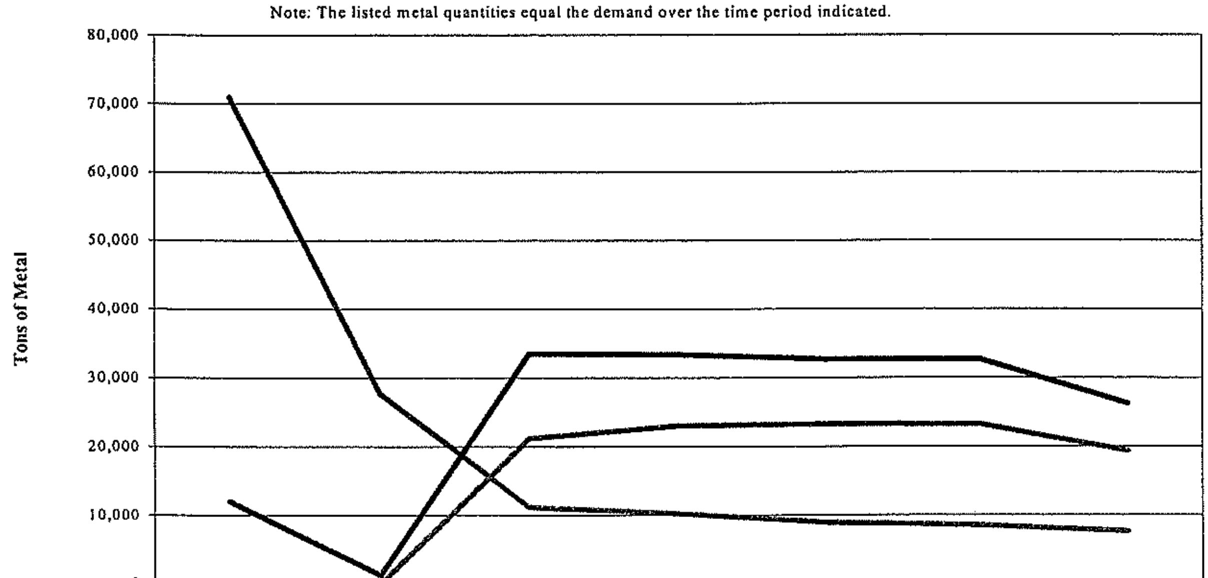


Exhibit 2-3 illustrates the Restricted Reuse Metal Product Demand from FY 2003 through FY 2035. The metals quantities listed in this table are the base quantities of metal needs reported by the field and do not contain any adjustment for the confidence level. The quantities listed are the summed yearly quantities within each time period.

Exhibit 2-3. Restricted Reuse Metal Product Demand
Note: The listed metal quantities equal the demand over the time period indicated.



	FY 2003-2005	FY 2006-2010	FY 2011-2015	FY 2016-2020	FY 2021-2025	FY 2026-2030	FY 2031-2035
Carbon Steel	71,005	27,645	11,185	10,232	8,897	8,457	7,580
Stainless Steel	12,013	1,288	33,428	33,328	32,640	32,640	26,223
Alloy 22	0	0	21,147	23,036	23,221	23,196	19,320

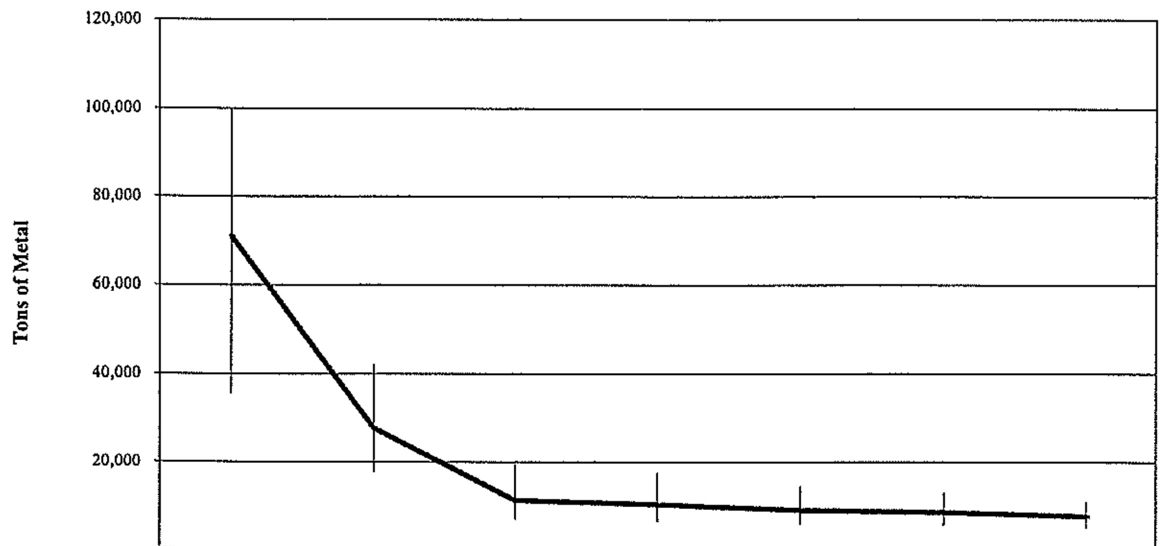
The demand for carbon steel products drops from a high of 71,005 tons in the period from FY 2003 to FY 2005 to an approximate average of 9,200 tons per period after FY 2011. Most of the demand for carbon steel is associated with waste container demands. The sites are indicating decreased demand as their D&D program works off its scope. The needs for Alloy 22 and for stainless steel become significant beginning in FY 2011. These needs are associated with the planned uses for stainless steel and Alloy 22 products in the High Level Waste Repository beginning in FY 2011 and continuing beyond FY 2035.

Exhibits 2-4, 2-5, and 2-6 reflect the data used to compile Exhibit 2-2. In these figures, individual metal types and life-cycle metal needs are illustrated. Most significant is that the confidence ranges are shown for each of the data points. The wide span in the confidence of the projected metal product needs quantities is quite evident. The table at the bottom of each graph shows, numerically, the differences between the base quantity reported and the maximum and minimum quantities projected from the confidence range reported in the data call.

Exhibit 2-4. Restricted Reuse Metal Product Demand

Tons of Carbon Steel

Note: The listed metal quantities equal the demand over the time period indicated.

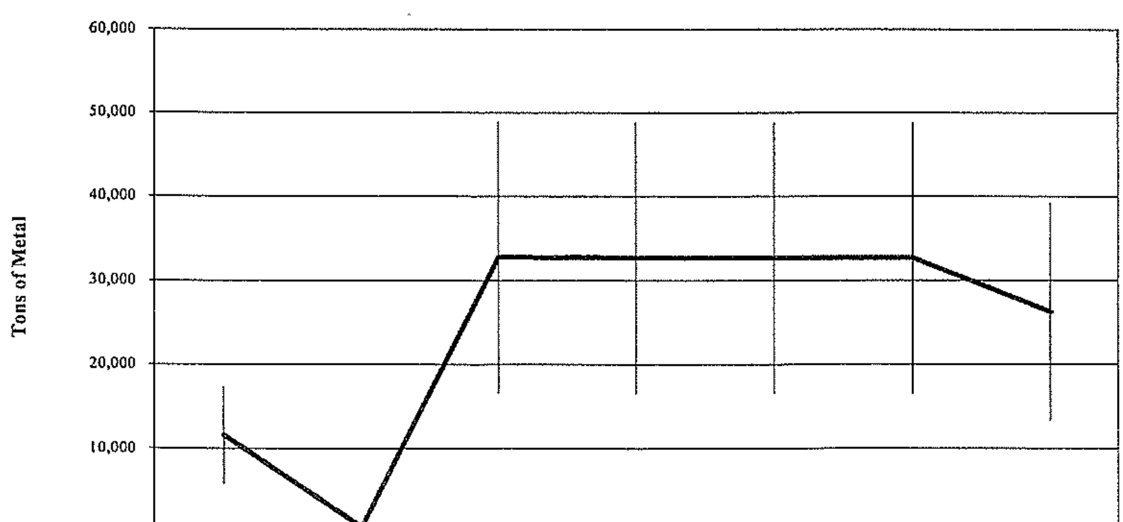


	FY 2003-2005	FY 2006-2010	FY 2011-2015	FY 2016-2020	FY 2021-2025	FY 2026-2030	FY 2031-2035
Maximum	100,051	41,905	19,277	17,496	14,379	12,974	10,926
Minimum	35,503	17,724	7,029	6,496	5,807	5,543	4,916
Base Qty.	71,005	27,645	11,185	10,232	8,897	8,457	7,580

Exhibit 2-5. Restricted Reuse Metal Product Demand

Tons of Stainless Steel

Note: The listed metal quantities equal the demand over the time period indicated.

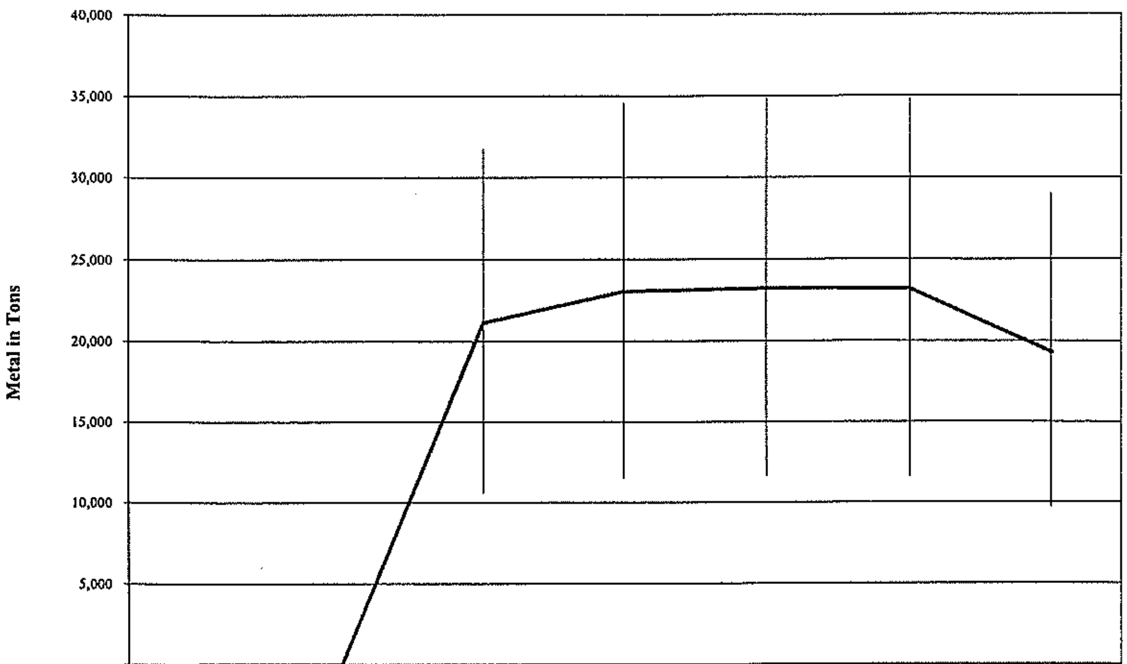


	FY 2003-2005	FY 2006-2010	FY 2011-2015	FY 2016-2020	FY 2021-2025	FY 2026-2030	FY 2031-2035
Maximum	17,295	725	48,936	48,786	48,786	48,786	39,160
Minimum	5,800	475	16,545	16,495	16,495	16,495	13,287
Base Qty.	11,600	600	32,740	32,640	32,640	32,640	26,223

Exhibit 2-6. Restricted Reuse Metal Product Demand

Tons of Alloy 22

Note: The listed metal quantities equal the demand over the time period indicated.



	FY 2003-2005	FY 2006-2010	FY 2011-2015	FY 2016-2020	FY 2021-2025	FY 2026-2030	FY 2031-2035
Maximum	-	-	31,720	34,554	34,831	34,794	28,980
Minimum	-	-	10,573	11,518	11,610	11,598	9,660
Base Qty.	-	-	21,147	23,036	23,221	23,196	19,320

The average confidence in the quantity of metal required to fulfill the total product needs requirement ranges from –47% to +49%. This yields a minimum metal need of 225,530 tons and a maximum metal need of 637,206 tons.

The Product Needs were classified into five categories using the Product Codes shown in Exhibit 2-7.

Exhibit 2-7. Product Category
• Boxes/small containers < 1,000 lbs tare
• Large containers/Roll-offs/Cargos/Sea Land
• Drums
• Infrastructure/Construction Products
• Other Products

Exhibit 2-8 shows each of these product categories, the total weight of the metal contained in the product category, the types of metal contained in each category, and the weights of the component metals in the category.

Exhibit 2-8. Component Metal in Each Product Category			
Product Category	**Total Metal Weight (Tons)**	**Type of Metal in Category**	**Component Metal Weight (Tons)**
Boxes/Small Containers (<1,000 lbs tare)	30,301	Carbon Steel	30,301
Large Containers/Roll-offs/ Cargos/Sea Land	44,748	Carbon Steel	42,074
		Stainless Steel	2,675
Drums	17,668	Carbon Steel	17,668
Infrastructure/Construction	59,300	Carbon Steel	44,700
		Stainless Steel	14,600
Other Products	274,463	Carbon Steel	10,258
		Stainless Steel	154,284
		Alloy 22	109,920

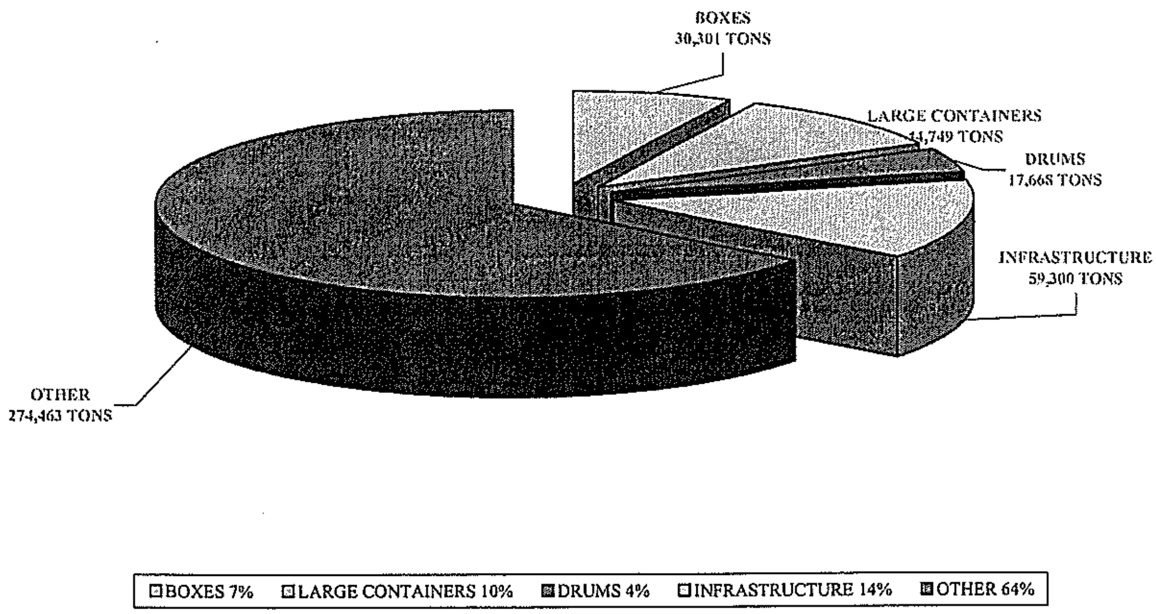
The total quantity of metal required to satisfy the projected base needs is 426,480 tons. As seen in this table, a significant quantity of the metals, 274,463 tons (64% of the total needs), resides in the Other Products category. The total metal weight required in the Other Product category is comprised of three metals: carbon steel (4%), stainless steel (56%) and Alloy 22 (40%). Most of these products support HLW and TRU waste program needs. The stainless steel and the Alloy 22 needs are products for the HLW repository.

Exhibit 2-9 illustrates the Distribution of Products Needs and the percent distribution of the product needs. The Infrastructure/Construction product needs comprise the second largest needs category, 14% of the total needs, and is comprised of carbon steel and stainless steel products primarily for future MOX fuel facilities at Savannah River. These components are structural steel and stainless steel process piping and equipment. The facility uses area of the needs data call may not have been investigated fully by those sites that will be hosting continuing missions requiring future capital construction projects. This investigation requires significant resources and time to develop an estimate for needs to support new facility construction. Given the schedule limits placed upon this data call and the difficulties associated with developing facility needs, there may be as much as an additional 50,000 to 100,000 tons of combined carbon and stainless steel needs that has not been estimated.

The Large Container, Boxes, and Drums categories combined to account for the remaining 21% of the product needs and total metals. These categories are comprised almost entirely of carbon steel products with about 3% of the total metal quantity in this category being stainless steel containers.

Exhibit 2-9. Distribution of Product Needs

Total Metal Needs = 426,480 tons



The following observations and conclusions were drawn from the Product Needs data call:

- There was a base product demand for a total of 426,480 tons of metal products from FY 2003 through FY 2035.
- Specific confidence associated with select product needs ranged from –10% to +350%.
- The average confidence in the quantity of metal required to fulfill the total product needs ranges from –47% to +49%. This yields a minimum metal need of 225,530 tons and a maximum of metal need of 637,206 tons.
- The demand for Other Products dominated the requested needs for recycled products which is comprised of shielding blocks, cask related items, and products for the HLW repository.
- The total demand of 274,463 tons of metal in the Other Products category consists of: 10,258 tons of carbon steel associated with shielding needs and cask products, 154,284 tons of stainless steel for HLW inner package shells, and 109,920 tons of Alloy 22 HLW outer package shells and equipment for the HLW repository.
- There is minimal need for these Other Products until FY 2011.
- The demand for carbon steel products drops from 71,005 tons between FY 2003 and FY 2005 to an average of approximately 9,200 tons from FY 2011 through FY 2035. This is directly related to the decrease in need for waste containers and boxes to support the D&D mission.
- The Infrastructure/Construction Product category comprises the second largest category of needs 59,300 tons of metal, comprised of carbon steel and stainless steel products primarily for future MOX fuel facilities at Savannah River. These components are structural steel, and stainless steel process piping and equipment.

- Confidence in the needs data in the out-years is low as a result of the immaturity of some site programs, in addition to uncertainties associated with forecasting needs to support D&D activities for facilities not yet fully characterized.

- When the sites were reporting on product needs to support continuing missions, there was a higher degree of confidence in the quantities required.

- Some of the uncertainty of both the needs and confidence associated with the needs data is associated with the lack of adequate time to fully investigate and define the site's needs. In several cases the field was required to unrealistically respond in less than a week.

- Although the FMC process aided the refinement of the data call, the FMC required a schedule time frame not allowed by the overall delivery schedule for the Feasibility Study, and this resulted in limited data confidence and a minimal depth of information.

- The Infrastructure/Construction Product needs area of the data call may not have been investigated fully by those sites that will be hosting continuing missions requiring future capital construction projects. Significant resources and time are required to perform an estimate for needs to support new facility construction. There may be as many as 50,000 to 100,000 tons of combined carbon and stainless steel needs that have not been reported, given the limits placed upon this data call and the difficulties associated with developing facility needs.

- Most sites identified that they could have used more time in investigating the product needs, but supplied the best information available in the allotted response time.

3. Surplus Metal Inventory

The Environmental Management (EM) Program's Decontamination and Decommissioning (D&D) activities are responsible for the majority of the current inventory of scrap nickel, carbon steel, stainless steel, and iron. D&D activities are also forecasted to generate the majority of the scrap metals that will become available to the Department over the next 35 years. As a result, the "feeds" information data call was limited to field operations offices with EM programs. Guidance was provided to EM managers to coordinate with other field program managers (e.g., Office of Science, Office of Defense Programs, Office of Nuclear Energy) to capture readily available information on scrap metal generated by D&D activities not under the EM program. While each operations office made one submission, data was requested for each site (e.g., Oak Ridge National Laboratory, Y-12 Plant, East Tennessee Technology Park) by project at EM's PBS level.

Two assumptions were provided to guide the operations offices in the data call:

- For volumes and cost estimates, assume FY 2001 Congressional Budget Request and FY 2002 target level funding, with no increases in funding in the out-years.
- Unless otherwise specified, assume policies, practices, etc. in place prior to the Secretary's February 14 moratorium and July 13 suspension.

Additionally, it was requested that the field supply relevant assumptions and notes with the supplied data so that reviewers could better understand the basis for the site's data and the confidence associated with the quantities and generation rates for the four metal streams. Small sites (<50 tons/year or 1,000 tons total through year FY 2035) were exempt from participating in the data call.

The data call requested an estimated weight (in tons) of the current inventory, and the projected scrap generation from D&D activities over the next 35 years. Basic information on the radiological nature of the metals was also asked for, including: the primary isotopes; the percentage of remote handled metal; and whether the metal would be volumetric alloy contaminated, surface contaminated, or non-contaminated. No specific information on activity levels was requested due to the focus on the Gaseous Diffusion Plants (GDPs) and the level of information already available for those feed streams. Finally, the percentage of metals that would be classified was requested. The data call included, to the extent practical, materials from facilities currently in the EM program and material expected to be transferred into the EM program (e.g., Portsmouth and Paducah).

Radiological information collected during prior maintenance and modification of the GDPs indicate that uranium (0.6-60 ppm) will be the principal contaminant of concern for scrap steel, and technetium (0.04-26 ppm) and uranium (46-282 ppm) will be the principal contaminants of concern for scrap nickel. In addition to the uranium and technetium, trace quantities of neptunium are expected in the GDP steel (<0.005-0.006 ppm) and nickel (<0.005-0.036 ppm) scrap. A wide variety of natural and fission product radionuclides may also be present in the metals if all sites are included.

Time would not allow for an independent validation of each submittal. However, a high level QA review was performed on the information to determine its completeness, and to identify anomalies in the data. Each site was contacted and specific questions were asked on the data, how the data were generated, and the sites' confidence in the accuracy of the information provided. Some unresolved issues associated with the Idaho Sites projections on the quantity of stainless steel that will be generated still remain. Based upon current information, the Idaho sites are projecting an approximate 50/50 split between stainless steel and carbon steel. However, the projection on the quantity of stainless steel may be optimistic.

Confidence in the data, especially in the out-years, at many sites is relatively low. When programs had experience in decommissioning site facilities, their confidence levels associated with predictions for future, similar facilities were much higher. In particular, the estimates for the GDPs (which account for approximately 57% of the current and forecasted scrap metals) have a fairly high degree of confidence, as detailed take-offs have been done on metals, and the decommissioning of one of the three plants is well underway. However, the generation profiles for metals (primarily carbon steel and nickel) could change significantly if the D&Ds of Portsmouth and Paducah are delayed beyond their current baselines. The assumed time frame for D&D of Portsmouth and Paducah are FY 2003 to FY 2014 and FY 2008 to FY 2015, respectively.

All of the sites were very concerned about putting too much credence in out-year estimates for D&D generation rates. Although they bound their estimates by establishing error ranges, impacts from funding, as well as changes to D&D priorities and cleanup standards, could have an even more significant impact on the generation rates.

An adjustment was made to the gross quantities supplied by the field to materials deemed unsuitable for the steel mill. Metals requiring remote handling were removed. A further reduction of 25% was made to the remaining quantities of steel and iron to account for metal that would not be recycled due to economic or radiological reasons (a factor based on experience with decommissioning at the Oak Ridge GDP). The reduction factor was not applied to the nickel, although some loss is expected during recovery and pretreatment.

Exhibit 3-1 identifies the total metal quantity projected to be available and the quantities of the four metals contributing to the total. The metal quantities are for both the current inventory and the projected D&D generation. **The data should be given no more significance than the nearest thousand tons.**

Exhibit 3-1. Potential Available Metal Quantities

Metal	Inventory[1]	Generation from D&D	Total by Metals
Carbon Steel	85,187	780,332	865,519
Stainless Steel	6,609	167,394	174,003
Nickel	9,700	27,906	37,606
Iron	11	7,525	7,536
Total	101,507	983,157	1,084,664

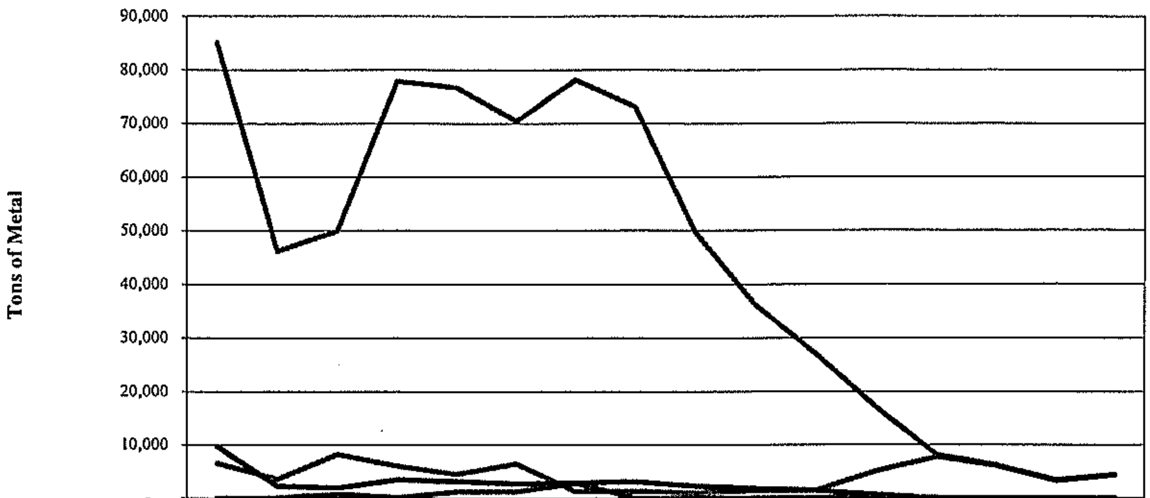
[1]All metal quantities are shown in tons.

Exhibit 3-2 depicts the largest quantity of metal being generated from D&D activities is in the FY 2003 through FY 2007 time frame. It also indicates that carbon steel is the primary contributor to the overall metal inventory being generated. The data should be given no more significance than the nearest thousand tons.

Exhibit 3-2. Current and Projected Generation of Metal by Year

"Feeds" Quantity of Metals

* Note: For the 5 year periods beginning in FY-2011, the listed metal quantities equal the generation/year



	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011-2015*	FY 2016-2020*	FY 2021-2025*	FY 2016-2030*	FY 2031-2035*
Carbon Steel	85,187	46,199	49,917	77,838	76,723	70,399	78,179	73,085	49,637	36,254	27,026	16,971	8,068	6,166	3,380	4,430
Stainless Steel	6,609	3,501	8,217	6,078	4,505	6,513	1,254	1,312	985	1,389	1,465	5,072	7,717	6,055	3,239	4,352
Nickel	9,700	2,283	1,879	3,476	3,168	2,670	2,874	3,114	2,233	1,807	1,467	587	0	0	0	0
Iron	11	53	778	101	1,181	1,267	2,822	75	97	53	53	105	26	26	26	26

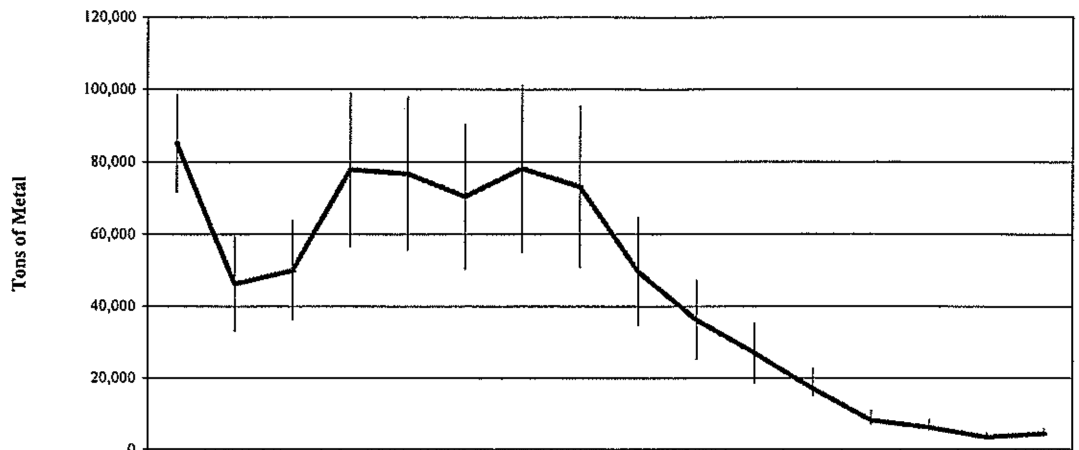
Fiscal Year

Exhibits 3-3 through 3-6 reflect both a minimum and maximum level for the current and projected inventory for metal based on the confidence level of the data, as well as the adjusted base quantity. **The data should be given no more significance than the nearest thousand tons.**

Exhibit 3-3. Current and Projected Generation of Metal by Year

Annual Tons of Carbon Steel

* Note: For the 5 year periods beginning in FY-2011, the listed metal quantities equal the generation/year



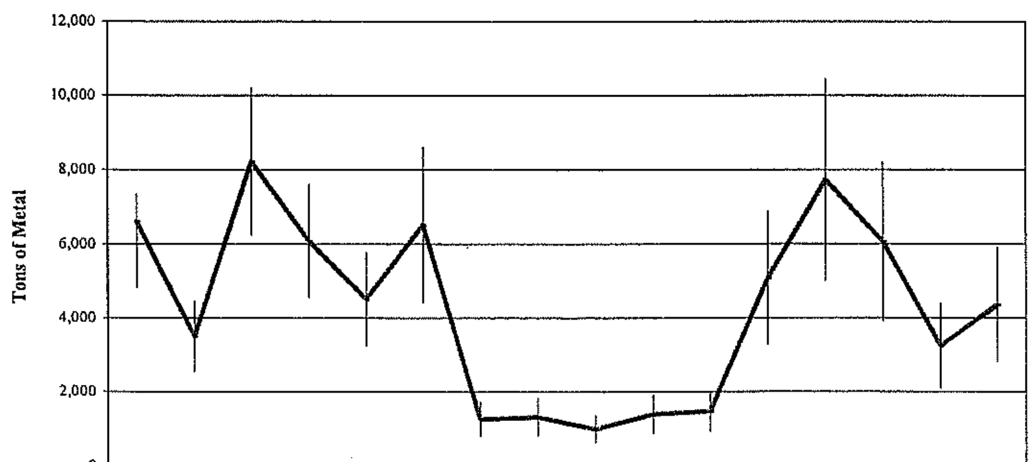
	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011-2015*	FY 2016-2020*	FY 2021-2025*	FY 2016-2030*	FY 2031-2035*
Minimum	71,634	32,983	36,159	56,610	55,655	50,355	55,056	50,688	34,725	25,198	18,575	14,950	6,919	5,325	2,908	3,824
Maximum	98,739	59,415	63,676	99,038	97,768	90,443	101,30	95,483	64,549	47,309	35,476	22,749	10,985	8,376	4,616	6,031
Final Qty	85,187	46,199	49,917	77,838	76,723	70,399	78,179	73,085	49,637	36,254	27,026	16,971	8,068	6,166	3,380	4,430

Fiscal Year

Exhibit 3-4. Current and Projected Generation of Metal by Year

Annual Tons of Stainless Steel

* Note: For the 5 year periods beginning in FY-2011, the listed metal quantities equal the generation/year



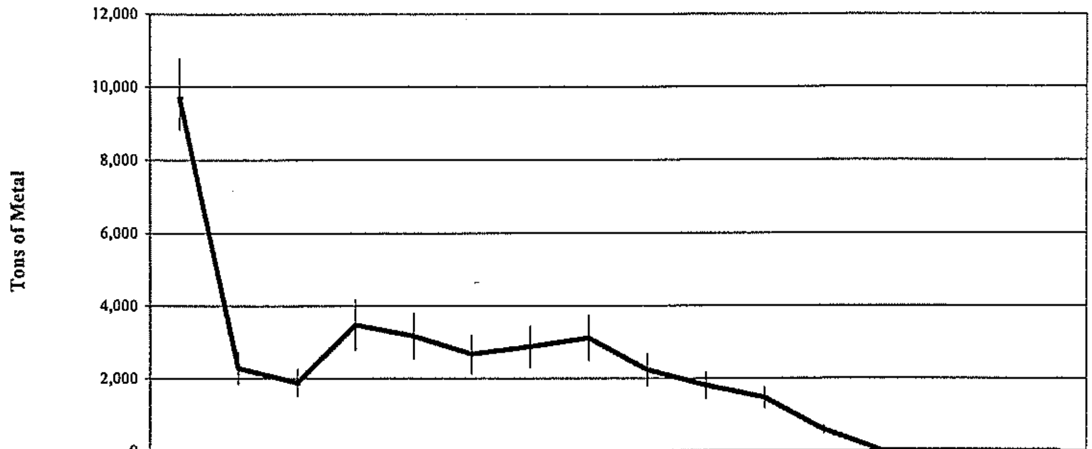
	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011-2015*	FY 2016-2020*	FY 2021-2025*	FY 2026-2030*	FY 2031-2035*
Minimum	4,815	2,534	6,233	4,536	3,225	4,413	785	808	610	864	912	3,266	4,994	3,912	2,081	2,806
Maximum	7,346	4,468	10,201	7,620	5,785	8,612	1,723	1,815	1,361	1,914	2,017	6,878	10,439	8,197	4,396	5,897
Final Qty	6,609	3,501	8,217	6,078	4,505	6,513	1,254	1,312	985	1,389	1,465	5,072	7,717	6,055	3,239	4,352

Fiscal Year

Exhibit 3-5. Current and Projected Generation of Metal by Year

Annual Tons of Nickel

* Note: For the 5 year periods beginning in FY-2011, the listed metal quantities equal the generation/year



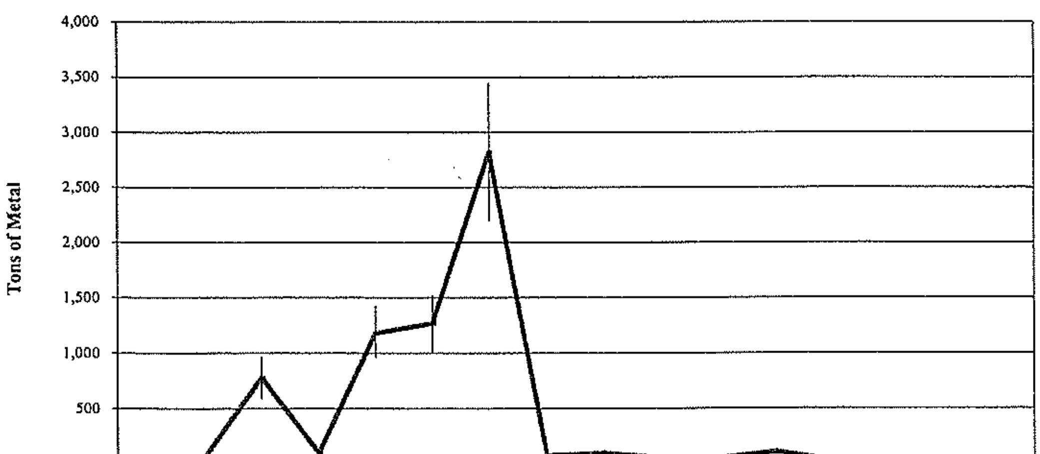
	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011-2015*	FY 2016-2020*	FY 2021-2025*	FY 2026-2030*	FY 2031-2035*
Minimum	8,831	1,826	1,503	2,781	2,534	2,136	2,299	2,491	1,786	1,446	1,174	469	0	0	0	0
Maximum	10,783	2,740	2,255	4,171	3,802	3,204	3,449	3,737	2,680	2,168	1,760	704	0	0	0	0
Final Qty	9,700	2,283	1,879	3,476	3,168	2,670	2,874	3,114	2,233	1,807	1,467	587	0	0	0	0

Fiscal Year

Exhibit 3-6. Current and Projected Generation of Metal by Year

Annual Tons of Iron

* Note: For the 5 year periods beginning in FY-2011, the listed metal quantities equal the generation/year



	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011-2015*	FY 2016-2020*	FY 2021-2025*	FY 2016-2030*	FY 2031-2035*
Minimum	8	39	591	111	957	1,011	2,199	51	67	39	39	79	20	20	20	20
Maximum	14	66	965	119	1,427	1,523	3,444	100	127	66	66	131	33	33	33	33
Final Qty	11	53	778	101	1,181	1,267	2,822	75	97	53	53	105	26	26	26	26

Fiscal Year

Exhibit 3-7 portrays each operations office's contribution to the total quantity of metal that has been, or is projected to be, generated from D&D activities over the next 35 years.

Exhibit 3-7. Contribution to Total Metal Quantity by Operations Office

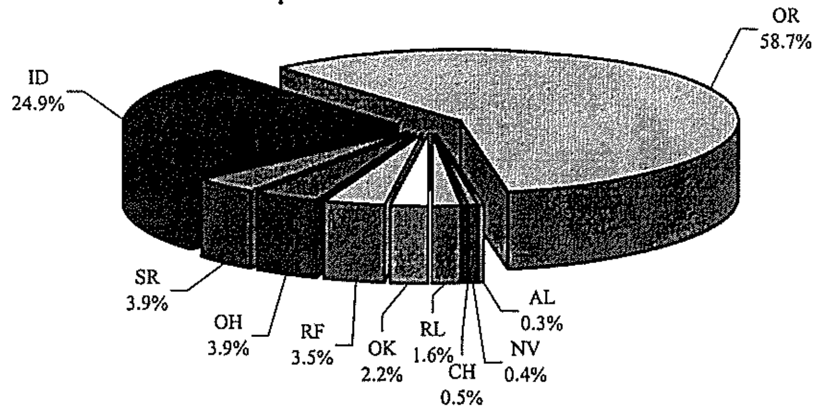


Exhibit 3-8 conveys each operations office's contribution to each of the metal types that were reported. Due to the limited amount of iron inventory, the carbon steel and iron inventories have been combined.

Exhibit 3-8. Contributions to Specific Metal Quantities by Operations Office

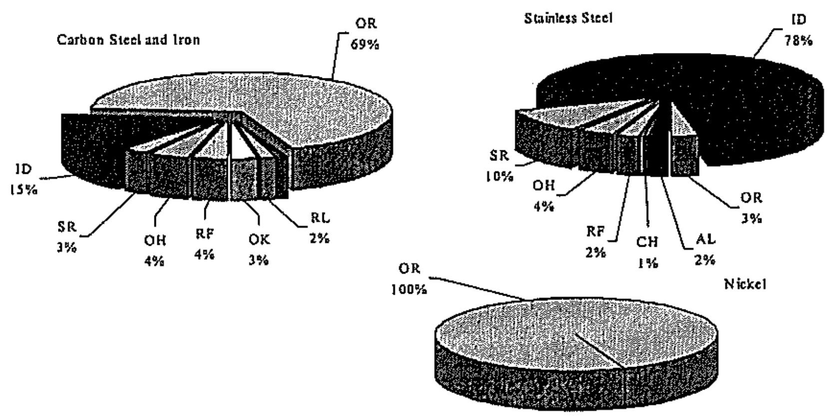


Exhibit 3-9 depicts the potential quantities of carbon steel, stainless steel, and nickel for the current and projected inventory for the three gaseous diffusion plants. **The data should given no more significance than the nearest thousand tons.**

Exhibit 3-9. Potential Current and Projected Generation of Metal Quantities from Gaseous Diffusion Plants

Metal	Inventory[1]	Generation from D&D	Total of GDP Metal	Percentage of DOE Metal
Carbon Steel	64,062	513,182	577,244	66%
Stainless Steel	117	5,195	5,312	3%
Nickel	9,700	27,904	37,604	100%
Total	73,879	546,281	620,160	57%

[1]All metal quantities are shown in tons.

The following observations and general conclusions can be drawn from the "feeds" data call:

- As expected, the GDPs dominate the current and future generation of carbon steel and nickel. The two largest contributors to stainless steel inventories are the Idaho and Savannah River sites. The Savannah

River contribution reflects its Nuclear Materials Stewardship strategy, which is limited to deactivation activities that reduce surveillance and maintenance costs to a minimum and does not include D&D activities.

- There appear to be sufficient quantities of carbon steel to meet the assumption of the 20,000 - 50,000 tons/year minimum threshold, at least until FY 2015. Carbon steel generation should average 45,000 tons/year until FY 2015.
- Stainless steel quantities will be well under 10,000 tons/year through FY 2035.
- The estimates for nickel have a high degree of confidence and are projected to total about 28,000 tons.
- There is significant uncertainty associated with the out-year data.
- Approximately 91% of the available metal is categorized as contaminated. However, discussions with the sites indicate that the contamination levels associated with the metals would be relatively low.
- Yearly generation rates and available metal types may be impacted by DOE site priorities and appropriated funding. By and large, the generation rates are consistent with site baselines. However, D&D activities are often not at the top of site clean-up priorities, and there is some probability that these schedules will slip, consequently stretching out the generation curves. The potential impacts of site priorities and appropriated funding were out of the scope of this data call, and could neither be quantified nor assigned an uncertainty value.

4. Alternatives for the Recycle or Disposal of Radioactively Contaminated Scrap Metal from the DOE Complex

Introduction

Alternatives for the recycle, reuse, and/or disposal of radioactively contaminated scrap metals have been defined at a high level in terms of the activities required to complete a particular recycle or disposal option. Primary alternatives are free-release, disposal, and recycling within the DOE complex. The radioactively contaminated material that would make up the possible feedstock for this process would come from three primary sources within the DOE complex: the enrichment processing facilities (EPFs, which include GDPs), reactor facilities (RFs), and plutonium processing facilities (PPFs). This distinction has been made because handling and waste treatment requirements, licensing, and worker health and safety may be significantly impacted by the types of radioactively contaminated metals that are processed. The primary focal points of the alternatives presented are the EPFs—particularly the GDPs, as they are expected to be the major contributors of the scrap metal stock suitable for recycling.

Many of the alternatives include elements that are common to most if not all of the alternatives. Common elements include characterization, dismantlement, and transportation. However, as will be discussed, the hazards and costs associated with these elements may vary depending on the specifics of a particular alternative, and can result in differences in the feasibility, implementation time, cost analysis, and environmental acceptability of a particular alternative.

The alternatives for the recycle/reuse of contaminated radioactive materials have been divided into six categories. They are:

- *Alternative 1: Free release of metals with no detectable contamination before or after decontamination*—Potentially contaminated metal inventories are segregated and characterized. Metals with no detectable contamination (as defined in the revised DOE Order 5400.5), either before or after decontamination, are released for unrestricted use. The contaminated fraction is disposed of at a DOE or commercial waste site.

- *Alternative 2: Disposal of all potentially contaminated metals*—Limited characterization and disposal, or long-term storage, of all potentially contaminated metals at a DOE or commercial waste site

- *Alternative 3: Decontamination at a commercial Electric Arc Furnace (EAF) and recycling for use at DOE facilities*—Potentially contaminated metals are segregated at the facility where they were generated and the low-level contaminated metals are processed at a commercial EAF that has been retrofitted and regulated for this application. The decontaminated, but still slightly radioactive, metal would then be rolled and fabricated into containers or other items for use within the DOE complex. Rolling and fabrication would be performed at commercial facilities, assuming that the radioactive contamination levels in the metal meet applicable criteria for rolling and fabrication.

- *Alternative 4: Recycle at a DOE Facility using an EAF moved to or built at that site*—An Electric Arc Furnace (EAF) system would be relocated or built at a DOE facility where the contaminated metals would be processed for use within the DOE complex. The rolling mill and fabrication facilities may also be located at this site.

- *Alternative 5: Recycle at a new commercial EAF*—Recycling would be performed by a commercial company at an EAF that was constructed and regulated specifically for the purpose of processing low-level radioactively contaminated metals from the DOE complex.

- *Alternative 6: Recycle at an existing Radioactive Scrap Metal (RSM) facility*—Existing regulated RSM processing facilities would be used for the initial decontamination and melting, with rolling and fabrication to be performed at commercial facilities.

Exhibit 4-1 presents an overview of the primary elements associated with each of the alternatives. Many of the alternatives have common elements, although the requirements for these common elements may vary depending on the alternative being addressed. The elements common to all scenarios are:

- source of the radioactive material,
- radioactive materials characterization,
- scrap metal component dismantlement and size reduction,
- metal segregation by radioactive material content,
- transportation, and
- disposal or recycle.

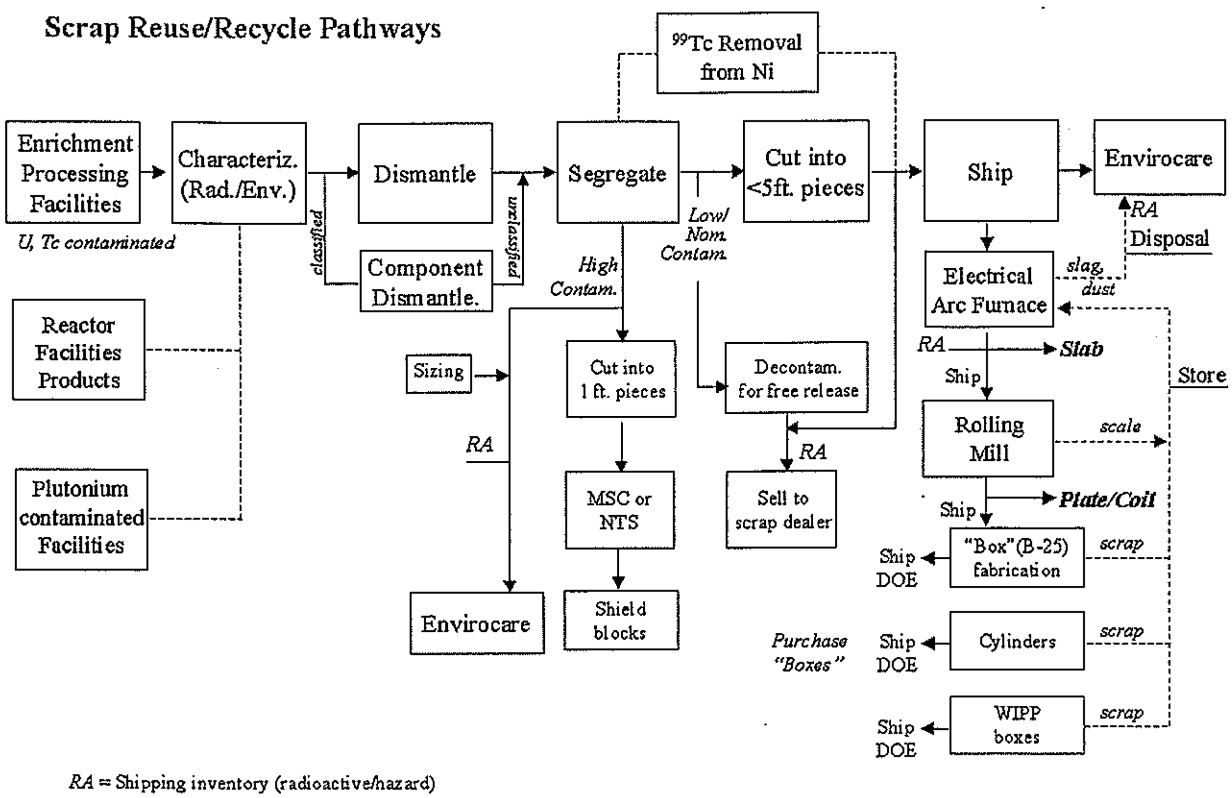
Source of the radioactive material—Three primary sources of radioactive scrap metal from the DOE complex have been identified: Enrichment Processing Facilities (EPFs), Reactor Facilities (RFs) and Plutonium Processing Facilities (PPFs). Although a single site may contain scrap metal contaminated with radionuclides from these three sources, in most cases the radioactively contaminated metals from these sources can be segregated, and provide a basis for defining the characteristics of a facility for processing radioactive scrap metal with different characteristic properties. The primary sources of contaminated scrap metal that may be recycled are the EPFs. These facilities are primarily located at the Paducah, Portsmouth, and Oak Ridge sites. Consequently, most of the processing and disposal assessments in this feasibility study are based on the characteristics of scrap metal from these facilities.

The primary radioactive contaminants present at the EPFs are depleted, natural, or enriched ^{235}U Uranium), and the long-lived ^{99}Tc that has concentrated in the converters from the enrichment process. The uranium radionuclides are expected to partition to the slag, and the ^{99}Tc would partition primarily to the metal product. ^{99}Tc is a low-energy beta radiation emitter that does not present a significant health and safety hazard.[1, 2] The distribution, concentration, and radiation dose impact of these radionuclides in the scrap metal to be processed is addressed in Section 5.

The radioactive materials from the RF and PPF sites pose other problems associated not only with the characteristics of the radionuclides (e.g., the volatility of ^{137}Cs [Cesium]), but also with the partitioning of some radionuclides into the metal product. These safety and environmental concerns can significantly change the requirements for processing contaminated metals from these sites.

The RF sites contain metals that have both surface contamination present, as is the case with the EPFs, and volumetric contamination present induced by the neutron activation of some RF components. The main long-lived radionuclides present as surface radioactive contamination on metals from the reactor facilities are ^{137}Cs, ^{90}Sr (Strontium), and ^{129}I (Iodine), with lower concentrations of other fission products and trace levels of transuranic radionuclides such as ^{239}Pu (Plutonium). In addition, there is volumetrically contaminated scrap metal that contains the neutron activation products ^{60}Co (Cobalt), ^{59}Fe (Iron), and ^{59,63}Ni (Nickel). Of the RF radionuclides (e.g., ^{137}Cs [Cesium]), the radionuclides that would be expected to volatilize and the neutron activation products that would partition to the metal product from any EAF process and produce a contaminated metal product, are the primary concerns for processing contaminated scrap metal from this source.

Exhibit 4-1. Option 1 –Segregate and Recycle



The PPF sites are contaminated with transuranic materials that would be present on the scrap metal as surface contamination. The primary radionuclides present are $^{239,240}Pu$ and ^{241}Am (Americium). These radionuclides may be suitable for surface decontamination and would be expected to partition to the slag formed during EAF operations. However, other issues related to regulation, handling, worker safety, and environmental concerns make processing scrap metal from these facilities a problem generally not addressed in this feasibility study.

Radioactive materials characterization—Radioactive materials characterization is required prior to their removal from any generator site to meet both Department of Transportation (DOT) shipping and facility receipt requirements. Furthermore, characterization is required as part of the segregation process to separate potentially radioactively contaminated materials into possible free release metals, low-level radioactively contaminated metals, and high-level contaminated metals. Characterization generally includes a combination of process knowledge and physical characterization using sampling and direct radiation measurements.[3] Improved technologies are being developed that allow the characterization of each piece to be performed following dismantlement, allowing the inventories for either disposal or recycling to be well-defined with relatively small uncertainty. This becomes an issue when special nuclear material (e.g., enriched uranium or plutonium) is involved, as both accountability and criticality issues become relevant for processing facilities.

Scrap metal component dismantlement and size reduction—Scrap metal component dismantlement and size reduction comprises the removal and sizing of components within a facility to a size suitable for either disposal or recycling. For the EPFs, this is a significant issue because large components, such as the converters, must be cut into relatively small pieces for either disposal or recycling. Dismantlement and sizing can have a significant impact on implementation and costs, because the sizes differ for each processing route. Typically, significant size reduction is required for both processing and disposal.

Metal segregation by radioactive material content—Metal segregation by radioactive material content is the separation of contaminated metals into groups that meet the acceptance criteria for the processing facility (either for recycle or disposal). The primary groups into which the potential scrap metal would be segregated are:

- Uncontaminated (suitable for free release or processing for DOE use)
- Low-level radioactive contamination (suitable for processing for DOE use)
- High level radioactive contamination (suitable for disposal only)

Metal segregation, as shown in Exhibit 4-1, may include the decontamination of some contaminated metals, such as the nickel from the gaseous diffusion plants, that may have ^{99}Tc contamination present. Segregation criteria are primarily based on the acceptance criteria for the commercial facility processing the scrap metal, whether the metal is processed for disposal or reuse. These criteria define the level of engineered and administrative controls required for the facility to process contaminated metals proposed for that site. Specifically, both radioactive and hazardous waste acceptance criteria are required. The acceptance criteria for a disposal site may be less rigorous than those for a processing facility where reuse of the metal is proposed. Metal acceptance criteria (MAC) for disposal and EAF facilities are discussed in the environmental section of this report.

Limited decontamination for specific items may be considered an element of the segregation action. In the case of the GDPs, the decontamination of some components may be performed to remove ^{99}Tc and some uranium prior to processing. This decontamination could affect the potential processing and uses for the contaminated steels, as discussed in the environmental section of this study.

Transportation—Transportation issues for the contaminated metals for either disposal or recycling are significant. Specific issues include: health and safety protection during packaging, radioactive material shipping, and unloading at the processing facility. The material must be contained in a suitable package for radioactive materials shipment, and the shipping costs must be included in the overall cost-benefit analysis. In some cases (e.g., onsite disposal), the packaging and shipping costs may be less than those for shipping the metal to a disposal site across the country.

Recycle and/or disposal—Following segregation and transportation, the potentially contaminated radioactive material becomes the feedstock for the recycle and/or disposal alternatives. The following sections provide a more detailed description of the: six alternatives, primary assumptions associated with each alternative, differences in the common elements, and products of each alternative.

Alternative 1

Free Release of Metals with No Detectable Contamination

Description

Alternative 1 is the free release of metals meeting the criteria of the newly revised version of DOE Order 5400.5, which is currently being revised to ensure that there is no detectable contamination on metals released for unrestricted recycling. This alternative allows the metal scrap to be decontaminated prior to being characterized, to meet the DOE Order 5400.5 release criteria. Any metal scrap that is contaminated at detectable levels will be disposed of at either DOE or commercial waste sites. Summarized below are the assumptions associated with this alternative, along with its primary differences relative to the other alternatives.

Assumptions

To assess the feasibility and the nominal costs associated with the free release of potentially contaminated metals, a number of assumptions must be made, as actual data are limited. A principle assumption concerns the quantities of potentially contaminated scrap metal that are either uncontaminated or can be decontaminated to meet the DOE Order 5400.5 criteria. The assumption has been made based on preliminary data that shows 25%-75% of the metals removed from the EPFs are either uncontaminated or can be decontaminated to meet free release criteria. If the metal is contaminated above radioactive background levels, than the metal is sent for disposal as discussed in Alternative 2.

Other specific assumptions for Alternative 1 are:

- Disposal of contaminated metals will be done at the generator site (e.g., the ORNL onsite disposal cell) to the disposal capacity of the site, with the balance disposed of at a commercial disposal site.

- All volumetrically contaminated, or difficult to decontaminate, metal components will be disposed of at DOE or commercial waste sites.

- Mixed waste (1-5% of all waste from the EPFs) will be disposed of at a commercial waste site that can accept mixed waste containing PCBs.

- Costs for the decontamination and disposal of potentially hazardous wastes generated will be included to determine whether decontamination is a feasible and cost effective alternative.

- No additional facility permitting or licensing costs will be incurred.

- All contaminated nickel will be disposed of at a classified waste disposal site.

- Free released carbon steel is estimated to sell at $65 per ton with a transaction discount of 25%.

These assumptions impact the performance of the five elements common to each alternative. The source of radioactive material assumed for this option is from the EPFs, although the same criteria may be applied to RFs and PPFs. The quantity of metals that might meet the free release criteria at these other sites is assumed to be similar, as much of the potentially contaminated metals may meet free-release criteria following characterization.

Radioactive materials characterization for this alternative has been assumed to be more extensive than that for the pure disposal alternative (particularly at onsite disposal locations), to provide a significant degree of confidence that the scrap metal meets the release criteria. Characterization requirements for the recycle alternatives are expected to be similar to the free release requirements.

Products

The primary products of this alternative are uncontaminated steels acceptable to the steel industry and the general public. These metals may be free-released following characterization, or where it is practical, following decontamination and characterization. Another product of this alternative is the reduced volume of waste for disposal at either onsite or commercial waste disposal facilities. Other products are the minimization of shipping costs to off-site disposal sites and the resulting reduction of disposal costs at these sites.

Alternative 2

Disposal of All Potentially Contaminated Metals

Description

Alternative 2 is the disposal of all potentially contaminated metals, with limited characterization and segregation to show the material meets the waste acceptance criteria for either onsite disposal or a commercial waste site. Disposal would be performed, where possible, at the onsite cells of the various sites and at commercial sites if the waste cannot be disposed of in the onsite cell. Disposal cells at the EDFs are currently located at Oak Ridge and Fernald. Other sites within the complex include the Hanford Disposal site, the Idaho Falls Radioactive Waste Management Complex, and the disposal site at the Nevada Test Site. The Hanford site and a commercial site can dispose of both low-level radioactive waste and mixed waste.

Assumptions

The primary assumption for this alternative is that scrap metal disposal would be done at onsite cells of the generating facilities for scrap metals that meet the cell's waste acceptance criteria and capacity. Other wastes (e.g., mixed) that do not meet the acceptance criteria, and those scrap metal wastes that exceed the capacity of the onsite cell, would be shipped to a commercial site for disposal.

Other assumptions include the following:

- Off-site disposal of classified wastes will be performed at NTS.
- The Hanford disposal site and a commercial waste disposal site would be used for excess low-level waste and mixed waste.
- Large containers (e.g., Sealand and Gondolas) would be used for disposal to minimize packaging and transportation costs.

Products

The primary result of this disposal alternative is the clearing of scrap yards and scrap metal disposed of at a few monitored disposal sites. This alternative has been tested and is currently in use.

Alternative 3

Decontamination at a Commercial Electric Arc Furnace (EAF) and Recycling for Use at DOE Facilities

Description

A commercial EAF will be regulated and retrofitted for processing low-level radioactively contaminated metals for reuse within the DOE complex. This facility would be regulated to ensure the processing a well-defined, limited metal recycle stream. Initially, it was proposed that the facility should be limited to scrap metal from the EPFs, from which the types and characteristics of the radionuclides present are well known. MAC will be defined that limit the radionuclide content of the feedstock. Limiting the feedstock's radioactive material concentration has multiple objectives

The primary objectives of the MAC are: to limit the retrofitting requirements for the facility, and to produce a metal product stream that can be rolled and fabricated at a commercial facility with limited radioactive material handling and regulation requirements and be reusable within the DOE complex.

Retrofitting the EAF facility for handling radioactive materials would be limited to some engineered and administrative controls on radioactive materials release. Primary engineered retrofits would be in the receipt handling of the radioactively contaminated scrap, slag handling and processing, and the off-gas handling system where HEPA filtration downstream of the baghouse would be required.

The metal product stream would have a low radioactive material content such that rolling and fabrication of the metal product stream could be performed at a facility with limited licensing requirements. It is assumed that rolling and fabrication would be performed at commercial facilities where the metal product's radioactive contamination levels would be regulated to a low level (based on risk) due to the small amounts of radioactive material present.

Assumptions

The primary assumption associated with this alternative is that a commercial entity will retrofit, and decontaminate, an existing EAF upon completion of the DOE metal recycling program. These activities would be funded through a metal recycling contract with the DOE that would provide sufficient funds to make this a commercially feasible project. Other specific assumptions are:

- The potentially contaminated radioactive metal would be segregated at the generating facility with metals that do not meet the MAC for the commercial facility (nominally 25% of all scrap metal, including remote handled scrap) being sent to a disposal or to a licensed RSM site. Some fraction would be disposed of at the generating site or at a commercial disposal site.

- The primary product streams are the metal product, slag containing refractory radionuclides (nominally ^{235,238}U for the EAFs), and radioactively contaminated baghouse dust. Very low concentrations of ^{239}Np and ^{239}Pu (0.6g ^{239}Pu from K25) may be present in the EPF steels.

- DOE would have administrative control of the product material.

- Contaminated metals could be transported in bags that could be dropped into the furnace for processing, thereby minimizing contamination.
- The total waste generated will be about 15% of the weight of the contaminated scrap metal processed. Wastes include:

- Slag waste stream of about 223 pounds per ton of liquid metal, containing essentially all of the $^{235,238}U$ from the EAFs. Based on the MAC, this waste stream would be low-level radioactive waste that could be disposed of either at the generating facility's onsite cell or at a commercial waste site.
- Baghouse dust, that will be a K061 mixed waste, will be disposed of at an appropriately licensed site.
- Refractory brick from the furnace will be changed twice per year and would be low-level radioactive waste.
- Spent pickle liquor, used for stainless steel production during the rolling process, would be mixed low-level radioactive waste.

- All waste will be accepted by DOE for disposal.

- Upon completion of the DOE processing program, the EAF would be decontaminated and decommissioned by the commercial facility owner/operator.

The six common elements for the EAF processing alternative would differ from the disposal and free release alternatives. The MAC would limit the radionuclide type and concentration of the metal feedstock for the EAF, whereas the disposal option would be less limited, and the quantity of metal suitable for free release would be less than that suitable for processing through the EAF. Both characterization and segregation issues would be similar to those encountered in the free release alternative. Transportation costs would be greater, as more of the contaminated steel would be transported to an off-site location.

Products

The primary product of this process is low-level radioactively contaminated metal that could be used for the production of metal within the DOE complex. Potential product examples are carbon or stainless steel that can be used for the fabrication of waste containers or coil/slab from the rolling mill.

Alternative 4

Recycle at a DOE Facility Using an EAF Moved to or Built at That Site

Description

An Electric Arc Furnace (EAF) system would be relocated or built at a regulated DOE facility where the contaminated metals would be processed for use within the DOE complex. The rolling mill and fabrication facilities may also be located at this site. The MAC, as discussed in the environmental feasibility section, will be defined that limit the radionuclide content of the feedstock. The purpose of limiting the feedstock's radioactive material concentration has several objectives.

Building or moving an existing facility to the DOE site would entail substantial costs for determining the facility's requirements. Primary engineered retrofits or design requirements for a new facility would be in the receipt handling of the radioactively contaminated scrap, slag handling and processing, and the off-gas handling system where HEPA filtration downstream of the baghouse would be required.

The metal product stream would have a low radioactive material content such that rolling and fabrication of the metal product stream could be performed at a facility with limited regulatory requirements. It is assumed that rolling and fabrication would be performed at commercial facilities where the metal product radioactive contamination levels in the metal would be at low levels, thus requiring limited regulation.

Assumptions

The primary assumption associated with this alternative is that a commercial entity will build or move an existing EAF to a DOE site. The building or moving costs would be significant as it is expected that a new building would be required to house the facility because DOE facilities are not designed to handle the large amounts of scrap metal that would be processed. Other specific assumptions, similar to those of Alternative 3, are:

- The potentially contaminated radioactive metal is segregated at the generating facility, with metals that do not meet the MAC for the DOE site and facility (nominally 15% of all scrap metal including remote handled) being sent to a disposal or a licensed RSM site.
- The primary product streams are the metal product, slag containing refractory radionuclides (nominally $^{235,238}U$ for the EAFs), and radioactively contaminated baghouse dust. Very low concentrations of ^{239}Np and ^{239}Pu (0.6g ^{239}Pu from K25) may be present in the EPF steels.
- Contaminated metals could be transported in bags that could be dropped into the furnace for processing, thereby minimizing contamination.
- The total waste generated will be about 15% of the weight of contaminated scrap metal processed, and all waste will be accepted by DOE for disposal.
- Wastes include:
  - A slag waste stream of about 223 pounds per ton of liquid metal containing essentially all of the $^{235,238}U$ from the EAFs. Based on the MAC, this waste stream would be low-level radioactive waste that could be disposed of either at the generating facilities onsite cell or at a commercial waste site.

- Baghouse dust, that will be a K061 mixed waste, would be disposed of at a site appropriately licensed for handling this type of waste.
- Refractory brick from the furnace will be changed out twice per year, and would be low-level radioactive waste.
- Spent pickle liquor, used for stainless steel production during the rolling process, that would be mixed low-level radioactive waste.

- Upon completion of the DOE processing program, the EAF would be decontaminated and decommissioned by the commercial facility owner/operator.

The six common elements for the EAF processing alternative would differ little from the commercial EAF alternative (Alternative 3). The MAC would limit the radionuclide type and concentration of the metal feedstock for the EAF. Both characterization and segregation issues would be similar to that encountered for the free release alternative. Transportation costs would be greater than the free release or disposal alternatives, as more of the contaminated steel would be transported to an off-site location. However, construction costs may be higher.

Products

The primary product of this process is low-level radioactively contaminated metal that could be used for the production of containers for use within the DOE complex. Specific product examples could be carbon or stainless steel feedstock that can be used for the fabrication of waste containers, or coil/slab from the rolling mill.

Alternative 5

Recycle at a New Commercial EAF Facility

Description

Recycling would be performed by a commercial company at an EAF that was constructed and licensed specifically for the purpose of processing low-level radioactively contaminated metals from the DOE complex. The EAF system would be built at a site chosen by the commercial company developing the facility. It is assumed that a long-term processing contract would be the basis for the development of this facility. The rolling mill and fabrication facilities may not be located at this site. MAC, as discussed in the environmental feasibility section, will be defined that limit the radionuclide content of the feedstock. The purpose of limiting the feedstock's radioactive material concentrations has multiple objectives.

Building a new facility at a commercial site would result in substantial costs to determine the facility requirements. Primary engineered design requirements for a new facility would be in the receipt and handling of radioactively contaminated scrap, slag handling and processing, and the off-gas handling system where HEPA filtration downstream of the baghouse would be required.

Assumptions

The primary assumption associated with this alternative is that a commercial entity will, in fact, build an EAF at a commercial site. Regulatory costs would be similar to those for the use of an existing, commercial EAF. Other specific assumptions, similar to those for Alternatives 3 and 4, are:

- The potentially contaminated radioactive metal is segregated at the generating facility. Metals that do not meet the MAC for the new facility (nominally 15% of all scrap metal including remote handled) would be sent to a licensed RSM site or disposed of.

- The primary product streams are the metal product, slag containing refractory radionuclides (nominally $^{235,238}U$ for the EAFs), and radioactively contaminated baghouse dust. Very low concentrations of ^{239}Np and ^{239}Pu (0.6g ^{239}Pu from K25) may be present in the EPF steels.

- Contaminated metals could be transported in bags that could be dropped into the furnace for processing, thereby minimizing contamination.

- The total waste generated will be about 15% of the weight of the contaminated scrap metal processed, and all waste will be accepted by DOE for disposal.

- Wastes include:

    - A slag waste stream of about 223 pounds per ton of liquid metal containing essentially all of the $^{235,238}U$ from the EAFs. Based on the MAC, this waste stream would be low-level radioactive waste that could be disposed of either at the generating facility's onsite cell or at a commercial waste site.
    - Baghouse dust, that will be a K061 mixed waste, would be disposed of at an appropriately licensed site.
    - Refractory brick from the furnace will be changed twice per year, and would be low-level radioactive waste.
    - Spent pickle liquor, used for stainless steel production during the rolling process, which would be mixed low-level radioactive waste.

- Upon completion of the DOE processing program, the EAF would be decontaminated and decommissioned by the commercial facility owner/operator.

The six common elements for this EAF processing alternative would differ little from the commercial EAF alternative (Alternative 3). The MAC would limit the radionuclide type and concentration in the metal feedstock for the EAF. Both characterization and segregation issues would be similar to those encountered in the free release alternative. Transportation costs would be greater than the free release or disposal alternatives, as more of the contaminated steel would be transported to an off-site location.

Products

The primary product of this process is low-level radioactively contaminated metal that could be used for the production of containers for use within the DOE complex. Specific product examples are carbon or stainless steel feedstock for the fabrication of waste containers or coil/slab from the rolling mill.

Alternative 6

Recycle at an Existing Radioactive Scrap Metal (RSM) Facility

Description

Existing RSM processing facilities licensed for radioactive metals processing would be used for the initial decontamination, with rolling and fabrication performed at commercial facilities. Recycling would be performed by a commercial company at an existing facility that was previously constructed and subsequently licensed specifically for the purpose of processing low-level radioactively contaminated metals from the DOE complex. This facility would either be modified or expanded, with the principal objectives to increase the quality of the product and production rates.

Assumptions

The primary assumption associated with this alternative is that a commercial entity will use an existing vacuum furnace or modify the facility at an existing commercial site. Licensing costs would be less, and the new license would primarily be a modification of the facility's existing license. Some specific assumptions for this facility are:

- The uses for the product from this facility may be limited if a vacuum induction furnace system is used.
- The low production output of current systems could be expanded to meet a limited DOE requirement.
- Existing nuclear licensing may limit both the time required for licensing and uncertainties associated with licensing a specific site.

The six common elements for this EAF processing alternative would differ little from the commercial EAF alternative (Alternative 3). The MAC would limit the radionuclide type and concentration of the metal feedstock for the Induction Furnace (IF). Both characterization and segregation issues would be similar to those encountered in the free release alternative. Transportation costs would be greater than the free release or disposal alternatives, as more of the contaminated steel would be transported to an off-site location.

Products

Specific product examples are carbon or stainless steel feedstock for the fabrication of waste containers or coil/slab the rolling mill likely produced at low volumes in current facilities.

Section 4 References

1. Evaluation of the Potential for Recycling of Scrap Metals from Nuclear Facilities, NUREG-1640, U.S. Nuclear Regulatory Commission, NUREG 1640
2. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575, U.S. Nuclear Regulatory Commission, December 1997.

5. Environmental Technical Feasibility of Alternatives for the Disposal or Recycle of DOE Contaminated Metals

Introduction

The environmental feasibility of alternatives for the disposal or recycle of DOE contaminated metals is addressed in this section. Specific issues include handling (for transportation, disposal, or recycle), facility contamination and cleanup, transportation, and potential radiation exposure to individuals who may come in contact with wastes and the metal product produced from recycle. The purpose of this section is to provide an overview of the environmental feasibility of each of the six disposal or recycling alternatives. The elements of the alternatives addressed include:

- The expected radioactive material contamination levels in the metal for the recycle options (includes radioactively contaminated material from the EPFs, RFs, and PPFs).
- Facility operations and the potential dose impact on workers, from initial contaminated material handling through use of the final recycle product within the DOE complex.
- Limits on the radioactive contamination in the material that would maintain facility contamination and radiation exposures at low and acceptable levels that meet the MAC.

The primary focus of this section is on the impact of the relative differences in the specific alternatives and their impact on technical feasibility

Radioactively Contaminated Metal Characteristics

This section summarizes the expected radioactive materials present and the radionuclide concentrations expected for feedstock to the various alternatives. As noted previously, the three potential sources of radioactively contaminated metals are: the Enrichment Processing Facilities (EPF), Reactor Facilities (RF) and the Plutonium Processing Facilities (PPF).

The radioactive scrap metal streams generally assumed to be present at each group of facilities, and that would be suitable for segregation and disposal or recycling, are the following:

- *Enrichment Processing Facilities* – The radioactively contaminated scrap metal streams from these facilities are primarily carbon steel, with limited amounts of stainless steel, and the nickel content of the converters. The radioactive contamination that is present is primarily surface contamination composed of particulate, depleted, natural, or enriched ^{235}U and long-lived ^{99}Tc that has concentrated in the converters as part of the enrichment process. Additionally, low levels of ^{237}Np and ^{239}Pu are also present. In all cases, this contamination is surface deposited material; however, if the contamination is trapped inside the component and is not easily accessible (for either physical abrasion or chemical decontamination), decontamination may not be practical or economically feasible. It has been estimated by facility staff at the EPFs, and for the purposes of this study, that of the total quantity of metals at the EPFs suitable for recycling, only about 50% is actually contaminated and that the remainder could potentially be released if it meets the requirements of the revised DOE Order 5400.5.

  Radioactive material contamination found on metals from the EPFs is expected to be variable depending on the facility and location where the metal was contaminated. However, the ^{235}U enrichment is expected to be relatively well known as most of the scrap metal from EPF facilities are from process sections only used to process very low enrichment uranium (nominally ≤ 3%). There is currently relatively limited information on the radioactive contamination levels expected for much of the scrap metal that might be processed. It is expected that most of the relatively small converters that contain high enrichment ^{235}U will likely be disposed of with no attempt at recycle. Consequently, the nominal maximum enrichment limit for most of the remaining uranium expected to be present is 3%.

Estimates of the quantities of ^{235}U, ^{99}Tc, ^{237}Np, and ^{239}Pu concentrations and inventories at the EPFs are primarily based on measurements performed at the Paducah site during a 1978 – 1982 plant cascade improvement project/cascade upgrade project (CIP/CUP). The equipment replaced during CIP/CUP was similar in design, operation, and enrichment levels at all three plants. For this analysis, the measurements from the Paducah equipment are considered representative for each GDP site.. The average concentrations and inventories estimated for the Paducah site are shown in Exhibit 5-1.

Exhibit 5-1. Radionuclide Content of Metals from the Paducah GDP[1]

Radionuclide	Average Concentration (ppb)	Average concentration (pCi/g)	Paducah Inventory (Ci)
^{235}U[2]	31,000	6.7E+1	0.19
^{237}Np	2.3	1.6	0.01
^{239}Pu	0.002	1.2E-1	0.001
^{99}Tc	17	2.9E+2	2.6

[1]Radioactive Contaminants in PGDP CIP/CUP Scrap Metal, KY/L-1225, October 1983.
[2]Uranium data was reported as elemental uranium content. For calculational purposes, it is all assumed to be ^{235}U

As shown in Exhibit 5-1, both concentrations and inventories are low with only trace amounts of ^{237}Np and ^{239}Pu present. Other data in KY/L-1225 suggest that the concentrations are localized, with the highest concentrations in the barrier tubes. Concentrations range over three to four orders of magnitude with most measurement data at the lower bounds.

Exhibit 5-2 lists the average contamination levels by metal type. These concentrations are based upon extremely limited data; however, these concentration data appear to be based on all the unclassified information currently available. Consequently, these data are assumed to be representative and bounding for the portions of the EPFs that may be recycled.

Exhibit 5-2. EPF Radioactive Material Concentrations by Metal Type [1]

Scrap Metal Type	$^{235,238}U$[2] (pCi/g)	^{99}Tc (pCi/g)	^{237}Np (pCi/g)
Steel	6.7E+1	2.9E+2	7.0E-1
Nickel	1.5E+3	4.04E+5	6.7E+1
Aluminum	1.2E+3	6.9E+2	2.1E+1
Copper	6.7E+1	2.9E+2	7.0E-1

[1]Radioactive Contaminants in PGDP CIP/CUP Scrap Metal, KY/L-1225, 1983.
[2]Assumed to be ^{235}U for calculational purposes.

- *Reactor Facilities*—Metal surface contamination is present at the RFs, and volumetric contamination that was induced by neutron activation of some RF components is also present. The primary long-lived radionuclides present as surface radioactive contamination on metals from the reactor facilities are ^{137}Cs, ^{90}Sr, and ^{129}I, with lower concentrations of other fission products and trace levels of transuranic radionuclides including ^{239}Pu. In addition, there is surface and volumetrically contaminated scrap metal that contains neutron activation products such as ^{60}Co, ^{59}Fe, and $^{59,63}Ni$. Of the RF radionuclides, some radionuclides (e.g., ^{137}Cs and ^{129}I) would be expected to volatilize and produce particulates in the off-gas that would have to be treated. Some RF neutron activation products would partition to the metal product from any EAF process, and would produce a contaminated metal product that is one of the primary concerns for processing contaminated scrap metal from this source.

Due to the wide range of radioactive material concentrations that might be present in steels from the RFs, maximum acceptable concentrations will be developed based on acceptable facility operational limits and worker doses. These data will be used to define the MAC for radioactively contaminated steels from the RFs. However, it must be assumed that the metal product would likely be contaminated with ^{60}Co and other neutron activation and fission products that would be expected to partition to the metal product.

- *Plutonium Processing Facilities*—The PPF sites are contaminated with transuranic materials that would be present on the scrap metal as surface contamination. The primary radionuclides present are $^{239,240}Pu$ and ^{241}Am. These radionuclides may be suitable for surface decontamination and would be expected to partition to the slag formed from EAF processing. Maximum acceptable concentrations for the feedstock metal would be developed based on acceptable facility operational limits and worker doses. These limits would be facility specific and highly dependent on the extent of both the engineered and administrative controls on contamination at the facility. These facility-specific data will be used to define a MAC for radioactively contaminated steels from the PPFs. However, other issues related to regulation, handling, worker safety, and environmental concerns make processing scrap metal from these facilities a problem that is generally not addressed in this feasibility study.

Facility Operations and the Dose Impact on Workers

The type of radioactive material present as contamination, and the concentrations present on the scrap metal, have a significant impact on numerous factors related to the processing of radioactively contaminated scrap metal for either disposal or recycling. Facility design and operational requirements may be quite different depending on whether the EPF, RF, or PPF radioactively contaminated metals are being processed. Primary factors that are affected include regulatory requirements, facility design, facility operations, and dose impact to workers. This section addresses the facility and operational issues for processing the various types of radionuclides present in the DOE Complex.

Facility issues for either the disposal or recycling of radioactively contaminated metals include transportation safeguards, waste acceptance criteria for a particular facility and worker radiation exposure limits. Facility issues have been divided into the following six categories:

a. Initial separation and packaging of steels for transportation to the facility including initial characterization for processing
b. Transportation to the processing facility
c. Facility contamination potential during processing and mitigation requirements
d. Handling and processing of effluents from the facility (e.g., baghouse dust and slag)
e. Metal processing at the rolling mill and fabrication facility
f. Use of the contaminated metals at DOE facilities

The following sections address each of these categories along with the potential dose impact to workers at each step. The radiological dose impact for each of the categories discussed are based on the critical–group dose factors developed in the Nuclear Regulatory Commission Report, *Radiological Assessments for the Clearance of Equipment and materials from Nuclear Facilities* NUREG 1640 Volumes 1 and 2.

Although some of the assumptions may vary from those used to develop the alternatives in the previous section, the models and assumptions used in this report are documented and are representative of the activities to be performed with several exceptions that are discussed. These data are used as a basis for estimating the relative dose impact on workers and to further develop the MAC for scrap metals to be processed at EAFs.

a. *Initial Separation and Packaging of Radioactively Contaminated Scrap Metal*—The initial separation by radioactive material content and packaging of the radioactively contaminated scrap metal is generally performed at the generation site. The process for clearing metal for release is well defined and includes characterization, segregation and independent verification steps prior to the release of radioactive metal per these criteria. The new revision of DOE Order 5400.5 will result in increased emphasis on characterization such that any scrap metals with detectable levels of radiation will not be suitable for release.

Of the metals within the complex, it has been estimated by EPF staff that about 50% of the potentially contaminated metals may meet the 5400.5 criterion and be suitable for free release. Of the remaining metals, a fraction (25%) will be unsuitable for anything other than disposal. These items include: smaller components with highly enriched uranium present, remote-handled neutron activated metals, and metals with a Greater-Than-Class-C (GTCC) designation. The primary groups into which the potential scrap metal would be segregated are:

- Uncontaminated (suitable for free release or processing for DOE use)
- Low-level radioactive contamination (suitable for processing for DOE use)
- High-level radioactive contamination (suitable for disposal only)

Of the metals with low-level radioactive contamination levels, some may be suitable for recycling. The characterization requirement for free release to the general public is expected to be the most rigorous; however, characterization for recycling will be done in two phases. The first phase will be in characterizing the metal for recycle (which may be more limited than that for free release), and then a second phase when the slag, baghouse dust, and product material is characterized for disposal or recycle. Although this characterization is expected to be relatively simple, as the slag and metal product are expected to be relatively homogeneous, the overall characterization efforts (phases 1 and 2) are probably similar to that for free release.

The radiation exposure to workers for segregation and packaging is expected to be similar for all scenarios except the disposal scenario, which may require a lesser degree of dismantlement and sizing (for onsite disposal), and less characterization than might be expected for the other alternatives. Use of the EAF alternatives allows the sizing required (5 ft. maximum dimension) to be minimized. This can result in a reduction in worker exposure as compared to other alternatives (e.g., disposal at a commercial site) where the maximum dimension is two feet. However, because of the wide range of radioactive material types and concentrations, it is not possible to define radioactive dose impacts for the segregation and packaging element, other than to suggest that the impact is probably similar for all alternatives.

As noted above, an assessment has been performed to evaluate the potential dose impact to workers and the general public for many of the aspects of disposal or recycling metals. This document, *Radiological Assessments for the Clearance of Equipment and materials from Nuclear Facilities,* NUREG 1640 Volumes 1 and 2, provides a basis for estimating the relative dose impact from radioactive material from activities related to disposal and processing. Critical group mass dose factors are used for comparison purposes, as they tend to be more conservative than the superficial dose factors.

Exhibit 5-3 presents the critical group mass dose factors for primary radionuclides found in the EPFs, RFs, and PPFs for the various processing activities to be performed. These data provide a method of estimating the relative radioactive dose impact of processing radioactively contaminated metals that are contaminated with different types and concentrations of radionuclides. The dose factors are based on the processing scenario described in NUREG 1640, which describes the scenario for processing contaminated metal through an EAF facility with a capacity of 500,000 tons/yr. This is ten times higher than the capacity of the EAF facilities proposed as part of this study and provides a conservative estimate of expected doses for activities that fall within the processing scenario described in the report.

For segregation and packaging, the dose factors (for scrap handling at the scrap yard) are highest for uranium and the transuranic radionuclides, which range from 1.1- 4.2 E-2 mrem/yr per pCi/g. In contrast, the dose factor for ^{99}Tc is five orders of magnitude lower, indicating that the dose from ^{99}Tc during handling is negligible. For the Paducah EPF average radionuclide concentration data (67 pCi/g), the radioactive doses to workers handling the radioactive scrap metal would be less than 1 mrem/yr, if doses from all radionuclides present in the scrap metal were summed.

For the ^{99}Tc contaminated nickel data in Exhibit 5-2 (4.04E+5 pCi/g) and handling of large amounts of scrap nickel (nominally 500,000 tons), the dose impact would be 0.48 mrem/yr. Consequently, for the purpose of scrap yard handling, doses from EPF metal processing can be considered essentially negligible. Projected doses from the RF facilities are expected to be lower than those from the EPFs for similar radionuclide concentrations, and those from PPFs would be similar for this handling activity.

b. *Transportation to the Processing Facility*—Transportation to the processing facility can have impacts on both the requirements for packaging and worker radiation exposures. Packages (nominally Sealand containers) will be large, and will be closed to prevent releases. Nominal dose impacts from the shipping of scrap metal, as indicated in Exhibit 5-3, are primarily from RF radionuclides (e.g., ^{60}Co and ^{137}Cs) that result in direct radiation exposure to the worker. Doses for handling EPF and PPF metals are lower for similar radionuclide concentrations and are expected to be negligible for the handling of EPF scrap metal.

c. *Facility Radioactive Contamination Potential during Processing and Radiation Exposures*—The potential for contamination of the facilities used for recycling is a factor that must be considered and depends on the type and quantity of radionuclides to be processed. Development of a facility for processing radioactively contaminated materials depends on a combination of engineered and administrative controls to minimize worker radiation exposures, contamination of the facility, and the release of radioactive contamination.

Exhibit 5-3. Critical Group Mass Dose Factors for Primary Radionuclides in Radioactive Scrap Metal—mrem/y per pCi/g[1]											
Scenario	Enrichment Processing Facilities			Reactor Facilities						Plutonium Processing Facilities	
	^{235}U[2]	^{239}Np	^{99}Tc	^{137}Cs	^{90}Sr	^{129}I	^{60}Co	^{59}Fe	^{63}Ni	^{239}Pu	^{241}Am
Scrap handling											
Scrap handling at scrapyard	1.1E-02	5.2E-02	1.2E-06	1.8E-03	1.6E-04	8.9E-05	8.1E-03	3.6E-03	3.6E-07	2.8E-02	4.1E-02
Transport of scrap metal	3.0E-03	2.3E-03	1.0E-06	2.3E-02	4.8E-06	0.0E+00	9.3E-02	4.1E-02	0.0E+00	1.7E-08	5.6E-05
Refinery operations											
Handling slag at refinery	1.3E-02	4.8E-02	6.3E-09	1.0E-06	2.2E-05	0.0E+00	7.8E-05	1.7E-04	2.1E-09	2.7E-02	4.1E-02
Handling EAF dust	8.1E-04	3.5E-03	4.8E-08	1.3E-02	1.1E-05	0.0E+00	6.7E-04	1.9E-04	1.4E-08	1.9E-03	2.7E-03
Refinery baghouse operations	5.9E-05	3.1E-04	1.6E-08	8.1E-04	3.1E-06	0.0E+00	3.4E-05	1.0E-05	5.9E-09	1.3E-04	2.4E-04
Handling refined metal prod at refinery	9.3E-06	4.4E-05	4.4E-07	2.4E-07	1.8E-07	0.0E+00	2.5E-04	7.8E-05	0.0E+00	2.4E-05	3.5E-05
Atmospheric release during refining	2.4E-04	1.1E-03	2.7E-08	5.9E-06	2.9E-06	2.3E-02	1.4E-05	1.3E-07	2.4E-09	5.9E-04	8.5E-04
Product Use											
Handling refined metal prod during distribution	4.1E-08	0.0E+00	3.6E-09	2.3E-07	5.2E-11	4.4E-10	2.4E-04	6.3E-05	0.0E+00	3.7E-12	2.6E-07
Vehicle constructed of metal product	2.7E-05	4.8E-05	2.6E-06	1.8E-04	3.7E-08	0.0E+00	2.0E-04	8.5E-03	0.0E+00	1.4E-09	5.2E-07
Proximity of large metal mass	1.7E-06	2.9E-06	1.5E-07	9.3E-06	2.3E-09	0.0E+00	9.6E-03	4.4E-04	0.0E+00	1.6E-10	3.7E-8
In proximity to small metal masses	3.0E-08	5.2E-08	2.7E-09	1.7E-07	4.1E-11	0.0E+00	1.8E-04	0.0E+00	0.0E+00	2.5E-12	6.7E-10

[1]Nuclear Regulatory Commission Report, *Radiological Assessments for the Clearance of Equipment and Materials from Nuclear Facilities* NUREG 1640 Volumes 1 and 2, (draft) March 1999.
[2]Dose factors are considered representative of those for ^{238}U

Engineered safety features at IFs or EAFs used to prevent radiation exposures are primarily focused on the major pathways where radioactive material would be distributed within a facility during scrap metal processing. These pathways are: the initial transfer from the storage container to the EAF, releases during refining, waste handling, and handling of the metal product from the facility.

Primary engineered effluent control features would be expected for either an EAF or induction furnace process. However, the extent of the engineered controls is expected to differ between the two and may be simpler for an induction furnace system, although this type of furnace is smaller than a typical EAF. The following list outlines the engineered effluent control features expected for either type of system:

- Processing spaces with minimal areas where contamination could not be easily removed or cleaned

- Negative pressure boundary where the scrap metal is unloaded so that airborne particulates are processed through the facility air treatment system

- Minimized mechanical disturbances during transfers to the furnace system to minimize radioactive particulate releases

- Enhanced off-gas treatment system that includes not only the current baghouse, but also a downstream HEPA filtration system with a nominal capability of removing 0.45-micron particulates

- Slag and baghouse handling equipment that minimizes worker contact with the material and enhances the ability to rapidly containerize it for disposal

In addition to these general engineered features, administrative controls would be required for worker dose monitoring and to provide the needed personal protective equipment for handling material where potential airborne radioactive contamination may be present.

Examination of Exhibit 5-3 for the EPF radionuclides indicates that the primary dose effects during EAF processing are from handling the slag containing the $^{235,238}U$. This is due to the refining process where essentially all uranium is concentrated in the slag. The dose effect for the average uranium concentration in the Paducah steels is negligible (0.87 mrem/yr). The dose effects of the ^{99}Tc are negligible for all aspects of the refining process. For ^{237}Np, which has lower concentrations in the Paducah steels, the dose effect would be 0.08 mrem/yr.

For radioactive materials from the reactor facilities, the highest dose factors are ^{137}Cs for handling the EAF baghouse dust (1.3E-2 mrem/yr per pCi/g) and the atmospheric release of ^{129}I due to refining; however, the quantities of ^{129}I are very low in any type of scrap metal to be processed. For neutron activation products, ^{60}Co is the highest at about 10^{-4} for several activities including handling the refined metal. Consequently, these dose factors would be considered limiting with respect to the development of the MAC.

In the case of the PPFs, the limiting factors is the slag handling at the refinery, with much lower dose factors for other handling processes that may contain very low concentrations of these radionuclides.

d. Handling and Processing of Effluent—As discussed above, the primary issue with respect to the entire refinery process is the handling and processing of effluents, with relatively little impact from handling the metal product from the facility. These dose factors are limiting to the use of the facility for processing metal streams from DOE facilities.

e. Metal Processing at the Rolling Mill and Fabrication Facility—Metal processing at the rolling mill and the fabrication facility is perhaps the most limited process from a regulatory and radiation dose impact point of view because it is proposed that these facilities be subjected to a very limited degree of regulation and administrative controls on worker radiation exposure. The proposal is to use a currently operating facility and limit the radionuclide content of the feedstock to these facilities to keep radiation exposures below levels that would require extensive monitoring. This can easily be done because each batch of metal processed through a refinery would be analyzed, and then a determination made whether the material meets the acceptance criteria for rolling and fabrication at that facility. Shown earlier, Exhibit 5-3 lists the dose factors for handling the refined metal product and the exposures that might be expected from proximity to a relatively small metal mass of the refined metal, a relatively large amount of metal, and the use of a car constructed of metal partly composed of the contaminated metal.
In all cases, for the documented scenarios in NUREG 1640, the calculated doses are very low for the handling of the refined metal product at the refinery and during its distribution. For the EPFs the key

radionuclide of concern for the metal product is the ^{99}Tc that would be present. If the maximum dose factor for metal handling (4.4E-7) is applied the expected radionuclide concentration in the nickel from the converters, the maximum dose would be 0.18 mrem/yr. This value has a number of highly conservative assumptions applied. They include the facts that the high ^{99}Tc concentration in the nickel is applied to all of the scrap metal processed through the facility and that the product is produced at a rate of 500,000 tons/yr. Consequently, for all handling and use of ^{99}Tc contaminated steels, this would be considered to a conservative dose impact. It should be made clear that the assumptions used to generate this dose factor are not representative of all activities performed during rolling and fabrication because during cutting and welding there may be potential for particulate production and inhalation. A dose scenario has not been developed for cutting and welding activities, although it is being investigated. For calculational purposes, the maximum critical dose identified in the EAF process will be used to determine the MAC for EPF metals.

f. Use of Contaminated Metals at DOE Facilities—Although there are no specific dose scenarios for the use of contaminated metals at DOE facilities, three scenarios in Exhibit 5-3 provide some bounding data on uses. These scenarios are the proximity to large and small metal masses and the vehicle constructed of the metal product. As indicated in the table, the highest exposure scenario is the vehicle constructed of the metal product. The dose factors for the EPF radionuclides range from about 2.6E-6 to 4.8E-5. In contrast, the dose factors for the RF generated radionuclides are much higher ranging up to 2.0E-1 for ^{60}Co. Consequently, the doses from the metal products from the EPFs are expected to be the most benign, and allow the highest concentrations of radioactive materials to be processed through the facility. In all cases, the dose from the use of the metal products from the Paducah plant would be well less than 0.1 mrem/yr.

Contaminated Metal Acceptance Criteria

Acceptance criteria are needed for radioactively contaminated metals to be processed through refinery facilities that would remove some radioactive constituents, thereby allowing the product metal to be used within the DOE complex. Primary criteria that must be addressed include worker exposure at all steps in the process, special nuclear material accountability, and criticality safety where fissile materials are being processed. The approach proposed for developing the metal acceptance criteria is to determine worker radiation exposures at the various process steps, and then use these data to determine the acceptable radionuclide concentrations in the feedstock.

The radioactive scrap metal process stream from the EPF's perhaps presents the best scenario for processing because of the decontamination of the metal product stream at the refinery. In this case, it is assumed that about 1% of the uranium and neptunium is partitioned to the metal product (this is considered to be a relatively conservative value) with the balance becoming waste as baghouse dust and slag. Approximately 95% of the ^{99}Tc is assumed to partition to the metal product, with the balance in the slag. The highest dose during processing is from ^{235}U during slag handling; however, since the refinery EAF is expected to be a nuclear facility, worker exposures are expected and would be administratively controlled. If the Paducah concentration data are considered representative of the EPF steels, the maximum radiation dose based on the NUREG 1460 scenario would be less than 1 mrem/yr with lesser doses from the ^{237}Np and ^{99}Tc.

Consequently, the primary limiting factor for the MAC is the dose to workers, and contamination of the rolling mill and fabrication facilities. Although a dose scenario for rolling plant personal and welding during fabrication has not been developed, the long-term exposure scenarios in Exhibit 5-3 provide an indication of the expected radiation exposures during this process. In the maximum exposure scenario (e.g., a vehicle constructed of the metal), the total dose from the Paducah scrap metal would be less than 5.0 E-3 mrem/yr, with the dose dominated by the trace amount of uranium that would still be present in the metal product. This would suggest that higher concentrations of uranium contaminated steels (10^2 higher) could be processed without exceeding a MAC limiting dose of 1 mrem/yr at the rolling mill and fabrication facility. Doses to end users of the metal would also be inconsequential. Therefore, relatively wide variations in the radionuclide concentrations in the feedstock could be accepted without affecting the quality and usefulness of the product. The uncertainty in this scenario is what the contributions from cutting and welding during the process may be, although the concentrations in the metal product are low. An assessment of this scenario is being performed.

The secondary issues to be addressed are the Special Nuclear Material (SNM) accountability and criticality issues. The data from Paducah are being used as representative data for ^{235}U content of the metals to be processed through the facility. If an individual EAF charge is 50 tons of contaminated scrap metal, the total ^{235}U content at 3% enrichment (which is appropriate for most contaminated metals at the GDFs) is about 41g per charge. The Paducah ^{235}U concentration data is assumed to be quite high for much of the scrap metal suitable for refining. Consequently, approximately six charges of slag (where most of the uranium is concentrated) could be kept onsite. The low concentrations in the product steels are not expected to significantly affect the site ^{235}U inventory for criticality purposes.

The fact that the EAF is a batch process would allow the ^{235}U containing slag generated from the EAF process to be removed to a secured site on a batch basis. An alternative approach for higher enrichment contamination would be to use administrative controls to keep the average scrap metal stream to be processed at a fraction of the 350g limit for a facility without a higher degree of SNM controls. These same limitations apply to criticality issues, which would be addressed via the same approach.

In the case of the RFs, the ^{60}Co content of the metal product, that would limit the amount of material that could be processed, would also limit the MAC. For the maximum user dose scenario (a vehicle constructed of the contaminated metal product), the maximum ^{60}Co concentration in the scrap metal to be processed at 1 mrem/yr would be 5 pCi/g, which is a low concentration below detectable levels for current handheld characterization methods. The PPF scrap metal limits would not be as low as the RF's but would primarily be dependent on potential airborne particulate releases during rolling and cutting operations.

Conclusions

The primary conclusion of the assessment of environmental technical feasibility is that although radioactively contaminated, metals from the EPFs, RFs, and PPFs could be processed. Also, the radiation dose impacts to workers either for disposal or recycle are similar for the radioactive materials from the three types of facilities. However, the engineered and administrative controls required to process contaminated scrap metal from the three types of facilities vary significantly. The processing scenario producing the most limited requirements for the processing of the radioactive scrap metal is the metal from the EPFs. This is primarily due to the fact that these facilities are contaminated with only a few radionuclides with well-defined characteristics (e.g., low volatility) during refining operations. Consequently, most radioactive material with high dose effects is expected to be concentrated in the slag or in the baghouse dust, whereas the product steel would essentially meet current guidance from the NRC and IAEA on free-release for unrestricted reuse.

6. Evaluation of the Health and Safety Considerations Associated with a Dedicated Melting Facility Receiving Radioactively Contaminated Metal from Gaseous Diffusion Plants

Introduction

This section assesses the potential health and safety implications of the six alternatives for the disposal/recycle of metals from the DOE complex. The emphasis is on the recycle options because the health and safety effects from disposal are relatively well known and can be estimated based on current data published elsewhere. Subjects herein addressed include the personnel radiation exposure pathways, from demolition through stainless steel box fabrication.

As part of the effort to produce weapons grade uranium during World War II, the United States researched three methods to separate and concentrate the fissile uranium isotope, ^{235}U (natural abundance 0.711%), from the more abundant non-fissile uranium isotope, ^{238}U (natural abundance 99.27%). These methods were gaseous diffusion, electromagnetic diffusion, and thermal diffusion. The gaseous diffusion method was selected because of its superior ability to produce large amounts of uranium enriched with the ^{235}U isotope.

In the gaseous diffusion process, uranium metal that has been chemically converted into the gas uranium hexafluoride (UF_6) is pumped through porous nickel diffusion barriers. The ^{235}U, UF_6 molecule has less atomic mass and thus has a greater ability to diffuse through the barrier than the ^{238}U, UF_6 molecule. By collecting and segregating the streams of diffused and non-diffused UF_6 gases, a stream of UF_6 enriched in ^{235}U is produced. However, because the degree of separation is very low for each pass through the diffusion stage, gaseous diffusion plants consists of thousands of diffusion stages. The DOE gaseous diffusion complex, which consists of plants at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio has approximately 11,000 diffusion stages.

The Atomic Energy Act in the early 1950s expanded the mission of DOE gaseous diffusion plants to produce fuel for commercial nuclear-fueled electric power stations. In the 1980s and 1990s, the reduced need for commercial power station fuel and the end of the Cold War reduced the need for enriched uranium. In 1985, DOE terminated separation and enrichment activities at the Oak Ridge plant and started decommissioning activities. In 2001, enrichment activities at the Portsmouth plant will cease. The D&D of the gaseous diffusion process facilities will generate substantial quantities (approximately 867,000 tons) of scrap carbon steel, copper, aluminum, and nickel over the 30+ year span of the D&D process. A large fraction of this scrap will be radioactively contaminated with ^{235}U and ^{238}U. Other radionuclides that will be present include technetium (^{99}Tc), neptunium, and possibly plutonium.

The largest quantity of metal, that contains the least hazardous radionuclides and activities, is that from the separation and enrichment facilities. This material appears to be the best candidate for dedicated recycling.

Since the bulk of the metal is carbon steel and nickel, the feasibility study has focused on products that could be made using commercially available technologies (e.g., electric arc and induction furnaces). A third available technology, the basic oxygen process was judged not suitable for this project because of a need for large furnace sizes capable of processing 200 to 300+ tons per batch. Whatever steelmaking method is chosen, the process must be able to oxidize the uranium, extract it from the metal, and fractionate it into the slag and dust. This is necessary to reduce the potential for personnel exposure during the melting and refining phases, the product manufacturing processes, and the handling and use of the final products.

Carbon, stainless, and specialty steels are routinely made in electric arc furnaces. Induction furnaces are not currently used on a commercial basis to make carbon or stainless steels because of their size and technical limitations (see Appendix A for a description of these two processes). Both furnace options are discussed in this section.

Potential Personnel Exposure Pathways

General Considerations

In assessing the potential exposure to personnel or the release of radioactivity to the environment, three radionuclides— ^{235}U, ^{238}U, and ^{99}Tc—must be considered for the EPFs. All will be found as an oxy-fluoride contaminant on the surface of the nickel and scrap carbon steel metals. Because of differences in the relative surface area of nickel and carbon steel process components, a significant majority of the contamination will be found on the nickel. In addition, the nickel will have to be released from security restrictions prior to leaving the DOE site. Nickel is necessary only if the dedicated melting facility produces stainless steel or other high-nickel alloy specialty steels.

When the carbon steel and nickel are melted, the uranium oxy-fluorides will preferentially partition to the oxide slag, while the technetium oxy-fluoride will reduce to a metal and alloy (within the nickel and iron) as volumetric contamination. The ^{99}Tc radionuclide has a radioactive half-life of 2.1E5 years and decays by beta emission to a stable ruthenium isotope, ^{99}Ru. The maximum energy of the beta is 294 keV, with an average energy of 85 keV. Metallurgically, technetium has a high probability of remaining in the metal when melted under the conditions found in an electric arc or induction furnace, with minimal fractions going to the dust or slag (EPA 1997). The maximum range of this beta in air is approximately 26 cm. The maximum range in steel is 0.01 cm, and 0.05 cm in calcium oxide (a major constituent of baghouse dust, along with iron oxide). Thus, it is unlikely that the ^{99}Tc will cause significant personnel dose exposure unless it is inhaled or ingested.

If ingested or inhaled, the technetium is likely to be in an insoluble form, thus the major organs of concern would be the lungs and large intestine. These scenarios can be controlled by using engineered systems (e.g., enclosed rooms with HEPA exhaust filtration, local exhaust systems with HEPA filtration, and anti-contamination clothing and respiratory protection) should air sampling indicate a need. Data obtained from analyses of nickel ingots produced at the Paducah Gaseous Diffusion Plant indicate that the ^{99}Tc contamination within the nickel could exceed the limits of 5,000 and 15,000 (average and maximum) disintegrations per minute per 100 square centimeters as found in DOE Order 5400.5 for the free release of material.

The uranium isotopes (^{235}U and ^{238}U) will be found on the nickel and diffusion process vessels and piping. ^{235}U has a half-life of 7.0 E8 years and is the parent of a series that decays by both alpha and beta emission, ultimately ending in the stable lead isotope ^{207}Pb. There are several gamma emissions in the series, starting with ^{235}U as well as ^{227}Th, ^{223}Ra, ^{219}Rn, ^{211}Pb, and ^{211}Bi. These make ^{235}U, in equilibrium with its decay products, a potential source of external gamma exposure to personnel handling slag and furnace dust.

Most uranium oxy-fluoride isotopes will partition to the slag (95% to 97%), with no more than 3% to 5% remaining in the metal or going to the dust (EPA 1997). Uranium has a very low probability of remaining in the metal, provided the metal is slagged during its refining phase. Sufficient slagging occurs in an EAF as a normal function of its steelmaking process. In the case of an induction furnace, oxygen must be added to assure the uranium is removed to the slag and remains there.
Using a 50-year time interval, ^{235}U will still be present at 0.9998 of its initial activity. However, the decay products will be reduced to approximately 0.001 of the ^{235}U activity. If one assumes the ^{235}U was

present at the unrestricted release limits found in DOE Order 5400.5 (5000 dpm/100 cm^2), the activities of the decay products will be approximately 5 dpm/100 cm^2. This is well below the limits for even the most restrictive radionuclides in DOE Order 5400.5—100 dpm/100 cm^2 (average fixed) and 20 dpm/100 cm^2 (removable). This concentration translates to approximately 4 x 10^{-5} Bq/g for each 100 cm^2 area, assuming a thickness of 2.5 cm.

If ingested or inhaled, the ^{235}U is likely to be in an insoluble form, thus the major organs of concern would be the lungs and large intestine. If the uranium is in a soluble form, the kidneys and bone become the areas of concern. Soluble ^{235}U presents a potentially more hazardous scenario than what is present with the insoluble form or with the ingestion or inhalation of ^{99}Tc. These scenarios can be controlled by using engineered systems such as enclosed rooms with HEPA exhaust filtration, local exhaust systems with HEPA filtration, and anti-contamination clothing and respiratory protection, should air sampling indicate a need.

^{238}U will be found as surface contamination in the diffusion vessels and piping. It has a half-life of 4.5 E9 years and is the parent of a series that decays by both alpha and beta emission, ultimately ending in stable ^{206}Pb. Gamma emissions tend to be weak with a low probability of occurrence until the series reaches ^{226}Ra and its decay products. The exception is ^{234}Th, the first decay product, that has a 90 keV gamma occurring 10% of the time. Since ^{234}Th has a 24 day half-life, it will produce a low level gamma exposure rate. However, in the 50-year time frame assumed for this analysis, the relative activity of ^{226}Ra and its decay products will only reach 7.0 E-10 of the activity of the parent ^{238}U. Thus, the potential for external exposure to personnel handling slag and furnace dust contaminated with ^{238}U is low, but likely detectable. Unlike ^{235}U, which will be in a steady state of decay in 50 years, the ^{238}U series requires more than a million years to reach equilibrium with ^{226}Ra and its decay products. Using a 50 year time interval, ^{238}U, ^{234}Th, and ^{234m}Pa will still be present at their initial activity. Beyond ^{234m}Pa, the relative activities decrease significantly. ^{238}U and several of its decay products are alpha emitters, with the rest being beta emitters.

If ingested or inhaled, the uranium is likely to be in an insoluble form. Therefore, the major organs of concern would be the lungs and large intestine. If the uranium is in a soluble form, the kidneys and bone become the organs of concern. This would present a potentially more hazardous scenario than what is present with the insoluble form or with the ingestion or inhalation of ^{99}Tc. However, because the more hazardous decay products will not be abundant, ^{238}U in this situation presents less of an internal hazard than ^{235}U. Exposure scenarios can be controlled by using engineered systems (e.g., enclosed rooms with HEPA exhaust filtration, local exhaust systems with HEPA filtration, and anti-contamination clothing and respiratory protection) should air sampling indicate a need.

Demolition Activities

It is assumed that full characterization will be performed prior to any demolition work to establish estimates of the existing contamination levels and the radionuclides present. These surveys would be used to develop the required health and safety protection plans to be employed during the demolition phase of the project. The survey data should include external exposure rate measurements, removable contamination measurements, fixed contamination measurements, and radionuclide identification. Contamination measurements should address both alpha and beta emissions.

It is assumed for this analysis that demolition would be conducted by contractors familiar with demolition processes, and that standard DOE orders will be in place governing the radiation safety aspects of the demolition. It is further assumed that the typical methods of dismantling large industrial facilities will be employed (e.g., torch cutting, abrasive cut-off wheels, and unbolting). The first two methods have the potential to generate airborne contamination, as does the entire dismantling process, including dropping and moving material by cranes and mobile equipment. It is anticipated that protective clothing, personnel respiratory protection, and localized exhaust systems with HEPA filtration will be necessary. A calculation made for demolition personnel exposed to external beta and gamma radiation shows the likely worst case scenario would be less than 100 mrem per year.

Workers who may potentially receive a radiation dose during these activities are:

- Radiation survey team personnel
- Demolition personnel
- Truck drivers & maintenance personnel
- Mobile equipment operators
- Mobile equipment maintenance workers
- Grit blasting personnel

Continuous air sampling, surface contamination smears, and direct measurements should be performed on typical activities during the demolition process, with consideration given to protective clothing to prevent personnel contamination and respiratory protection. It is possible that the scrap will have to be loaded into sealed transport containers. This will significantly slow down the loading process, which is usually performed using magnets and grapples.

Radiation protection and HAZMAT training will be required for all workers. Radiation safety training is likely to require at least an eight hour annual course, and HAZMAT training could require an initial 40 hour course with annual refresher courses of eight hours.

Steel Plant Activities

Scrap Handling

The radioactively contaminated scrap will be transported in closed containers and handled only in enclosed buildings having contamination control systems and HEPA filtered exhausts to limit the potential of spreading contamination and lower the cost of final decontamination at the end of decommissioning. This will impact the delivery rate of the scrap. Commercial steel mills have the ability to receive between 200 and 2,000 tons per day via truck and rail delivery. If the restrictions stated above are instituted, their capacity could be reduced to one-half or one-quarter of these levels.

At a steel mill facility handling non-radioactive material, scrap is typically received in open or tarp covered trucks and rail cars. Depending on the quantity, location, and unloading capabilities, barge transport is also possible. In the case of truck transport, the scrap is normally dumped directly on the ground. It is not typical to have paved beds under the actual scrap piles, but paving (either concrete or asphalt) is present for the roadway approaches to the scrap piles. Depending on the size of the facility and the amount of scrap desired, the scrap may either be kept in a roof covered structure or otherwise be exposed to the elements; the latter practice is most common. Rail transported scrap is transported in open rail gondola cars, unloaded by either magnet or grapple upon arrival at the steel plant, and stored like truck-delivered scrap. Rail cars may be sent directly to the melt shop, where the scrap can then be charged into the furnace's charge buckets from the rail cars.

For barge transport, scrap is typically carried in open barges, unloaded by either magnet or grapple upon arrival at the steel plant, loaded into trucks or rail cars, and handled as if the material arrived directly by truck or rail. Workers having a potential of receiving a radiation dose during these activities are:

- Scrap handling and preparation personnel

- Plant maintenance personnel
- Truck drivers/maintenance personnel

Continuous air sampling, surface contamination smears, and direct measurements should be performed on typical activities during scrap handling at the plant, with consideration given to protective clothing to prevent personnel contamination and provide respiratory protection. If the scrap has been loaded into sealed transport containers, there could be a delay in the initial unloading. However, once the scrap is unloaded, it can be handled in a normal fashion, provided the handling is conducted within enclosed buildings that have HEPA filtration systems.

Radiation protection and possibly HAZMAT training will be required for all workers. Radiation safety training is likely to require at least an eight-hour annual course, and HAZMAT training could require an initial 40-hour course with annual refresher courses of eight hours.

Melt Shop

Workers are present around the furnace during its loading and operation. In the case of an EAF, a high potential exists for the resuspension of contaminants during the loading of charge buckets and the charging of the furnace, as metal oxide fumes during the melting and refining phases, as fumes during the tapping of the furnace's molten metal into a ladle, and during slag tapping. Once the metal has been tapped into the ladle, there is minimal potential for the resuspension of radioactive materials unless ladle mixing or ladle metallurgical practices are employed. In these cases, additional potential (although significantly reduced) will exist for the suspension of particulate matter. Ladles are generally covered to prevent heat loss and the oxidation of the steel's surface layer. Commercial EAFs have not had to demonstrate the effects on furnace operations, production, or the efficiency of HEPA filtration resulting from the control of airborne radioactivity. However, similar controls have been added to EAFs to control toxic fumes, and the extension to radioactive materials does not appear significant.

In an induction furnace the potential for airborne dust generation is dependent on whether the furnace is a vacuum or open furnace. Open furnaces, especially air- or oxygen-injected furnaces, are similar to an EAF in the rate of dust production during the melting and refining phases. The total mass of dust will be similar to what is produced in an EAF of the same size. Charging scrap into the furnace is likely to have a lower potential for airborne dust generation if it is done on a piece-by-piece basis. This is also true for vacuum induction furnaces. Vacuum induction furnaces also have a negligible potential for airborne dust generation during melting and refining because they are sealed. Existing air induction melting furnaces (AIM) and vacuum induction melting furnaces (VIM) that process radioactive scrap metal have HEPA filtration systems to control the potential of personnel exposure and the environmental release of airborne radioactivity.

The melting facility could employ either a pressure caster to convert the molten metal into a slab that would then be rolled into plate, from which the containers would be fabricated, or use ingot casting. In both cases it is likely reheat furnaces will be required. If ingots are cast, the ingot will have to be rolled into a slab, bloom or billet, depending on the final product desired.

If ingots are cast, the ingot molds should be bottom cast or top cast using a snorkel to reduce the potential of airborne dust generation and molten metal spillage that occurs in open top ingot casting. Workers preparing the ingot molds should be issued personnel dosimeters and anti-contamination clothing. Air monitoring should be performed to determine if respiratory protection is necessary.

In a pressure caster, the ladle containing the molten steel is placed in a vessel that is sealed with a lid containing an insulated vertical tube called a snorkel. The snorkel mates with an opening in a machined graphite mold. Once all connections are made, pressure is applied to the ladle and the molten steel is pushed up the snorkel into the graphite mold. An opening (riser) is present for the escape of air from the mold. This riser should be fitted with a HEPA filter to capture any contaminated fumes or escaping gas. Once the slab solidifies and is removed from the mold, the sprue from the riser is removed using an automated cutting torch. This is usually an unmanned process and should be modified with a localized exhaust collection system that has a HEPA filter. The interior surface of the graphite mold is usually machined to restore its surface after a few hundred casts. If the metal is radioactively contaminated this process will have to be monitored and controlled to stop the spread of contamination. Alternatively, the entire pouring operation can be conducted in a HEPA-filtered environment.

In both pressure cast slabs and ingots, scale is created on the surface of the steel that is usually removed using water sprays. The water and scale are transported via flumes to a scale pit where the scale settles to the bottom, and the water is then filtered and recycled. Consideration will have to be given to the potentially contaminated scale and filter media in addition to the protection of workers who handle the scale and filter media.

Workers who have a potential of receiving a radiation dose during these activities are

- crane operators,
- furnace/melt shop workers,
- plant maintenance workers, and
- scale pit workers.

Melt shop workers and overhead crane operators are likely to have the greatest potential for internal exposure from airborne fumes and resuspended dust during bucket and furnace charging, furnace tapping and slagging, or casting operations. Crane cabs should be engineered to prevent the influx of fumes, and air conditioned to reduce the likelihood of keeping the cab doors opened. If the furnace is not enclosed in a separate room, it will need a localized HEPA-filtered exhaust system capable of collecting resuspended particulates during furnace charging, melting, and refining to prevent the spread of low level contamination throughout, and outside, the melt shop. This is one area where there is likely to be a difference between a commercial facility and a DOE-controlled facility. In a commercial facility sufficient measures would be taken to keep the contamination below a level that would require decontamination at the end of the plant's useful life. However, it appears that the DOE will consider decontaminating everything showing detectable radioactivity. This will significantly increase the cost for fume collection systems.

Personnel cleaning scale pits and plant maintenance workers have the greatest potential for exposure to surface contamination. These workers are likely to require anti-contamination protective clothing (e.g., Tyvek coveralls, rubber gloves, and boots). Respirators may not be necessary, however this need would be determined from air sampling data. External doses should be minimal (less than 1 microrem per hour) from the technetium because of its low beta energy and low potential to generate bremsstrahlung x-rays. The external dose potential from ^{235}U contamination present on the scrap or slag is less than 1 microrem per hour. Assuming a 25% occupancy rate close to the furnace and charge bucket loading areas, this would calculate to approximately 4.0 mrem per year. The external dose potential from ^{238}U is lower by a factor of 10 compared to ^{235}U.

Radiation protection will be required for all workers. Radiation safety training is likely to require at least an eight-hour annual course.

Slag Workers

The high melting and boiling point of uranium limits its potential for vaporization. This, along with its metallurgical chemistry, results in nearly all of the uranium fractionating to the slag (95 to 99%). Once the slag is tapped into the slag pot, there is little potential for the resuspension of radioactive material. The slag will cool and become rock-like, incorporating the radioactive material, and not have a potential for significant dust creation until it is processed or handled using heavy equipment. Slag is also generally sprayed with water for dust suppression. Since slag is not typically handled by personnel, but rather moved by conveyors and heavy equipment, the closest occupancy and highest occupancy rates are likely to be incurred by maintenance personnel working on the conveyor systems and heavy equipment. If the assumed scrap quantity contaminated with ^{235}U is charged to the furnace, it has been calculated that the dose rate at two meters from the slag will be slightly less than one microrem per hour (0.8). A high occupancy rate for these activities would be 25%. At this rate the maximum annual dose would be 0.4 mrem. Assuming that all slag will be disposed of as radioactive waste, there will likely be no external dose to members of the general public. The handling of the slag by heavy equipment and conveyors will result in a reduction in the slag's particle size and increase the potential for radioactive material suspension. It is likely the entire slag operation may have to be enclosed, or at least the heavy moving equipment cabs, to keep out suspended particulates. If slag handling and moving is conducted outside an enclosure, it should be done on a paved surface to help prevent the spread of contamination and facilitate decontamination. This is another area where there is likely to be an increased cost for a DOE controlled site, as compared to a commercially licensed facility.

An obvious potential exists for both external and internal dose exposure to workers loading the slag into containers for disposal. The internal exposure potential from this activity can be controlled by good engineering of the loading system, with a localized HEPA-filtered exhaust system and respirators to capture any dust generated. External doses are 1.6 mrem per year, assuming a 100% occupancy rate. Personnel contamination can be controlled using anti-contamination clothing. Continuous air sampling is recommended for this activity.

Radiation protection and HAZMAT training will be required for all workers. Radiation safety training is likely to require at least an eight-hour annual course, and HAZMAT training could require an initial 40-hour course with annual refresher courses of eight hours.

Exposure potential also exists for personnel loading the containers onto trucks for shipment to the disposal site. Doses for this activity will be well below the two mrem per year estimate for the previous scenario. Truck drivers (if this mode of transportation is used) transporting the loaded containers to the disposal site could receive a dose rate of around one to two microrem per hour.

Plate Mill/Shear/Crane/Forklift/Loading Dock/Maintenance Workers

The proposed melting facility may incorporate a rolling mill to produce plate for fabrication into waste containers. Rolling mills are usually automated and have a low occupancy rate within a few meters of the metal being rolled. Because of the potential for low level contamination, rolling as well as fabrication should be performed at the same location. This will reduce the potential for personnel exposure and contamination at multiple sites, and decrease the ultimate decommissioning costs to DOE at the end of the facility's useful life.

Once the metal is cut into its desired size by a shear, it will likely be moved using overhead cranes or forklifts. As in the case of the rolling mill and shear operators, it is unlikely these personnel will be within two meters of the metal for more than a few hours each day. Maintenance workers repairing mill equipment are even less likely to be exposed to the metal, and would have an even lower external dose potential than other workers. Based on the metallurgical fractionation potential for the three radionuclides, only ^{99}Tc has a potential for being present in the metal at any appreciable quantity. However, uranium contamination cannot be totally ruled out if the DOE uses methods designed to detect extremely low level contamination. The only likely exposure potential from the ^{99}Tc would be from bremsstrahlung within the metal. This has been calculated to be non-detectable (less than 0.001 microrem per hour). The annual dose estimate is less than one microrem at 25% occupancy within two meters. There is a low potential for ^{99}Tc contamination, and as such, workers should wear anti-contamination clothing. Airborne activity is not expected to be detectable. It is unlikely that there will be uranium contamination, but any protective measures taken for technetium should suffice for uranium. Radiation protection will be required for all workers. Radiation safety training is likely to require at least an eight-hour annual course.

Baghouse Operations

Metal oxide fumes generated during melting and refining in an EAF are usually collected in a baghouse. The fume laden air is drawn under vacuum into the plenum of the baghouse, from which it is directed to one section containing bags that filter the fume as the air passes through them. Periodically the fumes are blown from the bags by reversing the air flow or shaking the bags, dropping the dust into a tapered collection bin. The bins empty into a screw conveyor that carries the fume dust to a central unloading point used to load trucks. Baghouse dust will likely contain some low level ^{99}Tc and uranium not alloyed with the metal or fractionated to the slag. It is common to have spillage from the screw conveyors and the truck loading silos and filling tubes. This may require the baghouse and truck loading operation to be enclosed to prevent environmental releases.

There is a need for workers to enter the baghouse to change bags, clean the various chambers, and perform maintenance. Annual external doses are expected to be non-detectable based on a conservative 25% occupancy rate (0.1 microrem). Internal exposure is controlled by means of protective clothing (e.g., Tyvek coveralls, rubber boots, gloves) and respiratory protection. Personnel at risk include

- craft workers maintaining the baghouse,
- personnel cleaning and replacing the bags,
- personnel replacing the HEPA filters,
- personnel unloading the baghouse dust into trucks, and
- truck drivers.

In the case of unloading operations, the potential risk of exposure can be controlled by means of an enclosed local exhaust system with no internal occupancy once the unloading commences. Continuous air monitoring is recommended.

All three radionuclides are not likely to significantly fractionate to the dust during melting and refining (1% to 5%). The external dose potential would be greatest from the ^{235}U, and calculates to less than 0.001 microrem per hour using a concentration of 11.3 pCi/g. ^{238}U has a dose rate of one-tenth that of ^{235}U, while ^{99}Tc has a dose rate almost 5,000 times less than that of ^{235}U.

The baghouse dust may contain enough heavy metals to qualify as an EPA listed hazardous waste (K061). If this is the case, radiation protection and HAZMAT training will be required for all workers. If the dust does not qualify as K061, only radiation safety training is necessary. Radiation safety training is likely to require at least an eight-hour annual course, and HAZMAT training could require an initial 40-hour course with annual refresher courses of eight hours.

Metal Cleaning

There may be a need to clean the surface of the metal, a process called "pickling". In the case of stainless steel and specialty steel production, the "pickle liquor" is nitric acid and is used to remove the ferrous particles from the ferrous rolls picked-up during the rolling process. In the case of carbon steel, hydrochloric acid is used to remove oils and scale. In both cases, some dissolving of the metal occurs. Spent pickle liquor is a listed hazardous waste; if the metal is radioactively contaminated, the pickle liquor is likely to become a mixed waste.

Disposal Box Fabrication

The potential for external dose exposure during the fabrication and shipment of the disposal containers is low. The only radionuclide of concern is ^{99}Tc, which should not occur in an annual dose exceeding one microrem. There is a potential for inhalation and ingestion during welding if manual welding is performed. This can be controlled using both localized exhaust with HEPA filtration and respiratory protection. If automated welding techniques are employed, localized exhaust systems with HEPA filtration should be installed. Radiation safety training will be required, with a four- to eight-hour annual course.

Truck Drivers

Trucks may be the mode of transportation for scrap going to the melting facility, steel being transported to the fabricating facility, fabricated boxes being transported to the site of use, and the transport of the filled boxes to the disposal site. Individual truck drivers are expected not to exceed one microrem of exposure per year from any of these activities. There is a potential for internal dose exposure to truck drivers remaining in or near their trucks during the loading of contaminated scrap (if the scrap is not shipped in closed containers). This potential should be evaluated using continuous air sampling. It is expected that the drivers will require radiation safety training, at least to comply with U.S. Department of Transportation regulations, which can be accomplished with a four-hour annual training course.

Facility Contamination and Eventual Decommissioning

The need to reduce the volume and spread of radioactively contaminated material should be emphasized and designed into the facility during the planning phase. This is likely to impact furnace operations and slag handling the most, since these activities tend to be relatively uncontrolled at most steel plants in comparison to the controls normally found in facilities handling loose radioactive material.

Section 6 References

1. Evaluation of the Potential for Recycling of Scrap Metals from Nuclear Facilities, NUREG-1640, U.S. Nuclear Regulatory Commission.
2. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), U.S. Nuclear Regulatory Commission, NUREG 1575, December 1997.

7. Issues Regarding Worker Health and Safety Regulation

This section addresses differences in regulatory aspects in DOE and NRC regulation of a dedicated steel mill. Since Alternatives 1 and 2 do not consider the use of a steel mill to process metals, and Alternative 6 involves the use of an existing licensed facility, the focus of this section is limited to Alternatives 3, 4, and 5. The discussion in this section is for informational purposes only. A decision whether a steel mill would be licensed by the NRC, an Agreement State, or come under DOE requirements would be based on the relevant mission and operational conditions. For example, NRC may require specific statutory authorization to regulate a steel mill dedicated entirely to processing DOE scrap metal for future DOE use under each of these alternatives. In addition, amendments to the NRC's regulations that, for the most part exempt DOE and DOE's prime contractors from its regulations, may be necessary. Any costs associated with drafting and passing new legislation and amendments to the NRC's regulations are beyond the scope of this study.

Underlying Assumptions

In addition to the assumptions indicated in Section 4, this section assumes that the primary contaminants expected to be seen on the DOE metals to be recycled are: natural, enriched, and depleted uranium, and trace amounts of plutonium, technetium, neptunium, and possibly other mixed fission products. Although the uranium, neptunium, and plutonium are expected to accumulate in the furnace slag, it is assumed that the charge of metal placed into the furnace will be administratively controlled to ensure that there will never be a sufficient quantity of fissile material to form a critical mass in either the furnace or slag. In addition, administrative controls will be implemented to ensure that quantities of fissile materials sufficient to form a critical mass will never be onsite at any one time. Also, it is assumed under each of the alternatives that the dedicated facility is entirely segregated from all unrelated activities, and that there is no significant radioactive or hazardous chemical contamination present at the site prior to starting operations. Because this study presumes the steel mill will be operated by a contractor and that the DOE will only be purchasing the end-products of the steel mill, it is assumed that the contractor—not DOE—will be the licensee.

NRC Licensing v. DOE Requirements

The NRC's licensing process is notably different from the DOE's process for approving the safety approach of its contractors. The DOE's nuclear safety requirements are found in its nuclear safety regulations (10 CFR Parts 820, 830 and 835) and in DOE Orders, which are incorporated into the DOE's Management and Operating Contracts. The DOE's radiation protection approach permits its contractors to adopt alternate consensus standards, and tailor the overall safety measures implemented through DOE-approved Radiation Protection Plans and other safety documents, so that the safety requirements fit the specific activities and associated risks being undertaken. The Secretarial Officer responsible for environment, safety, and health matters must approve any exemptions from the nuclear safety regulations when the provisions relate to radiological protection of workers, the public, and the environment (See 10 CFR § 820.61). This process is typically accomplished in a matter of months, depending on the hazards and complexity of the operation.

In contrast, NRC licensing requires a more formal, prescriptive and public process. In the case of licensing the steel mill to process DOE scrap metals, the contractor would have to submit a formal license application to the NRC. The scrap metals will have contamination from source, byproduct, and special nuclear material as defined in NRC's regulations. Therefore, the license application will have to comport with the applicable requirements for specific licenses under Parts 30, 33, 40, 70, 71, 73, and 74. In addition, the contractor will have to comply with 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions". Deviations from the applicable requirements under each of these regulations would require that the applicant seek and obtain exemptions from the regulatory requirement from the NRC. The NRC has a great deal of discretion, and permits public participation in considering requests for exemptions, but whether any exemptions will be granted is uncertain. Seeking an exemption typically adds additional time to the licensing process, regardless of whether the exception is eventually granted.

With the exception of its costs under the Nuclear Waste Policy Act, the NRC is required by law to recover essentially all of its regulating costs. Consequently, the NRC charges licensing, inspection, and annual fees from its license applicants and licensees (See 10 CFR Parts 170 and 171). These are costs that would normally not be incurred under DOE regulation. Since the DOE will be relieved of some of its oversight responsibilities, however, some of these costs would be offset by a reduction in DOE's oversight costs.

Once the license application is submitted and accepted by the NRC, the NRC provides a process under 10 CFR Part 2 whereby interested parties may seek hearings to consider comments upon, and objections to, the licensing of the applicant's facility. Regardless of whether a challenger is successful, the impact on the license applicant can be detrimental because of the cost of the hearing process and the delay in licensing. Even where there is no challenger, the license application process can be costly and time consuming. For instance, obtaining a license for an Independent Spent Fuel Storage Installation for the Three Mile Island II reactor core debris took approximately three years and cost DOE approximately ten million dollars. We currently do not have sufficient information upon which to predict the amount of time or money it would take to license a steel mill under any of the applicable alternatives of this study.

The process for licensing the proposed steel mill will have other significant unknown factors. For instance, license applicants and NRC program managers typically use standard review plans for licensing a facility. However, since this would probably a first of a kind license[1], particularly in light of the mix of radioactive contaminants, it is highly unlikely that there is any standard review plan applicable to licensing a steel mill to process DOE contaminated metals. Additional issues arise from licensing under Alternative 3 (using an existing steel mill) because significant retrofitting may be required by the NRC as the NRC requires precise "as built" drawings of structures and equipment in restricted areas where radioactive materials are used or stored. In DOE's experience relating to the NRC certification of Gaseous Diffusion Plants, obtaining the requisite as-built drawings can be a costly and time consuming endeavor.

Licensing a steel mill under Alternative 4 (moving an electric arc furnace to a DOE site) raises its own unique regulatory issues. Siting the steel mill will have to account for other previous and ongoing DOE operations at the site that may impact the ability of the steel mill operator to obtain a license. Shared site features, such as the guard force, and potentially conflicting requirements like the physical protection requirements under 10 CFR Part 73 or the Material Control and Accounting requirements under 10 CFR Part 74, will have to be agreed upon between the DOE and NRC. In addition, other NRC regulatory requirements (e.g., its decommissioning requirements), may conflict with existing agreements entered into and enforceable under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

NRC's regulations implementing the National Environmental Policy Act of 1969 (NEPA), as amended, require somewhat redundant analyses on the part of the NRC prior to issuing a license. Unless the steel

[1] The writers have been informed that one state has licensed a steel mill to process metals contaminated with naturally occurring radioactive materials (NORM). However, the radiation safety requirements necessary for the NORM-contaminated metals are significantly different from those which would be necessary for protection from the mix of source, byproduct and special nuclear materials expected to be found on DOE's contaminated metals. Also, the State of Tennessee has licensed a facility with an air induction melting furnace and another facility with a vacuum induction melting furnace as opposed to an electric arc furnace being considered under Alternatives 3, 4 and 5.

mill comes within one of the NRC's regulatory "categorical exclusions" (see 10 CFR § 51.22), the NRC will at a minimum be required to issue an Environmental Assessment regardless of any previous NEPA analyses the DOE has performed. Although the NRC can rely on the DOE's analyses, the NRC's determinations under NEPA will be independent. This ultimately results in added licensing time and added costs to the licensee, that in this case will be borne by the DOE.

An additional complication may arise because the NRC primarily relies on DOE contractors for its NEPA evaluations. In the past, the NRC deemed use of a DOE contractor for the NEPA analysis when considering a DOE license application to be an "organizational conflict of interest" and, therefore, legally prohibited. Consequently, the NRC had to procure the services of another contractor which caused additional delay in the licensing. Under NRC regulations, the license applicant is prohibited from commencing construction if the proposed activity is one that the Commission has determined will significantly affect the quality of the environment, until the Director of Nuclear Material Safety and Safeguards (NMSS) has concluded, "balancing the environmental, economic, technical and other evidence against environmental costs and considering available alternatives, that the action called for is the issuance of the proposed license with conditions to protect environmental values" (See, 10 CFR § 30.33(a)(5)). Consequently, although DOE may have fully complied with NEPA, construction may not be initiated on the steel mill under any of the three applicable alternatives[2] until the NRC's Director of NMSS has made the required determination.

Under NRC regulation, significant changes in operations or changing the operator can have substantial cost and time impacts on the operation of the steel mill. If a licensee proposes to make changes in its operations that are not provided for in the conditions of the license, the licensee must formally apply for and obtain a license amendment from the NRC. Before any change in the operator can occur, the proposed new licensee will have to apply for and obtain a license transfer. Each of these processes can take both years and millions of dollars to accomplish. In contrast, under DOE regulations, significant changes in the operations of a facility can be accomplished through the DOE's approval of, and amendment to, the contractor's Radiation Protection Plan. Changes in the operator can occur with the new contractor adopting the existing Radiation Protection Plan. These changes are typically accomplished in a matter of months the under DOE's regulatory authority.

[2] Alternatives 3, 4, and 5

8. Cost of Dedicated Steel Mill

Background

Six alternatives for the recycle, reuse and/or disposal of radioactively contaminated scrap metals have been defined to a high level. Rough order of magnitude estimates were generated for each of the alternatives. The primary alternatives are free-release (as the baseline), disposal, and recycle/reuse.

Methodology

Due to the short time frame to complete this feasibility study and the lack of technical definition resulting from the accelerated schedule, several possible cost elements have been omitted. These elements include: compliance with Environmental Safety & Health (ES&H) regulations and DOE Orders concerning radioactivity or, alternatively, NRC regulation; possible downstream contamination from residual radioactivity; and waste generation and long-term stewardship concerns. Additionally, schedule impacts due to public perception and programmatic risks were not considered.

Further, without additional resolution in the area of the amount of radioactive contamination remaining in the initial product from an EAF, concerns remain regarding possible contamination of downstream processors, such as rolling mills and fabricators. This concern and its possible cost impact increases with the number of fabricators. As more products are required, (e.g., drums, various boxes, pipe, ductwork, valves, processing equipment, structural steel, Alloy 22, etc.), more processing facilities are involved. These two areas cited above could have significant costs associated with them, ultimately impacting the final decision of which alternative or combination of alternatives to pursue.

The radioactively contaminated materials that make up the feedstock for each alternative come from three main sources within the DOE complex: the enrichment processing facilities (EPF), reactor facilities (RF), and plutonium processing facilities (PPF). This distinction has been made because the cost, handling and waste treatment requirements, licensing, and worker health and safety may be significantly impacted by the types of radioactively contaminated metals that are processed. The primary focus of the alternatives presented are the EPFs, particularly the GDPs, as they are expected to be the major contributors of the scrap metal recycling stock.

Many of the six previously discussed alternatives include common processes. However, the costs associated with those processes vary depending on the specifics of each alternative and result in differences in the economic feasibility of pursuing a particular alternative. Exhibit 8-1 presents an overview of the primary processes associated with each of the alternatives.

Exhibit 8-1. Primary Processes Associated with Each Alternative

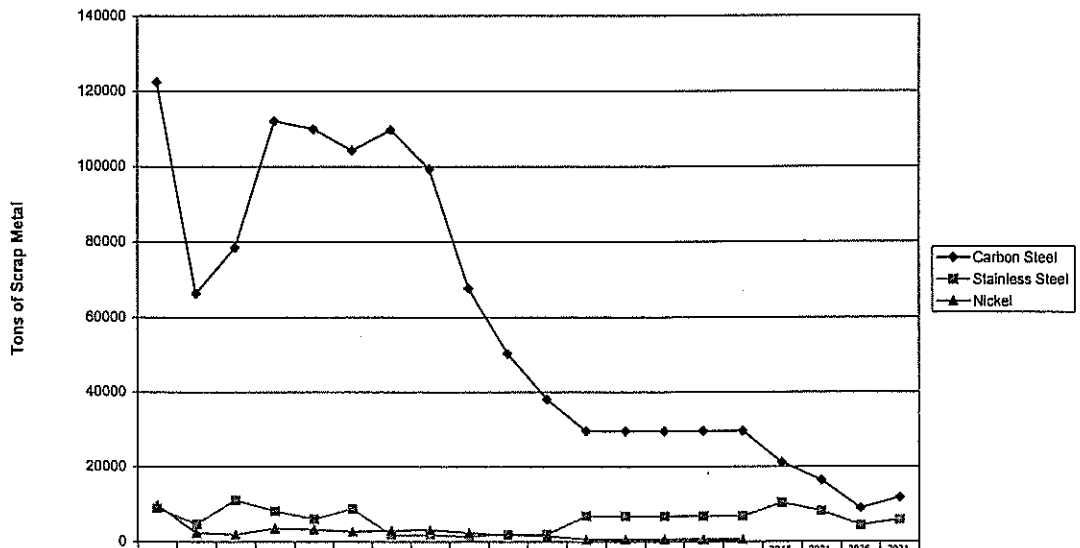
Process	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Pre-processing	×	×	×	×	×	×
Steel processing (EAF Options A, B, C, D)			×	×	×	
Alloy 22 processing (EAF Options A, B, C only)			×	×	×	×
Long-term storage of metal products			×	×	×	×
Purchase metal for container needs	×	×	×	×	×	×
Disposal of contaminated material	×	×	×	×	×	×
Free release of material	×					
Process material at RSM facility			×	×	×	×

Data Description and Quality

The cost analysis for the feasibility study was developed with the input from two separate data calls to the Field Offices. The first data call was for the feeds availability which identified iron, carbon steel, stainless steel, and nickel through the year 2035. The second data call identified potential internal needs of the department, by year, through 2035.

The Department of Energy "feeds" availability submitted in the September 8, 2000 data call, by metal type and year, is contained in the Exhibit 8-2. The most significant feed data submitted by volume are those regarding carbon steel and the most significant data by value are those regarding the nickel.

Exhibit 8-2. Carbon Steel, Stainless Steel, and Nickel Feeds (Annual)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016-2020	2021-2025	2026-2030	2031-2035
Carbon Steel	122409	66336.4	78549.9	112023	109878	104238	109673	99298.5	67825.3	50260	38057	29530.4	29530.4	29530.4	29530.4	29530.4	21081	16329.4	8859.2	11744.4
Stainless Steel	8812	4687.9	10956.4	8104.22	6007.2	8683.63	1672.17	1749.06	1313.52	1852	1953	6762.6	6762.6	6762.6	6762.6	6762.6	10288.8	8073	4316	5802
Nickel	9506.83	2263	1879	3476	3168	2670	2874	3114	2233	1807	1467	586.6	586.6	586.6	586.6	586.6				

Fiscal Year

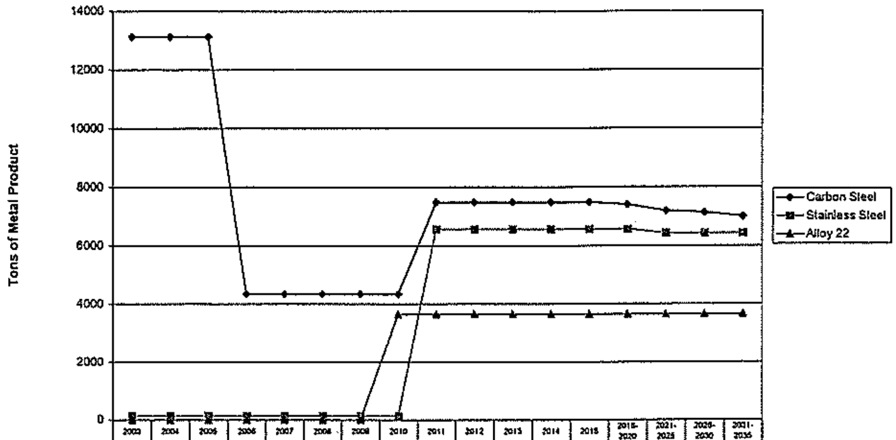
Needs

The Department of Energy "needs" requirements submitted in the September 22-27, 2000 data call, by metal type and year are contained in Exhibit 8-3. Exhibit 8-3 displays the near term need for carbon steel and an increased need for stainless and Alloy 22, starting in the year 2011 and continuing through 2035. The analysis of the needs data revealed that in order to meet the carbon steel needs through the use of contaminated metals within the DOE Complex for the years 2003 through 2006 (~40% of the total carbon steel needs), any alternative must start in the year 2003.

The Alloy 22 container needs were derived from the February 23, 2000 Preliminary Draft For Review Yucca Mountain memorandum entitled *Possible Use In the Repository of Slightly Contaminated Nickel From Decommissioned Gaseous Diffusion Plants*. The Alloy 22 containers contain 52,600 tons of nickel. With a 60% nickel content, the Alloy 22 containers weigh ~88,000 tons.

The majority of the stainless steel container need is also based on the aforementioned memorandum. The 316 stainless steel containers include 21,600 tons of nickel. With a 14% nickel content, the 316 stainless steel containers weigh 154,300 tons. The remaining stainless steel needs are for SRS, DWPF, and plutonium containers.

Exhibit 8-3. Carbon Steel, Stainless Steel, and Alloy 22 Needs (Annual)



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016-2020	2021-2025	2026-2030	2031-2035
Carbon Steel	13125.4	13125.4	13125.4	4344.471	4344.471	4344.471	4344.471	4344.471	7456.465	7456.465	7456.465	7456.465	7456.465	7400.139	7165.096	7128.635	6991.848
Stainless Steel	137.5	137.5	137.5	137.5	137.5	137.5	137.5	137.5	6566.071	6566.071	6566.071	6566.071	6566.071	6566.071	6428.571	6428.571	6428.571
Alloy 22	0	0	0	0	0	0	0	3652.778	3652.778	3652.778	3652.778	3652.778	3652.778	3652.778	3652.778	3652.778	3652.778

Fiscal Year

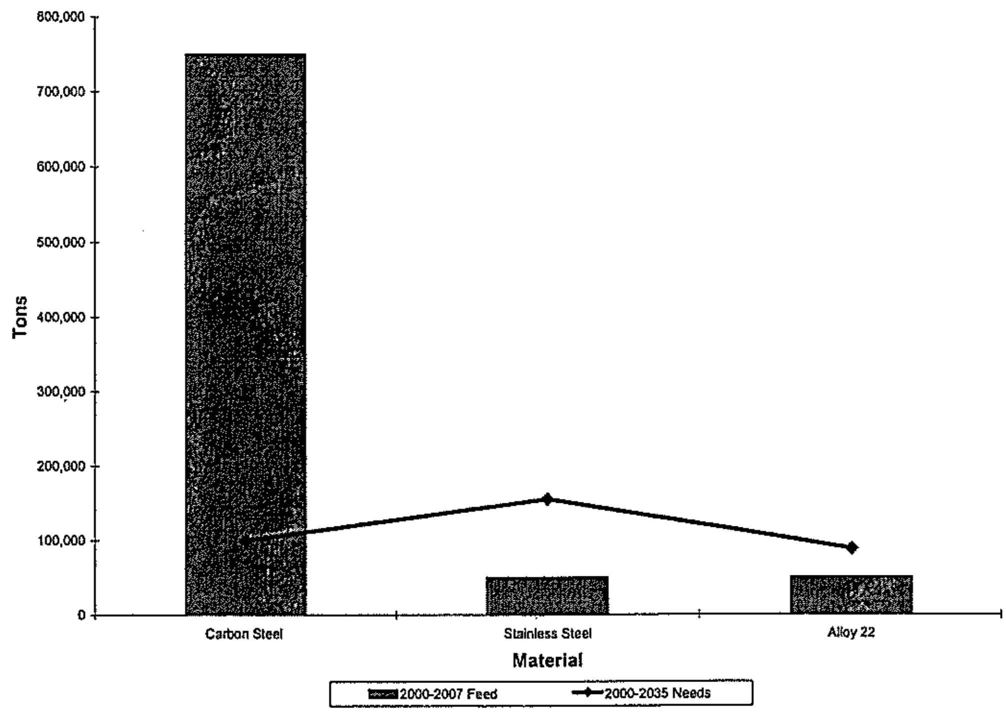
Piping, valves, and process equipment needs for stainless steel and carbon steel were not considered when establishing the material balances used in the cost study. These materials were excluded because the feasibility study assumed the products made from the recycled steel could be made in a rolling mill and fabrication shop. Piping, valves, and process equipment require casting and extruding.

The carbon steel needs used in the material balances established for the cost study are approximately 100,000 tons. This quantity was established and agreed to by the team before all of the needs data were received. The total quantity of carbon steel containers, structural steel, and ductwork needed is approximately 112,000 tons. Increasing the carbon steel needs by ~12% will not change the cost of any of the alternatives appreciably.

In addition to the uncertainty in the needs and feeds data, the cost estimates developed for all of the alternatives have a relatively high level of uncertainty due to the cost of the material for the needed containers and the exclusion of several cost elements from the technical basis. In some alternatives, the cost of purchasing materials is greater than 50% of the cost of the alternative. The largest of the material costs is the Alloy 22 required by RW. The Alloy 22 was assumed to cost $14,000 per ton ($7/lb) to purchase as coil. Since all alternatives require the purchase of some Alloy 22 (ranging between 28,000 tons and 88,000 tons), a 25% change in the price of Alloy 22 will result in a change of 10% to 15% in the cost of a given alternative. A larger change in the price of metal will result in a larger contribution to an alternative's uncertainty.

The availability of material feed during the 2003-2007 timeframe is contained in Exhibit 8-4. There is an ample supply of carbon steel during that timeframe to meet the total reported needs for the period 2003 through 2035. However, additional nickel will need to be purchased in order to meet the needs for stainless steel and Alloy 22 up to the year 2035.

Exhibit 8-4. Availability of Feeds Material and Total Needs



The following paragraphs discuss the estimated uncertainty resulting from metal price variations and the potential impact of the cost elements that have not been included.

Alternative 1

The estimated uncertainty in the cost estimate for Alternative 1 is ±25%. Nearly all of the uncertainty is due to the cost of purchasing the metal needed for DOE's containers. The cost of decontaminating and verifying scrap for free release is a significant cost driver but the cost is well-documented with recent actuals. The accuracy range for Alternative 1 is $2,280,398K to $1,368,239K.

Alternative 2

The estimated uncertainty in the cost estimate for Alternative 2 is ±25%. As in Alternative 1, nearly all of the uncertainty is due to the cost of purchasing the metal needed for DOE's containers. The cost of disposal is a significant cost driver, but disposal costs have been evaluated extensively by the Department and are well-documented. The accuracy range for Alternative 2 is $2,486,385K to $1,491,831K.

Alternative 3

The estimated uncertainty in the cost estimate for Alternative 3 is +100% and -25%. The capital and operating costs of the steel mill were estimated for a steel mill processing clean scrap metal. The additional capital required to modify an existing steel mill, and the additional operating cost required to accommodate radioactive materials have not been included in the cost estimate because the technical requirements have not been specified in the technical analysis. Likely additional costs include radiation containment systems and as-built drawings of the entire mill. This alternative requires radioactive materials to be managed and processed in an existing non-radioactive facility. The accuracy range for the four options are Alternative 3A, $2,418,208K to $906,828K; Alternative 3B, $2,542,802K to $953,551K; Alternative 3C, $2,569,312K to $963,492K; Alternative 3D, $2,681,598K to $1,005,599K.

Alternative 4

The estimated uncertainty in the cost estimate for Alternative 4 is +100% and -25%. The uncertainty of this alternative is less than that of Alternative 3 because the EAF is moved to an existing DOE facility where radioactive materials are already managed. The upgrades to the existing steel mill and the added cost of operating with radioactive materials have not been included, but are expected to be significantly less than Alternative 3. The accuracy range for the four options are Alternative 4A, $2,280,176 K to $855,066 K; Alternative 4B, $2,844,770K to $1,066,789K; Alternative 4C, $2,871,282K to $1,076,731K; Alternative 4D, $2,802,126K to $1,050,797K.

Alternative 5

The estimated uncertainty in the cost estimate for Alternative 5 is +100% and -25%. The uncertainty of this alternative is less than Alternative 3 because a new EAF is built, and the additional costs to make the mill a radioactive materials facility would be a smaller percentage of the cost of a new mill than that of a retrofitted mill. Many of the capital costs will be higher for a radioactive facility, but adding in those requirements at the beginning of the design and construction phase would result in a lower additional cost. The accuracy range for the four options are Alternative 5A, $2,304,022 K to $864,008 K; Alternative 5B, $2,868,616 K to $1,075,731 K; Alternative 5C, $2,895,128 K to $1,085,673 K; Alternative 5D, $2,825,972 K to $1,059,740 K.

Alternative 6

The estimated uncertainty in the cost estimate for Alternative 6 is +50% and -25%. The cost to produce stainless steel alloys in the MSC induction furnace has been documented, but producing a higher grade alloy (Alloy 22) may result in higher operating costs. The accuracy range for Alternative 6 is $2,255,342K to $1,127,671K.

The uncertainty associated with the feeds and needs data reported are reflected in Exhibits 8-5 and 8-6 below. The feeds data was viewed as a rough order of magnitude for all of the options. The uncertainty associated with the feed data will affect the 6 alternatives in relation to disposal, through-put available, etc.

Exhibit 8-5. Feeds

Material	Inventory (FY 2000)		Projected Generation (2001-2035)	
	Tons of Metal	Uncertainty	Tons of Metal	Uncertainty
Carbon Steel	113,600	± 16%	1,050,500	± 30%
Stainless Steel	8,800	± 27%	223,200	± 34%
Nickel	9,800	± 10%	27,900	± 20%

Exhibit 8-6. Needs

Material	Type	Amount (tons)	Uncertainty
Carbon Steel	Containers	83,800	+57% / -34%
Carbon Steel	Structural	24,000	±50%
Carbon Steel	Ductwork	4,000	±50%
Carbon Steel	Piping, Valves	16,700	±50%
Stainless Steel	Containers	157,000	+20%
Stainless Steel	Piping, Equipment	14,600	±50%
Alloy 22	Containers	88,000	+20%

Cost Components of Each Alternative

Alternative 1

- Characterization of material at the generator site
- Dismantle in large pieces (except for nickel)
- Dismantle, declassify, and package nickel parts
- Segregate material
- Decontaminate for free release
- QA/certify for free release
- Selling costs (including marketing)
- Equipment surveillance, maintenance, and replacement
- Purchase appropriate boxes for transportation and storage
- Size material for disposal or for DOE reuse
- Storage and surveillance costs for stored material to be reused by DOE
- QA/certify for disposal
- Transportation to disposal facility
- Disposal costs at Envirocare, RL, NTS, or onsite cell
- Indirect costs
- Profit or fee

Alternative 2

- Characterization of material at the generator site
- Dismantle in large pieces (except for nickel)
- Dismantle, declassify, and package nickel parts
- Segregate material
- Purchase appropriate boxes for transportation and storage
- Size material for disposal
- QA/certify for disposal
- Transportation to disposal facility
- Disposal costs at Envirocare, Hanford, NTS, or onsite cell
- Indirect costs
- Profit or fee

Alternative 3

- Characterization of material is at the generator site
- Dismantle in large pieces (except for nickel)
- Dismantle and package nickel parts
- Chemically process nickel
- Segregate material
- Retrofit EAF for radiation control and containment
- Monitor incoming material to EAF
- Monitor outgoing material from EAF
- Equipment surveillance, maintenance, and replacement
- Facility maintenance
- Purchase appropriate boxes for transportation and storage
- Size material for disposal or for DOE reuse
- Storage, surveillance, and security costs for stored material to be reused by DOE
- QA/certify for disposal

- Transportation to disposal or processing facility
- Purchase existing steel mill
- Disposal costs at Envirocare, Hanford, NTS, or onsite cell
- DOE Health, Safety, & Security administration costs (includes protective equipment)
- Licensing costs
- Deactivation and Decommissioning costs
- Indirect costs
- Fee or profit

Alternative 4

- Characterization of material at the generator site
- Dismantle in large pieces (except for nickel)
- Dismantle nickel parts
- Chemically process nickel
- Segregate material
- Equipment surveillance, maintenance, and replacement
- Facility purchase and relocation costs
- Replacement of facilities and equipment that could not be moved
- Facility maintenance
- Purchase appropriate boxes for transportation and storage
- Size material for disposal or for DOE reuse
- Storage, surveillance, and security costs for stored material to be reused by DOE
- QA/certify for disposal
- Transportation to disposal or processing facility
- Disposal costs at Envirocare, RL, NTS, or onsite cell
- DOE Health, Safety, & Security administration costs (includes protective equipment)
- Licensing costs
- Deactivation and Decommissioning costs
- Indirect costs
- Fee or profit

Alternative 5

- Characterization of material is at the generator site
- Dismantle in large pieces (except for nickel)
- Dismantle nickel parts
- Chemically process nickel
- Segregate material
- Equipment surveillance, maintenance, and replacement
- Capital cost of new facility
- Facility maintenance
- Purchase appropriate boxes for transportation and storage
- Size material for disposal or for DOE reuse
- Storage, surveillance, and security costs for stored material to be reused by DOE
- QA/certify for disposal
- Transportation to disposal or processing facility
- Disposal costs at Envirocare, NTS, or onsite cell
- DOE Health, Safety, & Security administration costs (includes protective equipment)
- Licensing costs
- Deactivation and Decommissioning costs

- Indirect costs
- Fee or profit

Alternative 6

- Characterization of material at the generator site
- Dismantle in large pieces (except for nickel)
- Dismantle nickel parts
- Chemically process nickel
- Segregate material
- Equipment surveillance, maintenance, and replacement
- Facility maintenance
- Purchase appropriate boxes for transportation and storage
- Size material for disposal or for DOE reuse
- Storage, surveillance, and security costs for stored material to be reused by DOE
- QA/certify for disposal
- Transportation to disposal or processing facility
- Disposal costs at Envirocare, Hanford, NTS, or onsite cell
- DOE Health, Safety, & Security administration costs (includes protective equipment)
- Deactivation and Decommissioning costs
- Indirect costs
- Fee or profit

Cost Analysis for Each Alternative

Alternative 1

The total estimated cost (presented in constant FY 2000 dollars) for Alternative 1 is approximately $1.8 billion over the next 35 years. The cost drivers are the purchase of containers (85%), and the cost of QA for free release (9%). Facilities are in place and adequate to accommodate the recycle program, therefore no additional capital costs are anticipated.

It is estimated that it will cost the DOE approximately $213 million to have the free release recycle program in place for 35 years. The anticipated offset from the sale of the decontaminated metal to a scrap dealer is $73 million, which represents only a 3% recovery of recycle program costs. The Department's container needs will be purchased at an additional cost of $1,611 million, bringing the total estimate to $1,824 million.

Alternative 2

The total estimated cost (presented in constant FY 2000 dollars) for Alternative 2 is approximately $2.0 billion over the next 35 years. The cost drivers are the purchase of containers (81%) and the cost of QA for disposal (10%). Capital cost to build required onsite CERCLA cells is estimated at $68 million.

It is estimated that it will cost the DOE approximately $378 million to dispose of contaminated metal over the next 35 years. The Department's container needs will be purchased at an additional cost of $1,611 million, bringing the total estimate to $1,989 million.

Alternative 3

The total estimated cost (presented in constant FY 2000 dollars) for Alternative 3 is approximately $1.2 billion in operating costs over the next 35 years. Capital cost to retrofit an existing EAF to meet DOE requirements is estimated at $110 million. Due to the feedstock available within DOE for processing, the Department will need to purchase additional material to support its container needs. The cost drivers are the estimate to process the material (32%) and the cost to purchase additional feedstock for container needs (49%).

It is estimated that it will cost the DOE approximately $651 million to produce containers made from decontaminated metal in an EAF over the next 6-10 years. The Department's additional container needs will be purchased at a cost of $626 million, bringing the total estimate to $1,277 million.

Electric Arc Furnace Feed/Production Rates of Options for Alternatives 3/4/5

Four electric arc furnace (EAF) feed/production rates were evaluated as part of this cost study. The alternatives were analyzed for different annual and total feed rates, and for different amounts of stainless steel and Alloy 22 produced. This analysis was necessary because the total stainless steel needs exceeded the stainless steel feeds available during the EAF's operational time frame.

Alternatives 3, 4, 5, and 6 were analyzed based on five different production options. These options are shown in Exhibit 8-7.

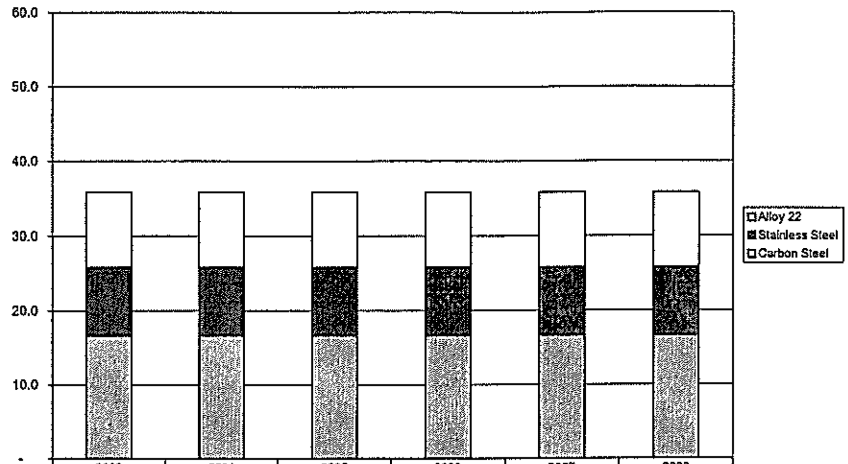
Exhibit 8-7. Alternative Production Options

Discriminators	Alternatives 3/4/5 A	Alternatives 3/4/5 B	Alternatives 3/4/5 C	Alternatives 3/4/5 D	Alternative 6
Years of Operation	6	6	10	6	6
Tons Carbon Steel Produced	100,000	103,000	100,000	103,000	0
Tons Stainless Steel Produced	55,000	155,000	155,000	155,000	0
Tons Alloy 22 Produced at EAF facility	60,000	42,000	45,000	0	0
Tons Alloy 22 Produced at RSM facility	0	0	0	42,000	60,000

The four options for the three alternatives 3/4/5 are:

A. Total EAF Output of 215,000 Tons - Beginning in 2003 and operating for six years, the EAF produces 100,000 tons of carbon steel, 55,000 tons of stainless steel, and 60,000 tons of Alloy 22. This alternative uses all of the available nickel feed to maximize the production of Alloy 22. The average annual production rate is 36,000 tons per year, which corresponds to approximately 670 melts per year (see Exhibit 8-8).

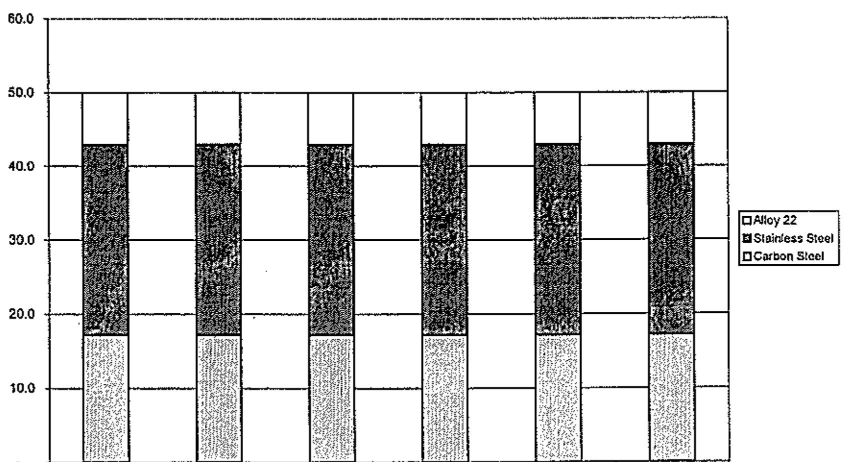
Exhibit 8-8. Production of Metal Product in EAF - Option 3A/4A/5A



	2003	2004	2005	2006	2007	2008
Alloy 22	10.0	10.0	10.0	10.0	10.0	10.0
Stainless Steel	9.2	9.2	9.2	9.2	9.2	9.2
Carbon Steel	16.7	16.7	16.7	16.7	16.7	16.7

B. Total EAF Output of 300,000 Tons - Beginning in 2003 and operating for six years, the EAF produces 103,000 tons of carbon steel, 155,000 tons of stainless steel, and 42,000 tons of Alloy 22. This alternative uses a portion of the available nickel to produce enough stainless steel to meet all future needs (through FY 2035). The remaining nickel is used to produce Alloy 22. The average annual production rate is 50,000 tons per year, which corresponds to approximately 940 melts per year (see Exhibit 8-9).

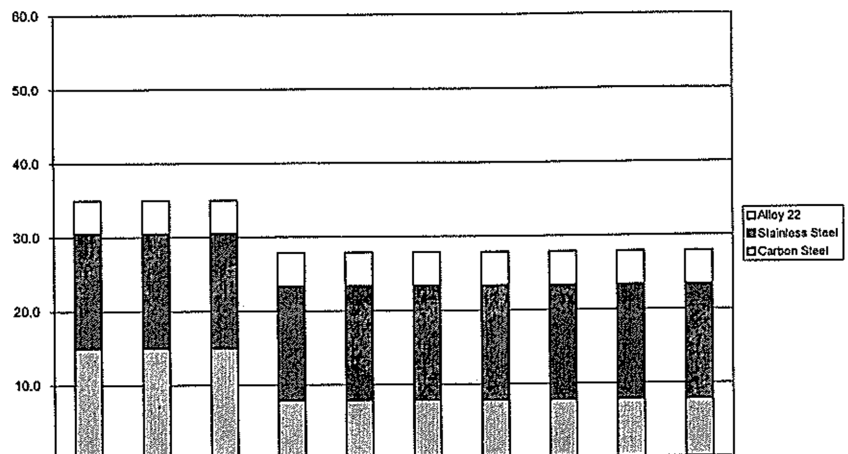
Exhibit 8-9. Production of Metal Product in EAF - Option 3B/4B/5B



	2003	2004	2005	2006	2007	2008
Alloy 22	7.0	7.0	7.0	7.0	7.0	7.0
Stainless Steel	25.8	25.8	25.8	25.8	25.8	25.8
Carbon Steel	17.2	17.2	17.2	17.2	17.2	17.2

C. Total EAF Output of 300,000 Tons - Beginning in 2003 and operating for ten years, the EAF produces 100,000 tons of carbon steel, 155,000 tons of stainless steel, and 45,000 tons of Alloy 22. This alternative is similar to Alternative B but the EAF operates for ten years, which increases the amount of stainless steel scrap available, thereby reducing the amount of nickel consumed to make stainless steel. The amount of remaining nickel is slightly more than Alternative B and is used to produce Alloy 22. Operating costs are higher because the EAF operates for ten years. Also, production rates are assumed to be higher in the first three years to produce the carbon steel needed in the 2003 to 2005 timeframe. The average annual production rate is 30,000 tons per year, which corresponds to approximately 560 melts per year (see Exhibit 8-10).

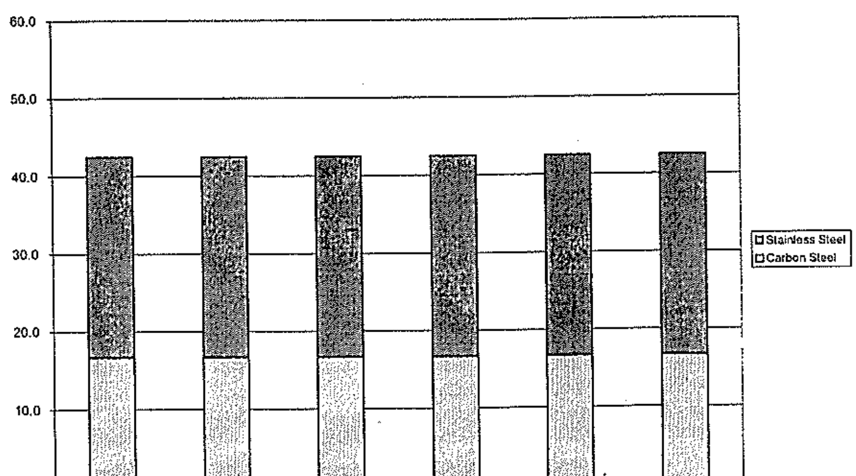
Exhibit 8-10. Production of Metal Product in EAF - Option 3C/4C/5C



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Alloy 22	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Stainless Steel	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
Carbon Steel	15.0	15.0	15.0	7.9	7.9	7.9	7.9	7.9	7.9	7.9

D. Total EAF Output of 255,000 Tons - Beginning in 2003 and operating for six years, the EAF produces 100,000 tons of carbon steel and 155,000 tons of stainless steel. This alternative produces the same amount of carbon steel and stainless steel as Alternative B, but no Alloy 22 is produced in the EAF. All Alloy 22 is produced in the MSC induction furnace. This alternative evaluates the cost impacts of the EAF and crew not being able to produce Alloy

Exhibit 8-11. Production of Metal Product in EAF - Option 3D/4D/5D



	2003	2004	2005	2006	2007	2008
Stainless Steel	25.8	25.8	25.8	25.8	25.8	25.8
Carbon Steel	16.7	16.7	16.7	16.7	16.7	16.7

22 to RW's specification. The average annual production rate is 42,500 tons per year, which corresponds to approximately 800 melts per year (see Exhibit 8-11).

Alternative 4

The total estimated cost (presented in constant FY 2000 dollars) for Alternative 4 is approximately $1.25 billion in operating costs over the next 35 years. Capital cost to build or move/retrofit an existing EAF to meet DOE requirements is estimated at $171 million. Due to the feedstock available within DOE for processing, the Department will need to purchase additional material to support its container needs. The cost drivers are the estimate to process the material (33%) and the cost to purchase additional feedstock for container needs (45%).

It is estimated that it will cost the DOE approximately $777 million to produce containers made from decontaminated metal in an EAF over the next 6-10 years. The Department's additional container needs will be purchased at a cost of $644 million, bringing the total estimate to $1.421 billion.

Alternative 5

The total estimated cost (presented in constant FY 2000 dollars) for Alternative 5 is approximately $1.25 billion in operating costs over the next 35 years. Capital cost to build an EAF to meet DOE requirements is estimated at $183 million. Due to the feedstock available within DOE for processing, the Department will need to purchase additional material to support its container needs. The cost drivers are the estimate to process the material (33%) and the cost to purchase additional feedstock for container needs (45%).

It is estimated that it will cost the DOE approximately $789 million to produce containers made from decontaminated metal in an EAF over the next 6-10 years. The Department's additional container needs will be purchased at a cost of $644 million, bringing the total estimate to $1.433 billion.

Alternative 6

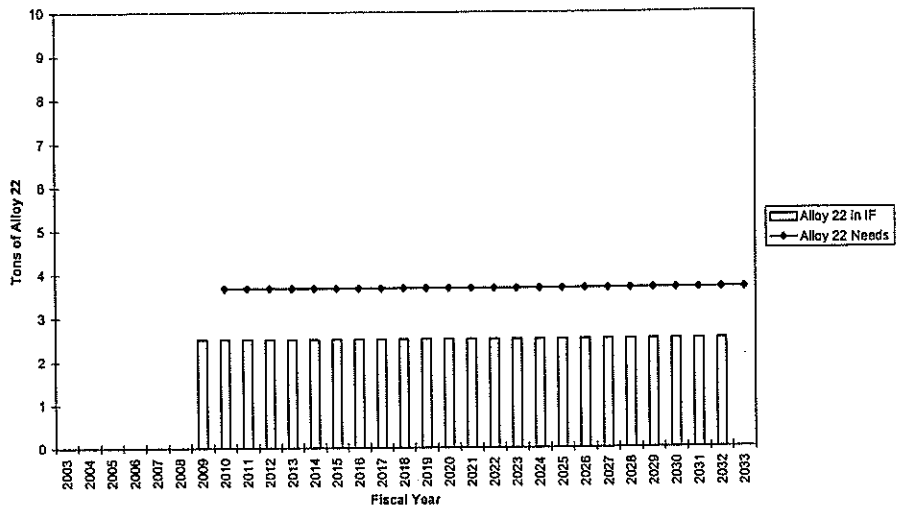
The total estimated cost (presented in constant FY 2000 dollars) for Alternative 6 is approximately $1.5 billion in operating costs over the next 6 years. Due to the feedstock available within DOE for processing, the Department will need to purchase additional material to support its container needs. The cost drivers are the estimate to process the material (28%) and the cost to purchase additional feedstock for container needs (51%).

It is estimated that it will cost the DOE approximately $733 million to produce containers made from decontaminated metal in a RSM over the next 6-10 years. The Department's additional container needs will be purchased at a cost of $771 million, bringing the total estimate to $1.504 billion.

There is one option that relates only to producing Alloy 22 in an induction furnace. This option is for Alternative 6.

As Exhibit 8-12 indicates, all Departmental needs for Alloy 22 from 2009 through 2035 cannot be made with the anticipated nickel feed available. Some material will need to be purchased to meet DOE requirements.

Exhibit 8-12. Alloy 22 Needs and Production in Induction Furnace - Option 6



Products of Each Alternative

Alternative 1

1. Uncontaminated steel/metals that are acceptable to the steel industry/public and placed on the free market for recycle
2. All contaminated metal to disposal
3. Decontaminated metals recycled for DOE reuse

Alternative 2

1. Cleared scrap yards

Alternative 3

1. Blocks (activity too high for EAF)
2. Disposals (dust, trash, slag metal)
3. Feedstock (carbon steel, stainless steel, Alloy 22)
4. Coil/slab if needed

Alternative 4

1. Blocks (too high activity for EAF)
2. Disposals (dust, trash, slag metal)
3. Feedstock (carbon, stainless steel)
4. Coil/slab if needed

Alternative 5

1. Blocks (too high activity for EÁF)
2. Disposals (dust, trash, slag metal)
3. Feedstock (carbon, stainless steel)
4. Coil/slab if needed

Alternative 6

1. Coil (Alloy 22 only)
2. Disposals (unused metal)

Discussion

The study's alternatives can be grouped into two major categories. These categories are: existing practices (Alternatives 1, 2, and 6) and new activities (Alternatives 3, 4, and 5). Alternative 1, free release of metal under the revised DOE Order 5400.5A, is an enhancement of previously existing practices. Alternative 2, disposal, is currently being utilized. Alternative 6, use of existing RSM processors, is being used by DOE and other Federal Agencies. Alternatives 3, 4, and 5, variations of retrofit or construction and operation of an EAF, represents a departure from established practices and therefore may have programmatic risks that are absent from Alternatives 1, 2, and 6.

Initial assessment of the feeds data indicates that sufficient feed exists for all needs except Alloy 22. At this level of analysis, the feasibility of the alternatives cannot be determined based solely on cost. This is due to the wide range of confidence levels in the feeds and needs data and the uncertainties inherent in converting private industry practices to DOE standards.

There are several issues affecting the cost of the alternatives that were not addressed in this cost analysis due to time constraints and the need for additional technical guidance. These issues are summarized within the following categories:

- **Compliance:** Regulatory aspects, such as permitting, ES&H, safeguards and security, long-term stewardship and DOE Order compliance have not been thoroughly addressed in Alternatives 3, 4, and 5 due to schedule limitations. Implementing requirements could have a significant impact on both capital and operating costs.

- **Technical:** Several issues remain unresolved relating to the technical aspects of Alternatives 3, 4, 5, and 6. These include the abilities of the EAF and the induction furnace to produce Alloy 22 to RW's specifications, the potential for radioactive contamination at the rolling mill and fabricator, undocumented waste type, and generation forecasts from the various processing activities. The additional requirements and D&D activities, and long term stewardship liabilities that may result after a more thorough technical analysis, could increase the costs associated with these options.

- **Cost:** A make or buy analysis for each product that is anticipated to be produced in Alternatives 3, 4, 5, and 6 was not done because the schedule did not allow data validation to take place (only high-level quality assurance), and a comprehensive technical analysis of the data is required to determine if the preliminary technical basis is still supported.

- **Programmatic Risk:** DOE programmatic risk and issues related to public perception regarding radioactive material have not been factored into this cost analysis. The risk and issues could both have a significant cost and schedule impact.

Recommended Path Forward

- Complete QA and verification of feeds and needs data.

- Further study Alternatives 1, 2, 3, 4, 5 and 6, and combinations of alternatives including a make or buy analysis of the Department's needs, exploratory discussions with disposal sites, the steel industry, and existing RSM facilities to improve the credibility and completeness of this study.

Cost Factors

Nickel Chemical Processing

The nickel from the three GDPs contains ^{99}Tc. The ^{99}Tc will remain in the metal when processed in the EAF and will not partition into the slag. To reduce/eliminate the ^{99}Tc in the final product, the nickel will be processed to remove ^{99}Tc prior to feeding to the EAF.

*Nickel processing cost = ($1.00 per pound) * (2,000 pounds per ton) * (tons of nickel)*

Cut into <5-ft Pieces

The scrap metal needs to be cut into pieces prior to shipping and feeding to the EAF.

*Cut into 5-ft pieces cost = ($400 per ton) * (tons of metal fed to EAF)*

Electric Arc Furnace

Capital costs for the EAF include upgrades to an existing EAF (Alternative 3), moving an existing EAF to a DOE facility and upgrading (Alternative 4), purchasing a new EAF (Alternative 5), preparation of an environmental impact statement and license/permit applications (Alternatives 3, 4, and 5), D&D of the EAF (Alternatives 3, 4, and 5), and D&D of the site (Alternatives 3, 4, and 5). Operating costs for all EAF options include the maintenance of license and permits, EAF operating costs (e.g., labor, electricity, etc.), and additives (e.g., chromium, nickel, molybdenum) to the melts.

Purchase/Disassembly/Reassembly - These costs provided by Dr. Gordon Geiger in Excel spreadsheets on August 24 and August 29, 2000.

Permitting/Licensing - Estimated to be $5,000,000 to apply for and obtain a permit, and $500,000 per year to maintain license and permits.

*Cost to maintain license/permit = (Permit maintenance/year) * (# of years EAF operates)*

Instrumentation to Measure Radioactivity in Scrap - Doug Akers (INEEL) reported a cost of $200,000 per unit for measuring radioactivity levels in scrap steel. Unit will be used at shipping sites and receiving sites. Five units are assumed.

*Instrumentation Cost = ($200,000 per unit) * (5 units)*

Operations - These costs provided by Dr. Gordon Geiger in Excel spreadsheets on August 24 and August 29.

Additives - Production of Alloy 22 and stainless steel requires the addition of some metals (e.g., chromium, molybdenum, etc.). Average Alloy C-22 chromium content is assumed to be 18%, nickel 60%, and molybdenum 18%. Molybdenum and chromium need to be added to the GDP nickel to make Alloy 22. Average stainless steel chromium contents of 18% and nickel 10% were assured. Some stainless steel was assumed to be produced from scrap stainless steel. Additional stainless steel is assumed to be produced by using some of the GDP nickel and adding scrap carbon steel and

Ferrochrome. Ferrochrome is used as an additive in an EAF. Some experts believe Ferrochrome cannot be used in an induction furnace to make alloys, rather suggesting that pure chromium must be used. However, MSC has been successful in producing stainless steel to ASTM specifications with Ferrochrome. The cost model assumes Ferrochrome can be used in the MSC induction furnace.

*Additive cost = (amount of additive required) * (additive cost/ton)*

D&D of the EAF at completion - The EAF building is estimated to be 720,000 square feet in size (Geiger). D&D of similar size/type buildings ranged in costs from $37 to $137 per square foot, with an average of $100/square foot.

*Cost to D&D EAF = (720,000 square feet) * ($100/square foot) = $72,000,000*

D&D of Site at completion - Estimated to be $10,000,000.

Long-Term Storage of Scrap Metal and Metal Products

Since Needs and Feeds do not necessarily coincide, long-term storage costs have been estimated for carbon steel product, stainless steel scrap and product, and Alloy 22.

*Storage cost of scrap metal/metal products = ($2/ton-year) * (tons of metal) * (years stored)*

Cost to Purchase Metal for Container Needs

Since the technical analysis has not established the conditions and requirements for rolling and fabricating the needed containers, the cost analysis uses *coil product* as the common end point for all options. Coil will need to be purchased when a specific metal's needs exceed EAF/induction furnace product.

*Cost to purchase metal (coil) = ((metal needs) - (EAF/induction furnace output)) * ($ per ton of metal coil)*

Disposal Cost

The amount of material requiring disposal in the options analyzed consists of unused/unneeded scrap, slag from EAF operations, and dust from EAF operations. After determining the amount of material requiring disposal (using the material balances developed for the cost analysis), the tons of waste are converted to cubic meters and per cubic meter disposal costs are applied to the volume disposed.

*Cost of disposal = ((tons disposed) / (tons per cubic meter)) * ($/cubic meter disposed)*

The cost per cubic meter disposed was calculated using disposal costs for onsite CERCLA cells at Hanford, Oak Ridge Reservation, and Fernald; DOE disposal facilities at NTS and Hanford; and the Envirocare commercial disposal facility. Disposal at CERCLA cells is limited to onsite wastes. The slag and dust cannot be disposed of in CERCLA cells. The remaining wastes, including all slag and dust, were assumed to be disposed of at either Hanford, NTS, or Envirocare (the average of the three costs was used). MLLW was assumed to be one-third of the waste and LLW two-thirds.

Free Release of Material

Under Alternative 1, scrap metal can be free-released after decontamination and verification. Volumetrically contaminated and remote-handled (RH) metals are assumed to be non-releasable. Non-contaminated metal and 50% of the surface-contaminated metal are assumed to be free-released. The cost of decontaminating and quality assurance/verification/validation activities are $600/ton and $190/ton, respectively.

*Cost of decontaminating = ($600 per ton) * (tons of surface-contaminated metal)*
*Cost of QA = ($190 per ton) * (tons of surface-contaminated metal)*

Sell to Scrap Dealer

The carbon steel and stainless steel scrap free released will result in revenue to DOE. The price of scrap carbon steel is assumed to be $67.50 per ton (a 25% discount from the current scrap price of $90 per ton). The price of scrap stainless steel is assumed to be $450 per ton (a 25% discount from the current scrap price of $600 per ton).

*Revenue from sale of scrap metal = (tons of scrap released) * (price per ton of scrap)*

Process Material at MSC

MSC has an induction furnace that was assumed capable of producing Alloy 22. The cost to produce any alloy is reported to be $3.50 per pound, exclusive of raw materials and additives. In Alternatives 3D and 6, MSC uses the available GDP nickel, adds the chromium and molybdenum, and produces Alloy 22 to meet the requirements of RW.

*Cost to process material at MSC = ($3.50 per pound) * (2,000 ponds per ton) * (tons of nickel + additives)*

Process Material at GTS

GTS produces shield blocks from contaminated scrap metal. For Alternatives 3A-3D, 4A-4D, 5A-5D, and 6, the remote-handled scrap metal is fed to the melter at GTS.

*Cost to process material at GTS = ($2,160 per ton) * (tons of RH scrap metal)*

Transportation Costs

Transportation of material is required for the following:

- Shipment of scrap metal to the EAF
- Shipment of scrap metal to MSC
- Shipment of scrap metal to GTS
- Shipment of unused scrap metal to a disposal facility

Since the location of the EAF has not been specified, exact shipping distances and costs cannot be estimated to a high degree of accuracy. Instead, an average shipping distance and cost per mile have been used for this feasibility cost study. As conditions and requirements are further defined, the transportation costs can be estimated more precisely.

Processed metal and containers must also be shipped to the rolling mill, the fabrication shop, and then the ultimate user. Since the technical analysis has not established the conditions and requirements for rolling and fabricating the needed containers, these transportation costs have not been included in this cost model.

Exhibit 8-13. General Cost Assumptions				
Cost Assumptions	**Range of Values (if applicable)**	**Cost Used in Model**	**Units**	**Source**
Purchase Cost of Carbon Steel (Hot-Rolled)	$360-$400/ton	$380	$/ton	LaMastra
Purchase Cost of Stainless Steel	304SS ($1,800-2,000) 316 SS ($2,400-2,600)	$2,200	$/ton	LaMastra
Purchase Cost of Alloy 22	$7/pound	$14,000	$/ton	LaMastra
Selling Price of Scrap Carbon Steel (to DOE)	$90/ton with 25% discount	$67.50	$/ton	LaMastra
Selling Price of Scrap Stainless Steel (to DOE)	$0.30/lb with 25% discount	$450	$/ton	LaMastra
Decontaminate Scrap Metal		$600	$/ton	Sheely
QA for Free Release of Scrap Metal		$190	$/ton	Sheely
Nickel Processing to Remove Tc-99	$1/pound	$2,000	$/ton	Powell
Cut into 5-ft Pieces		$400	$/ton	November 1995 Report - S. Warren
Storage Costs		$2	$ton-year	November 1995 Report - S. Warren
Operations Cost for MSC Induction Furnace	$3.50/pound	$7,000	$/ton	Sheely
Scrap Metal Density		450	lbs/cubic meter	Geiger
Quantity of Dust Produced (EAF)	Provided in spreadsheet	36	lbs/ton scrap charged	Geiger
Quantity of Slag Produced (EAF)	Provided in spreadsheet	222	lbs/ton liquid steel	Geiger
Disposal Cost @ Hanford ERDF		$62	$/m3	March 2000 Report to Congress
Disposal Cost @ Fernald OSDF		$135	$/m3	March 2000 Report to Congress
Disposal Cost @ ORR EMWMF		$180	$/m3	March 2000 Report to Congress
LLW Disposal Cost @ Hanford/NTS/Envirocare (avg)	$516-$709 per cubic meter	$605	$/m3	March 2000 Report to Congress
MLLW Disposal Cost @ Hanford/NTS/Envirocare (avg)	$889-$1228 per cubic meter	$1,002	$/m3	March 2000 Report to Congress
Retrofit Existing EAF	Costs provided in spreadsheet	$22,440,000	$	Geiger
Move EAF to DOE Site	Costs provided in spreadsheet	$82,704,000	$	Geiger
Purchase NEW EAF	Costs provided in spreadsheet	$94,627,000	$	Geiger
Permitting/Licensing		$5,000,000	$	
Instrumentation to Measure Radioactivity	$200,000 per unit	$1,000,000	$	Akers
Operation of EAF	Costs provided in spreadsheet	$12,575,000	$/yr	Geiger
Maintenance of Permits/License		$500,000	$/yr	
D&D of EAF	$31-137 per square foot of building	$100	$/sq. ft.	D&D costs at Fernald

9. Conclusion and Recommendations

This study assessed the feasibility of a DOE dedicated mill (furnace system) that would enable the recycling of excess carbon steel, stainless steel, and nickel within the DOE complex. It would recycle metals from radioactively contaminated process buildings that are scheduled to be decommissioned and dismantled in the next ten years. A primary conclusion is that the DOE complex could use all of the nickel and stainless steel, and a small fraction of the carbon steel (nominally 100,000 tons) that will be generated. The method for recycling this metal for use within the DOE complex has not been completely defined due to the uncertainties described below.

It is concluded that the concept of a dedicated steel mill cannot be accepted or rejected because of the uncertainties in the estimated cost to implement, primarily associated with the uncertain level of demand for product in the DOE complex and the uncertain costs associated with disposal, decontamination, and regulation. The potential savings of such a pathway is sufficient that further study is recommended. Key areas for further work are:

- The confidence in the total demand for restricted use products is low (see section on Restricted Reuse Metal Product Demand). The worst-case example is the future waste container product needs resulting in a confidence range from –50% to +350%. It is recommended that the data call information be validated over the next several months.
- The use of a dedicated furnace is largely dependent on having a metal scrap inventory with low levels of contamination. It would only use steel scrap that met the revised Order 5400.5 for free release, or if the contamination was limited to uranium. This contamination should not exceed the Metal Acceptance Criteria (see Section 5). It would result in the efficient removal of the contamination from the metal by the furnace refining process (See Appendix A). The assumption that this contamination level is realistic for the bulk of the steel from the Enrichment Processing Facilities should be verified.
- It is recommended, as a sequel to the second bullet, that the personal exposure be better defined for the recycling through the furnace, rolling, and fabrication steps (see Sections 5 and 6).
- It is recommended that the cost estimates (see Section 8) be developed further to both reduce the uncertainties in the estimates and make the cost allocation logic more transparent and explainable.
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